Report of the Joint Committee
Of the Senate and Assembly
Dealing With the

WATER PROBLEMS OF THE STATE

Submitted to the Legislature
of the
State of California

JANUARY 18, 1929

MEMBERS OF THE COMMITTEE

SENATE MEMBERS

RALPH E. SWING, *vice chairman*_____San Bernardino
H. C. NELSON_____Eureka
WILL R. SHARKEY_____Martinez
EDWIN A. MUELLER_____El Cajon

ASSEMBLY MEMBERS

B. S. CRITTENDEN, *chairman*_____Tracy
VAN BERNARD_____Butte City
E. G. ADAMS, *secretary*_____Livingston
F. W. MIXTER_____Exeter

ASSEMBLY CONCURRENT RESOLUTION No. 30.

Providing for the appointment of a committee on water problems.

WHEREAS, It is necessary that the Legislature of the State of California have available adequate information so as to enable its members to consider proper legislation looking to the adoption of a state-wide plan for the conservation and use of the waters of the state; now, therefore, be it

Resolved by the Assembly, the Senate concurring, That a committee of eight members, consisting of four members of the Assembly to be appointed by the speaker of the Assembly, and four members of the Senate to be appointed by the president of the Senate, be appointed to make an investigation of the water problems of the state and to recommend to the Legislature of the State of California at the forty-eighth session thereof some state-wide policy for the conservation and use of the waters of the state; and be it further

Resolved, That said committee shall proceed to organize by the election of one of its members as chairman and by the election of a secretary, and shall proceed with said investigation in such manner as may be determined by said committee; and be it further

Resolved, That each department, board, commission or officer of the State of California, whenever requested to do so by said committee, shall furnish to said committee such assistance as it may require; and be it further

Resolved, That said committee is hereby authorized to hold public hearings at any place in the State of California at which hearings the people shall have opportunity to present their views to the committee; and be it further

Resolved, That said committee is hereby authorized and empowered to do any and all things necessary to make a full and complete investigation of the matters herein referred to and is hereby authorized and empowered to require the production of books, agreements, documents and papers of every kind; to issue subpoenas and to compel the attendance of witnesses, and to procure testimony. Each of the members of said committee is hereby authorized to administer oaths, and all the provisions of article eight of chapter two, title one, part three of the Political Code of the state relative to the attendance and assemblage of witnesses before the Legislature and committees thereof, shall apply to the committee appointed under this resolution. The said committee is hereby given leave to sit during the session of the Legislature, during the recess thereof and during the interval between sessions thereof, at any place in the state as said committee shall from time to time determine.

LETTER OF TRANSMITTAL

January 18, 1929.

To the Members of the Legislature, State of California,
Forty-eighth Session, 1929:

Your Joint Committee of the Senate and Assembly has the honor to submit to you its report on the water problems of the state. In the preparation of its report it has endeavored to study carefully the various reports made to the Legislature during the past eight years by the State Engineer, to have additional studies made under his direction; also to appoint a Legal Advisory Committee and have made available to the Legislature a report from it, and to have other reports and data assembled so that the members of the Legislature and the people of the state might have the benefit of this information and be better prepared to consider any legislation pertaining to the state's water problems.

Your committee has also in its report made definite recommendations pertaining to a statewide policy for the conservation and use of the state's waters. In making such recommendations the committee has followed your instructions in the resolution providing for its appointment. It is, however, fully cognizant of the magnitude and complexity of the problem and the far-reaching effects of adopting a new policy on the part of the state as well as the danger in doing nothing.

The committee wishes to call your attention to some of the important reports which have been filed with it, which may be of value to other members, should they desire to study them. Too much credit can not be given the many reports which have been presented from time to time to the Legislature on water problems by the State Engineering Department.

PARTIAL LIST OF OTHER REPORTS

Salt Water Problems of San Francisco Bay and Delta, by Thomas H. Means.

Report of Legal Advisory Committee to Joint Legislative Committee, dated October 27, 1928.

Report on Kennett Reservoir Development, an Analysis of Methods and Extent of Financing by Electric Power Revenue, by Lester S. Ready, Consulting Engineer, under the direction of Edward Hyatt, State Engineer.

The stenographic report of the proceedings before your committee in San Francisco on February 20, 21 and 22, 1928, and also April 16, 1928, and November 23, 1928.

Memorandum to the Joint Legislative Committee Pertaining to the American River, by A. M. Barton, Chief Engineer of the State Reclamation Board.

Report of Irrigation Investigation in California, by the United States Department of Agriculture. 1901. Bulletin 100.

Your committee wishes to mention the valuable assistance of all state departments called upon, and particularly the Department of Public Works, including Mr. B. B. Meek, its director, and State Engineer Edward Hyatt and his assistants, and the members of the Legal Advisory Committee, namely, Messrs. Henry E. Monroe, chairman, F. G. Athearn, Louis Bartlett, W. B. Bosley, Spencer Burroughs, A. L. Cowell, Homer J Hankins, S. B. Robinson, Edward F. Treadwell and Samuel C. Wiel, all of whom have freely given the committee able assistance. The committee wishes to express its gratitude to the various chambers of commerce and other organizations throughout the state for the splendid assistance they have given in furnishing a means of contact with the public generally. The press of the state has materially helped to make our public meetings successful; in fact, throughout the state there seems to have been a friendly attitude toward the work of the committee and a spirit of helpfulness.

B. S. CRITTENDEN, Chairman,
RALPH E. SWING, Vice Chairman,
E G. ADAMS, Secretary,
VAN BERNARD,
F. W. MIXTER,
H. C. NELSON,
WILL R. SHARKEY,
EDWIN A. MUELLER.

METHODS PURSUED BY COMMITTEE

Promptly after the appointment of the various members by the Lieutenant Governor and the Speaker, they met in Sacramento and organized. They also mapped out a plan of procedure.

The study involved covered such a wide range and the data to be obtained was so extensive and the problems involved were so numerous and complex that it was with some difficulty that the committee could determine where to begin and how to proceed.

PHYSICAL CONDITIONS.

It was obvious almost from the beginning that the committee should obtain a physical picture of the portions of the state that are affected by present water developments or that might be affected, and the parts also that produce the water supply. It was also clear that the various reports made to the Legislature since 1921 by the State Department of Engineering pertaining to the water problems should be given exceptionally careful study. Mr. Paul Bailey, State Engineer, at the first meeting of this committee, suggested that the best results would be obtained by the committee, so far as possible, by viewing dam and reservoir sites in the mountains mentioned in the report, as well as viewing developments in all the valleys of the state which the report had included.

Mr. Edward Hyatt, the State Engineer, following Mr. Paul Bailey, readily agreed to this plan and personally accompanied the committee on various tours of investigation from Eureka in the north down through the Sacramento and San Joaquin valleys and finally finishing at San Diego.

These investigation tours were so planned that during the day the committee would be shown a particular dam or reservoir site or a particular water development or physical condition mentioned in the report, and in the evening a public meeting would be held in the community the committee was visiting and the State Engineer would publicly explain his report as it applied to what had been seen during the day.

These meetings were well attended by the public, and the committee enjoyed a free exchange of views on water problems between the State Engineer and those present.

This method was followed at meetings held at Eureka, Redding, Red Bluff, Oroville, Marysville, Placerville, Grass Valley, Willows, Sacramento, Stockton, Richmond, Pittsburg, San Francisco, Merced, Modesto, Fresno, Delano, Porterville, Visalia, Hanford, Tulare, Bakersfield and other places.

The same method was also followed at meetings held in Los Angeles, San Bernardino, Riverside, Santa Ana, Fallbrook and San Diego, the water problems of the southern part of the state being, of course, of different nature to a large extent from those in the north, but are just as acute, important and serious, as will hereinafter appear.

ADDITIONAL REPORTS REQUIRED

Before the committee had proceeded far in its work it became obvious that a clear understanding should be had of the law applicable to the problems under consideration, hence the committee authorized its chairman to invite eleven well known attorneys to constitute a Legal Advisory Committee, to advise it as to the present status of the law.

This Legal Advisory Committee is composed of:

Messrs. Henry E. Monroe, Chairman,
F. G. Athearn,
Louis Bartlett,
W. B. Bosley,
Spencer Burroughs,
A. L. Cowell,
Homer J. Hankins,
S. B. Robinson,
Edward F. Treadwell,
Samuel C. Wiel.

Their report is marked Exhibit "A" and is affixed hereto and thereby made a part of the report of this committee.

It also appeared to the committee that more detailed study should be made of the revenue which might be obtained by the state from incidental power to be developed at any one of the dam sites and also the economic burden which the state would have to assume under the different methods of developing and handling of power. Kennett Dam was chosen as typical as to power possibilities and a report was prepared by Mr. Ready, under the direction of State Engineer Hyatt, and is marked Exhibit "B," attached hereto, and made a part of this report. Various supplemental reports have been prepared by the State Engineer at the request of the committee, as the result of its study.

PREVIOUS INVESTIGATIONS

It has been in the minds of many of our thoughtful citizens throughout the state for many years that some plan for the orderly development of the water resources of the state should be adopted.

In 1901 the United States Department of Agriculture made a report of irrigation investigations in California under the direction of Mr. Elwood Mead. This investigation was brought about by special requests of leading citizens of California. Their communication to Dr. A. C. True, Director of Agriculture, was as follows:

To Dr A. C. True,
Director, Office of Experiment Stations,
U. S. Department of Agriculture:

The undersigned earnestly desire that Mr. Elwood Mead be detailed by the department to conduct a series of irrigation investigations in California, and trust that you may feel justified in forwarding this request to the Honorable Secretary of Agriculture with your approval. We have, of course, ascertained that the proposed detail will not be contrary to Mr. Mead's inclination or judgment.

We respectfully submit that nowhere in America are there irrigation problems more important, more intricate, or more pressing than in California. Neither are there any whose study would be more greatly instructive. We can offer, we presume, examples of every form of evil which can be found in Anglo-Saxon dealings with water in arid and semiarid districts.

GREAT SUMS HAVE BEEN LOST IN IRRIGATION ENTERPRISES. STILL GREATER SUMS ARE ENDANGERED. WATER TITLES ARE UNCERTAIN. THE LITIGATION IS APPALLING.

Among the things necessary to be known before we can hope for well-considered legislation upon the conservation and distribution of our waters are the following:

First. The amount of water in the streams.

Second. The duty of water in the different irrigation basins.

Third. The claims upon the water, collated by streams and not by counties as now.

Fourth. The nature of water right titles.

Fifth. The adjudicated claims upon the waters.

Sixth. The lands now irrigated and susceptible of irrigation.

Seventh. The possible increase of water for beneficial use by storage in each system.

Eighth. The extent to which the irrigable area can be increased by better methods of distribution and use.

(Signed by) E. J. Wickson, acting director, University of California Experiment Station; J. A. Filcher, manager State Board of Trade; William Thomas; David Starr Jordan, president, Leland Stanford Junior University; E. B. Pond, president San Francisco Savings Union; William Alvord, president, Bank of California; Charles H. Gilbert, vice president California Academy of Sciences; Marsden Manson; T. A. Kirkpatrick, vice president P. C. M. M. D. Company; E. E. Patten; Grant S. Taggart; Frank Soule, professor of civil engineering, University of California; Julius Kahn; Victor H. Metcalf; German Savings and Loan Society, by B. A. Becker, president; E. J. Le Breton, president French Savings Bank of San Francisco; California Safe Deposit and Trust Company; W. E. Brown, vice president Crocker-Woolworth National Bank; Hibernia Savings and Loan Society, by Robert J. Tobin, secretary; M. H. De Young, San Francisco Chronicle; J. M. Gleaves, president California Water and Forest Society; David M. de Long, manager Nevada and Monette Placer Mines; R. H. Goodwin, United States Deputy Mineralogical Surveyor; Frank W. Smith; Ernst A. Denicke, president Germania Trust Company; C. E. Grunskey, civil engineer; George C. Perkins; Andrew W. Kiddie, United States Deputy Mineralogical Surveyor.

In 1913 another investigation was made by the State of California. The report made by Dr. Mead pursuant to this request is very comprehensive and is on file with the United States Department of Agriculture, known as Bulletin No. 100.

Following this federal report other investigations and studies of the water problem were carried on by the State of California, which culminated in 1921 in a general demand for an investigation of the water resources of California, and numerous appropriations and investigations were made, all of which show the important part that water plays in the economic activities of the state.

GENERAL DEVELOPMENT

California is an empire in the making. Since the days of the padre there has been a continuous development of the agricultural lands of the state. In order to do that, reclamation of lands from overflow was necessary. Provisions for flood control to prevent storm waters inundating cities and valleys have been made. The state being semi-arid, irrigation has been gradually developed for summer cropping. The growth of our large cities has required the storage and transportation of domestic water supply and the building of large dams for the development of electric energy. Much of our water law rose out of conflicting claims between miners subsequent to the discovery of gold. These developments have continued steadily with the growth of the state.

LACK OF COORDINATION IN PAST DEVELOPMENT OF THE STATE RECLAMATION

In the beginning of the reclaiming of the delta of the Sacramento and San Joaquin rivers and other lands, individuals and small districts built levees around their property until dozens of reclamations were made, each without regard to the other. Thereafter it became a struggle between them for existence, because each reclamation project deterred the flow of the river, raised the water level, and caused the lower levees to break. This continued to a point where it became disastrous to the lowlands

STATE POLICY OF RECLAMATION AND FLOOD CONTROL

The state early adopted a policy of flood control on the Sacramento and San Joaquin rivers. It cooperated with the federal government and the landowners along these streams and proceeded to control the height to which levees on the rivers might be raised.

In other words, it made the delta and Sacramento and San Joaquin valleys possible for reclamation by individuals or districts. The state also contributed a considerable sum toward flood control in Los Angeles County.

IRRIGATION DEVELOPMENT

The development of water for irrigation of agricultural lands in the Sacramento and San Joaquin valleys has been gradual, but extensive. It has been done by individuals, associations and various types of irrigation districts. Water for some of these developments is pumped from rivers directly to the lower levels Some of them pump their water from subterranean sources. A more general practice perhaps is to store water in the high elevations nearest the valleys and to transport it to the lands in summer as required. All of these developments have been worked out, each as a single unit, without regard to their effects upon any other irrigation system or the needs of any other person or persons. In southern California conservation of the flood waters is effected by spreading such waters upon the debris cones at or near the mouths of the streams.

MUNICIPALITIES AND POWER COMPANIES

Municipalities and power companies have added to the complexity of the situation by constructing huge dams in the higher elevations for the storage and transportation of water for domestic purposes or the development of electric energy for general public use.

Each and all of these developments have been the result of the great development of the population of the state. They are the products of the economic needs of the state, but each and all of them in their construction and operation have had in mind only the success of the individual project.

None of them has been installed, developed, constructed or operated in coordination with the interests of any other part of the state. Only the persons to be served by the individual project have been considered.

Such developments are not to be condemned but are indicative of the industry of our people; they have created unlimited wealth for the state and made possible the growth of great cities and numerous towns.

WHY THIS INVESTIGATION?

The intensive development before mentioned, desirable though it may be, has brought about many physical changes. New conditions have been created.

Reclamation in the Sacramento Valley and dredging of the mouth of the Sacramento and San Joaquin rivers has caused storm waters to rush more rapidly to the sea. The intensive development of irrigation in the Sacramento and San Joaquin valleys and the storage of water for power and domestic uses has drawn upon the summer flow of those streams until the supply of fresh water in the delta channels in summer months has been materially decreased.

The manner in which present conditions in the delta may have been changed from their natural state is discussed in the report of Thomas H. Means on the "Salt Water Problem," which report is hereto annexed, marked Exhibit "C."

In the San Joaquin Valley from Fresno south practically the entire surface run-off from the tributary mountains is now utilized except in case of extreme floods, and the pumping of underground water is relied upon to sustain the farm areas as well as the towns that have been established therein. Literally thousands of wells are being pumped to furnish necessary water throughout the greater portion of the growing season in this area. All of the towns of the San Joaquin Valley obtain their domestic supply from wells.

By reason of these conditions the ground water levels from Kings River south are falling. In many improved localities this is true to such a serious and alarming extent that federal farm loans have been discontinued. It is not a question there of irrigating new areas that is involved so much as the maintaining of existing developments.

In Bulletin No. 12 of the California Engineering Department, on page 24, it is stated: "Large areas deriving their supply from underground sources are facing a dropping ground-water plane. These areas are extending as their communities expand. Without additional supplies, well levels in these regions will continue to drop until either the underground basins are exhausted or the cost of pumping water to the ground surface exceeds its value."

Again on page 25 it says "Not over two-thirds of the area now under irrigation in California can obtain water as needed, with reasonable certainty."

Quoting again on page 22 of the same report, "Practically all of the summer flow of California streams that are accessible is now in use."

That the limit of development which can safely be made by the individual enterprises has now been reached is probably best shown by the institution of vast numbers of legal controversies between cities and others, power companies and other appropriators, between the delta interests and all irrigators or appropriators in the Sacramento and San Joaquin valleys.

Perhaps this is best illustrated by a recent suit filed in the superior court in the county of San Joaquin, in which there are 500 party plaintiffs against approximately 500 party defendants. Of course, it is not the duty of this committee to influence any action now in the courts. We merely mention this fact as illustrative of what seems to be the beginning of an era of endless litigation, and to show that the water

problems are acute. Already the scarcity of water is alarming the users in the different parts of the state. It is obvious that development has reached its maximum under present conditions.

It is obvious from the reports and from common knowledge, and so far as we know it is not disputed, that the development of the Sacramento and San Joaquin valleys and in the San Francisco Bay section has brought about a dangerous encroachment of salt water, a depletion of the water supply in the San Joaquin Valley for lands now under development; and with no reserve for further growth, and shortening of the distance on the river in which navigation can be enjoyed. In addition many cities and highly developed communities are annually menaced by floods, a great industrial district without a sufficient fresh water supply, a depletion of the water supply available for individual development and a continuing condition of legal strife involving water rights, all due largely to water consumed by various methods of development.

In other words, the great interior basin of California and portions of the territory surrounding San Francisco Bay have almost reached the limit of economic development of its water resources under the present policy of the state and under present conditions. Large agricultural areas and present investments are in danger of retrogression and depreciation; and all interests are more or less unstable on account of threatening litigation and uncertainty of future water supply.

SOUTHERN CALIFORNIA-COLORADO RIVER

South of Tehachapi lies an area known as the coastal plain. It comprises one of the richest and most densely populated sections in the state. Within it is located practically all of the cities and metropolitan areas of the south. Its development has been rapid and to meet its ever increasing demands, its water resources have been exploited to the maximum. If growth is to continue and further development in this region take place, the water necessary therefore must come from the Colorado River. This is the only available source. In the passage of the Swing-Johnson Bill congress has made possible the construction of the dam necessary to make the Colorado River water available for use upon the coastal plain. A sufficient quantity of water can be obtained from this source for such use. To make this water available for use on the coastal plain it is necessary that it be transported by means of an aqueduct from a point on the river below the dam. This will require an aqueduct of approximately 225 miles in length and construction of a system of tunnels through the Coast Range Mountains, as well as the construction of two and possibly three gigantic pumping plants to lift the water from the river level to an elevation which will permit it to flow by gravity to a point of use. Such water is only for domestic use and will not be available for irrigation. The cost of such aqueduct and necessary pumping plants has been given careful consideration by the engineering department of the city of Los Angeles, which city has already expended upward of $2.000,000 in surveys and in the study of this problem. The committee is advised, and we are of the opinion, that the procuring of such water from the Colorado River is absolutely essential to the further development of southern California.

THE SANTA ANA RIVER SYSTEM

The Santa Ana River system has its source in the San Bernardino range of mountains. The waters of this system flow through and constitute the source of water supply for the more fertile part of the counties of San Bernardino, Riverside and Orange. This river system has a large and productive water shed reaching from Beaumont to the San Antonio River and extending from the foothills in the San Bernardino Valley to the crest of the San Bernardino range of mountains. The heavy run-off from the higher reaches of this watershed rapidly descends into the valley, swelling the streams, causing them to overflow, flood and destroy valuable property. These floods carry down and deposit on the valley land large quantities of debris and detritus causing additional damage. The turbulent flood waters are heavily impregnated with silt and slickins which, when deposited on the debris cones, prevent the sinking of the water. Protection from these floods and conservation of a part of such storm waters have been carried on locally by volunteer subscription, resulting in only partial relief. The project is of such magnitude and the cost of a proper solution so great that it cannot be borne by those directly interested.

Four years ago this matter was brought to the attention of the state Legislature and action was then taken authorizing the state engineer to cooperate with the interested counties in an effort to work out and submit a feasible plan for economically controlling such floods. Since being so authorized the state engineer, in conjunction with engineers and others representing said counties, has carried on and made an exhaustive study of the rainfall, run-off and storm damages of said river system and the problems therein involved. Such study has been practically completed and the report is or soon will be filed. Such study has demonstrated that there are no available dam sites with sufficient reservoir capacity to make flood control feasible by storage, except, perhaps, the site at Prado, near the boundary between Riverside and Orange counties. A dam at such place would in no wise relieve the upper counties from a continuation of present conditions. However, there are deep and extensive debris cones extending along the entire foothill area of this water shed. These cones are composed of coarse gravel, rocks and boulders. They are very porous and water readily sinks to the deeper strata and percolates into underground channels and subterranean reservoirs. With proper controlled dams and diversion works the run-off from the higher watersheds could be controlled as it enters the valley and be diverted to these cones and sunk through the porous gravel beds into the deeper strata, underground channels and subterranean reservoirs of the valleys. Such diversion would effectively control the floods and incidentally conserve large quantities of water now flowing unused to the sea.

An economic program for the control of this river system should extend over a period of years and should be cooperated in by the interested counties and the state. It has long been the policy of this state, in situations such as this, to cooperate with those directly interested in carrying on work of controlling floods. In pursuance of such policy the state has contributed to the control of the floods of the Sacramento River and the floods of Los Angeles County. Similar treatment should be accorded those interested in the control of the floods of the Santa Ana River system.

MATTER OF STATE CONCERN

When a condition arises in the state in which practically all persons are and all property is directly or indirectly affected, it becomes a matter of interest to the state itself. The state has been fortunate during the past fifty years in that physical conditions have been such that private interests of one kind or another or subdivisions of the state could successfully develop the water resources of the state sufficiently to supply all the needs of the people and to build up unlimited values in property and create vast wealth. It is unfortunate that the time has arrived when present investments are endangered and future developments are about to cease on account of conditions which have arisen from the development of the state up to the present time. This situation exists throughout the highly developed portions of the entire state and is of paramount interest to the state as a whole.

PHYSICAL POSSIBILITIES

The various reports heretofore placed in the hands of the Legislature covering a study of water resources of the state since 1921, are referred to and made a part of this report, although not affixed hereto. These reports were prepared and concurred in by the State Engineer and the following recognized experts: Louis C. Hill, J. B. Lippincott, Wm. Mulholland, A. Kempkey, A. J. Cleary, G. A. Elliott, B. A Etcheverry, F. C. Hermann, W. L. Huber. These reports are unusually full, clear and carefully prepared, and have definitely answered the question for us from an engineering standpoint. There seems to be comparatively little, if any, difference of opinion in regard to the conclusions reached on egineering matters. It will not be necessary to recite herein data which is there available for your study, except to call attention to such facts as we feel will support our conclusions. Said reports conclude with a recommendation of a coordinated plan for the development of practically all of the state's water resources.

COORDINATED PLAN

It was not intended by that recommendation that any such plan would be completed for many years. It is the thought of the report as well as of this committee that development should not proceed more rapidly than economic needs of the state require, but as it progresses the various uses of water should be coordinated, and the plan suggested in those reports should be so far as practicable recognized and followed.

STREAM REPLENISHMENT

It is well known that the water supply of this state is derived from its annual snow and rainfall which is heaviest in the mountain areas.

"THREE-FOURTHS OF ALL OF THE STATE'S WATERS REACH THE OCEAN WITHIN FORTY-FIVE DAYS AFTER THE TIME OF THEIR PRECIPITATION AS RAIN OR SNOW UPON THE MOUNTAIN AREA." (See page 21, Bulletin No. 12 Department of Public Works, dated 1927.) Again, "The long, warm, almost rainless summers require water in large quantities for all human endeavors, but the summer flow in the streams most valued of all, is only the drain water in wake of the great volume of winter and spring run-off." (Idem. 22) "Three-fourths of all this water lies within the

northerly third of the state's area, while three-fourths of the need for water lies within the southerly two-thirds of the state's area." (Idem. 22.)

If it is an engineering possibility to construct a dam or dams which will store those flood waters which would otherwise run to the sea within forty-five days, and release them so as to replenish the Sacramento River in summer in excess of its present need for individual development, and by such increased summer flow in the delta push back the salt water, it will again make the great Sacramento Valley safe for development and the delta safe for investment, and also better conditions along the water front.

If it is an engineering possibility to replenish the waters of the San Joaquin River to supply the needs of lands already developed, it will have saved the investments in great agricultural enterprises in that portion of the state. If by a salt water barrier Suisun Bay and the delta can again be made fresh, industry again will be interested in locating there. As economic conditions require, all of the water resources on the western slopes of the Sierra Nevada may be developed as needed. In addition to all previous developments the state may, as its needs require, increase its present developments and its present property values. Cities may grow without limit and without friction. Litigation over water rights will be reduced to a minimum. Irrigation districts and reclamation district bonds and land mortgages and values will be stabilized. Northern and central California will be safe for another long period of intensive development.

The question of engineering practicability has been well answered by the reports of the State Engineer. It has been shown by that study that a dam may be built on the main Sacramento River at Kennett, with a capacity of 2,900,000 acre-feet; that this conservation of flood water would reduce flood flow by one-half at Red Bluff, sustain navigation during the year on the Sacramento River and prevent the encroachment of salt water into the fertile delta to a point near Antioch, and leave a large surplus for the San Joaquin. This reservoir site is ideally located. It has unusually large capacity, with a dam to the moderate height of 420 feet, which capacity could be increased by raising the height of the dam. This dam site is located on an exceptionally firm, igneous formation. Other dams and reservoirs may be constructed, some of which are the Iron Canyon with a capacity of 1,100,000 acre-feet, the Oroville Reservoir on Feather River with a capacity of 345,000 acre-feet; Narrows Reservoir at Yuba, with a capacity of 445,000 acre-feet; Parker Reservoir, with a capacity of 100,000 acre-feet and the Folsom Reservoir on the American River, with a capacity of 307,000 acre-feet. There is no one structure by itself which is more happily located for quantity of storage and safety of construction than Kennett, and there is no other single structure which comes as near answering the present needs of the northern part of the state as does Kennett. It has other economic advantages which will later be considered.

The engineering feasibility of the salt water barrier has been recognized as a part of the coordinated plan mentioned by the State Engineer in his report. It has also been made the subject of a report known as the Walker Young report; also, this matter has been thoroughly presented to the committee by Thomas H. Means in his report on "Salt Water Problems," heretofore mentioned.

Referring to page 48 of Mr. Means' report the summary of Mr. Walker Young's report is favorably quoted as follows: "The summary of Young's report gives his main engineering conclusions as follows:

1. The construction of a salt water barrier is feasible at either San Pablo Point or at one of three sites near the upper end of Carquinez Strait.
2. The barrier can be utilized for both rail and automobile traffic.
3. The cost will depend upon the method of construction. A barrier can be built at Army Point with bridge of 50-foot clearance for $49,600,000. at Benicia for $46,200,000; at Dillion Point for $44,700,000; at Point San Pablo for $75,200,000.
4. The barrier will pass a flood of 750,000 second feet (larger than any flood measured into Suisun Bay) with an estimated raising of water surface of 0.7 of a foot at the barrier, at Army Point, and about 0 55 of a foot at Collinsville. Water levels in the delta under extreme conditions are estimated to be below elevations of high water computed by flood control engineers of the state. With a barrier at Point San Pablo, the raise in water level would be slightly less than at Army Point.
5. The barrier would effectively handle both water transportation through locks and bridge transportation.
6. The barrier would store fresh water and prevent the encroachment of salinity now taking place every summer.
7. The barrier would prevent teredo from working above its location
8. The barrier can be operated so as not to be a detriment to the fishing industry.
9. The elevation at which water is maintained above the barrier in summer has not been determined To begin with it should be held a little below ordinary high tide.

The engineers agree that a salt water barrier can be built successfully across Carquinez Strait and provide for navigation and fish regulations; that it will not elevate the level of the water above the barrier to such an extent as to endanger the levees of the delta. The creation of a fresh water lake around the delta as well as around the industrial sites along the water frontage near the great centers of population is of great value and of general benefit. It would also make available for private and public development the excess waters of the Sacramento and San Joaquin rivers. It would also eliminate further litigation between riparian land owners and appropriators.

SAN JOAQUIN VALLEY

The report of the State Engineer is quite complete and convincing that waters from the tidelands may be pumped up the San Joaquin River by a system of dams and pumping plants and levees along the river, and canals extending from Friant on the upper San Joaquin to Kings River and from Kings River south to Erlimart. This system would make available water for replenishing the supply of the San Joaquin Valley.

ECONOMIC QUESTION

The committee is convinced that the projects are feasible from an engineering standpoint, and is convinced also that the water problems of California are critical. Therefore, the more serious and difficult problem of the practicability of these projects from an economic standpoint must be considered.

The original cost estimates for the construction of Kennett Dam, together with the power house, made in the state engineer's report is $80,000,000. One of the most expensive items is the requirement of the removal of that portion of the Southern Pacific railroad which

passes through the reservoir site. In addition, portions of the state highway must be relocated. However, the state engineer and his consultants feel certain that the estimates are liberal in the matter of costs of such changes. Should it be determined that the best interests of the state require the construction of such a dam, it is presumed that the Southern Pacific Company will cooperate in rerouting its line.

The purpose of the Ready report is to show what revenue the state might expect from power at Kennett. It is based upon the original estimate made by the state engineer as to the construction of the dam but changes the estimate of the cost of the power plant by reducing it $10,000,000, thus making the total cost $70,000,000 instead of $80,000,000. This saving of $10,000,000 can be effected by the production of primary power only and the elimination of secondary power which we deem not economically feasible. His estimates are also based upon the operation of the reservoir coordinately for control of salinity to Antioch, control of floods of the Sacramento River to 125,000 second-feet, making available an irrigation supply for the San Joaquin Valley of 330,000 acre-feet per season, or 1000 second-feet maximum rate of flow, and also for the generation of power incidental to the primary uses of the reservoir.

Concerning the marketing of power Mr. Ready, on page 3 of his report, says: "With reasonable cooperation between the state and the existing agencies, absorption of Kennett output will present no serious difficulties. The existing utilities have met problems relatively greater than the absorption of the output of Kennett."

Mr. Ready's study discloses that $64,000,000 of the $70,000,000, together with the interest on said $64,000,000, in all probability could be paid off on forty-year bonds at four and one-half per cent interest, which can be retired by the sale of power at 3.5 mills per k.w.h. at the switch. This revenue would be reduced approximately sixty per cent if the dam were operated entirely for irrigation. Our conclusions are that from an economic standpoint $64,000,000 of the $70,000,000 can be paid off by power in event the water is not released primarily for irrigation. Should power be reserved for pumping water up the San Joaquin River this revenue would be reduced by the extent of the value of the power so used.

Several different locations have been suggested for the salt water barrier. It is estimated that the cost of a barrier at Army Point would be $49,800,000 The cost of the construction of dams, levees and canals for transporting of water up the San Joaquin River is estimated at $24,000,000. Such a construction on the San Joaquin River would have a capacity of 3,000 second-feet, sufficient to supply 450,000 acres of land. The total cost of these three units, to wit: the Kennett Dam, the Salt Water barrier and the San Joaquin pump system and canals would be $144,000,000

FEDERAL AID

Federal aid in the construction of any of the units herein mentioned may be looked upon as a possibility.

President-elect Herbert Hoover in his address before the Sacramento Chamber of Commerce, June 27, 1925, is quoted as saying: "I speak for myself alone, but I feel we need a reconsideration of the whole basis of the expenditure of the reclamation fund. I would have these

funds used in pouring cement into our canyons and thus storage and more storage. And it should be done under the leadership and responsibility of the state governments. We should by this time know that the federal government has made a ghastly failure as a land speculator. In the long view it can never make a failure in contributing to storage works that will last over a hundred generations.

"We could even find an immediate return from such action for I believe it could be substantiated that the increment in federal income tax alone would finance and more than warrant these outlays. We are all engaged in great effort at tax reduction. But a soundly run business house not only looks after expenditure, it looks to increased revenue. A nation reduces taxes by increasing its wealth and thus spreads the burden. These are reproductive works we are talking about; they are not charity.

"From all of which I am convinced that a marginal contribution to these great works, over and above private and local effort should, if necessary, be borne by the state at large and by the nation at large."

FOOTHILL PROBLEMS OF NORTHERN AND CENTRAL CALIFORNIA

The foothill sections of northern and central California have furnished much of the basic wealth of our state and should not be overlooked in the development of the water resources of those parts of the state. It is important that the state retain such authority over the water coming within its control as will insure a sufficient supply for use within the watershed where such water originates when and as the same may be needed and reasonable provision should be made for maintaining the mountain streams of such territories in the interest of and for the protection of fish and game and for supplying the reasonable demands of outdoor recreation and sports and the demands for all other beneficial uses. Reservation of water for use in this area presents a difficult problem. Economically speaking, lands fartherest from market and from centers of population and land difficult of development are among the last to be brought under cultivation and unless provision is now made for caring for the demands of these lands as well as for the other beneficial uses when and as needed, the right for use for such purposes may be lost. Of the waters brought under control of the state the right of use of such part thereof as may be reasonably anticipated as necessary for supplying and caring for all the aforesaid uses should at this time be reserved, and alloted for such uses as required. In supplying areas of deficiency of water from areas of surplus only such water as is not needed to serve vested or other property rights, or necessary for supplying the uses and purposes hereinbefore mentioned should be considered and no water should be diverted from the area of origin which is now or which may ever be required for any beneficial use within such area of origin.

AMERICAN RIVER WATERSHED

The development of the American River watershed and the storage and controlling of the waters of the American River and its tributaries has been before the Legislature for the past four years. The project has grown in magnitude from the first thought of constructing a dam at Folsom to the present one of constructing at least three dams on the

American River. This project seems at this time to be one which may be undertaken and completed at a comparatively early date by money mostly provided by private companies and on such terms and conditions as will make it operative for flood control from North Sacramento, down stream, for the development of large quantities of power as well as for making some additional water available for domestic and irrigation purposes. The consideration of this now is important, as was demonstrated by the large area of suburban property flooded last March from this river. Data is not available at this time sufficient for this committee to make a definite report on conditions and terms that should be placed in any lease or contract in which the state may enter for the development of this great project; however, we believe it to be to the interest of the entire state that this project should be undertaken at once in substantially the same manner provided in the act passed by the last Legislature and approved May 17, 1927, and reported in chapter 569, page 955, Statutes 1927. We believe that another statute with substantially the same provisions should be reenacted and we have confidence the State Department of Finance will be able to negotiate some contract which will be beneficial to the state and fair to all.

CONCLUSIONS AND RECOMMENDATIONS

First—That the coordinated plan for the development of water resources of California as summarized in Bulletin 12, Summary of "Report of the Water Resources of California and a Coordinated Plan for Their Development," as filed with the Legislature in 1927 by the State Engineer and the Department of Public Works, Division of Engineering and Irrigation, be approved as the plan and policy to be followed by the state, subject, of course, to such modifications and changes as further studies shall demonstrate to be necessary or advisable.

Second—That the state should construct, own and operate Kennett Dam with a view to the conservation and most beneficial use of the surplus waters of the Sacramento River along lines favorably affecting flood control, salinity control, navigation and irrigation, and that the state should construct and own a power house at this dam and reserve to itself full authority to operate both dam and power house for the primary purpose of regulation and use of water for the aforesaid purposes and for the secondary purpose of hydro-electric power development. The power should be sold at the switch on contract to be made with the highest bidder before construction of the dam and power house is begun, said contract to run a reasonable length of time from date of delivery of first energy; said contract also to provide for allotment to the state at sale price, plus actual transmission costs, so much of the power as will be required for the San Joaquin Valley pump system and any or all other projects requiring electrical energy that may hereafter be built by the state in connection with the development of its water resources.

Kennett Dam should be constructed, as recommended by the State Engineer, to the height of 420 feet, but on a foundation calculated to support an additional 120 feet.

Third—That the construction of a salt water barrier at or near Army Point at a cost of approximately $50,000,000 is necessary for a complete carrying out of the coordinated plan for the development of the water resources of California as recommended in the first paragraph of these recommendations.

Fourth—That the construction of dams, pumping plants, aqueducts, and levees for the purpose of pumping and transporting water from the Sacramento River to and for use in the San Joaquin Valley at a cost of approximately $24,000,000, is necessary for the complete carrying out of the coordinated plans for the development of the water resources of California as recommended in the first paragraph of these recommendations.

Fifth—The question as to whether bonds for the construction of said salt water barrier and the dams, pumping plants and aqueducts for the San Joaquin Valley referred to in paragraphs three and four of these recommendations be voted at the same time as the bonds for the construction of the Kennett Dam is being held in abeyance by the committee for further consideration.

Sixth—In southern California 80 per cent of the water supply is now being drawn from wells and all available stream flow utilized. The ground water levels are being lowered by overdraft. The population increased from 1910-1920 85 per cent, and this ratio is continuing. The only adequate relief must come from the Colorado River. The building of the Boulder Canyon Dam has been provided for by congressional appropriation. There remains the construction of the aqueduct, the cost of which may be $150,000,000. This water is to be used by the cities of the south for domestic purposes. Eleven towns are now organizing for this purpose. The cost of carrying out the plan will be very burdensome. Besides this condition, there is the very serious situation as to water supply in Imperial and Coachella valleys and possibly other parts of the state along the lower Colorado River. If a comprehensive state project is adopted some provision should be made to extend assistance to these municipalities and agricultural areas in southern California. The ways and means for so doing can not now be definitely stated. They will be given further consideration in conference with representatives of that section during the next 30 days.

Seventh—That the financial cooperation of the United States government should be given in this undertaking, that steps should be taken by the state at once to acquaint the federal government with this proposed development, that the proper state officials be authorized to enter into negotiations with the federal government to that end, but that there be no delay in either the submission of the bond issue or actual construction of the proposed works pending such time as final decision is made by the government as to whether it shall aid California as requested

Eighth—That the state give such assistance toward the control of flood waters of the Santa Ana River as may be necessary and consistent with the policy as applied to the Sacramento River and the Los Angeles flood control.

Ninth—That the state renew and continue its water filings on such streams as may, in the judgment of the state engineer be needed now or hereafter for the purpose of carrying into effect the flood control or other policies contemplated in the coordinated plan, provided, however, that such filings should be released if and when such waters are needed for developments undertaken by others than the state itself of projects in harmony with the coordinated plan.

In conclusion your committee desires to state that it has avoided all reference to ways and means of financing the above recommended projects and to announce that during the constitutional recess it will conduct public hearings in San Francisco and Los Angeles to receive suggestions from all interested as to this phase of the undertaking, other questions held in abeyance. In the deliberations of this committee we have considered at least two possible methods of financing, one by a statewide bond and the other by district assessments according to benefits. We are open minded on both of these, and any other possible plans that may be suggested.

Shortly after this Legislature reconvenes for the second session we will submit a supplemental report, with our recommendations as to how this development is to be financed.

Signed:

B. S. CRITTENDEN, Chairman,
E. G. ADAMS, Secretary,
RALPH E. SWING, Vice Chairman.
H. C. NELSON,
WILL R. SHARKEY,
VAN BERNARD,
FRANK W. MIXTER,
EDWIN A. MUELLER

EXHIBIT "A"

REPORT OF LEGAL COMMITTEE TO JOINT LEGISLATIVE COMMITTEE APPOINTED TO INVESTIGATE THE WATER PROBLEMS OF THE STATE AND TO RECOMMEND SOME STATE-WIDE POLICY FOR THE CONSERVATION AND USE OF WATER.

EXHIBIT "A"

Report of Legal Committee to Joint Legislative Committee Appointed to Investigate the Water Problems of the State and to Recommend Some State-wide Policy for the Conservation and Use of Water.

To the Joint Legislative Committee appointed to investigate the water problems of the state and to recommend some statewide policy for the conservation and use of water.

GENTLEMEN:

The committee of attorneys appointed by your chairman to advise you with regard to legal questions arising in connection with your investigations and in the preparation of your report has made a study of the state of the law with respect to the matters within the scope of your investigation, and now submits a statement of its conclusions.

Assembly Concurrent Resolution No. 30, in pursuance of which you are proceeding, declares that the purpose of your appointment is "to make an investigation of the water problems of the state and to recommend to the Legislature of the State of California at the forty-eighth session thereof some statewide policy for the conservation and use of the waters of the state."

It is apparent from this language that the problem before you, in the solution of which you have asked our counsel on legal questions, is, stated in a broad way, how the most extensive practicable use may be made of the waters of the state, and it is equally obvious that this involves radical interference with the natural flow of our streams and underground waters, both by the diversion and distribution of these waters in ways widely at variance with the course of nature, and, also, by arresting the flow of water by impounding it in storage reservoirs and releasing it for various uses at times widely different from the times when it was wont to flow.

The fundamental water law of the state is the riparian right, but it is recognized that the water resources of the state are sufficient to irrigate large areas of land in addition to the lands riparian to our streams. In order to irrigate this additional area, it may not be necessary to take from riparian owners the quantity of water needed for the economical irrigation of riparian land, but, obviously, the water in excess of the amount required for economical irrigation of riparian lands can not be taken if the riparian owner is to enjoy the full flow of the stream, and the question, therefore, presents itself at the threshold of the problem as to how the state may make this broader use of the water consistently with private rights.

JUDICIAL DECISION

The Legislature in 1850 adopted the common law of England in its entirety, except so far as it was contrary to the constitution and statutes of the state. In doing so, it did not even embody the clause embodied in like laws of other states limiting such adoption of the common law in so far as it was applicable to conditions in the state. It has been suggested that the adoption of the common law, together with the riparian doctrine which was part of it, was accomplished by the Legislature after careful consideration of the subject. So far as we have been able

to ascertain, there is no evidence that the Legislature realized or discussed the fact that it was adopting the riparian doctrine of water rights. After this enactment in 1850 the Legislature passed practically no law making any definition whatever of water rights until the adoption of the codes in 1872. When the codes were adopted, they codified the customary law regarding appropriations of water, but were careful to add: "The rights of riparian proprietors are not affected by the provisions of this title." Certainly, no criticism could be made of a court arriving at the conclusion that the Legislature had intended not only to recognize, but thereby to protect riparian rights. The Legislature passed no other law on the subject until 1887, when it repealed this provision, but in the repealing act expressly provided that "the repeal of this section shall not in any way interfere with any rights already vested." Again, the courts could hardly be criticised for holding that this was intended to protect all riparian rights which had vested at that time.

The courts, therefore, being unaided by the Legislature and all of the meager legislation on the subject indicating that riparian rights did exist in the state, could hardly be seriously criticised for so deciding. They felt that it would be in the nature of legislation to hold that the riparian doctrine could only be deemed to have become the law of the state so far as applicable to our conditions, which require the use of all of the waters of the state on arid lands, and that, therefore, the right was limited to the quantity of water reasonably required when economically applied. The courts, having pronounced the contrary rule respecting these property rights, it is too much to expect that at this day the courts would reverse that ruling. This, however, does not prevent the courts from deciding as original propositions any particular features of the riparian right not decided in previous cases. But, as a general proposition, the general right and its incidents must be deemed to have become so fixed that they are not likely to be changed by mere judicial decision.

FLOOD AND FRESHET WATERS

It has been frequently suggested that the difficulty could be avoided by holding that riparian rights do not extend to what are sometimes called "flood" or "freshet" waters. These terms are frequently used with various meanings, but, in their broadest significance, they usually mean waters which the streams are not able to hold within their banks, but which, either on account of heavy rains or melting snows, so swell the stream that large areas of land are overflowed and inundated. These terms are so occasionally used with reference to extraordinary and irregularly occurring flows through ordinarily dry-washes, or flows which are otherwise unforseeable or undependable, even though held within the banks Some support has been given by decisions of the courts of this state to this contention, but the only cases which can now be thought to represent the present view of the courts in which this doctrine has been given any effect is in regard to water of streams in which extraordinary freshets are sometimes caused by excessive and unexpected rainfall. Such water has been held to be no part of the water to which the riparian owner is entitled. On the other hand, the Supreme Court has quite definitely held that with respect to the great

rivers of the state, which are affected primarily by the melting snow, the floods caused by such melting regularly occur, and can be foreseen, and are expected, and, therefore, are part of the regular flow of the stream to which riparian owners are entitled Even, therefore, if a person deemed it economically feasible to reservoir the waters of the extraordinary and unforseen freshets and it was held that this might legally be done, it would not solve the problem which we have before us, which has to do with the great rivers of the state, which are filled primarily by the melting snow, and with respect to which it has been held that the floods caused thereby are subject to riparian rights. Both the melting of the snow and the ordinary rainfall can be foreseen, and the floods which result are not extraordinary, but, under the decisions, would seem to constitute a part of the regular flow of the stream to which the riparian owner is entitled. The result is, that while in individual cases it might be that a decision might be obtained with respect to a particular stream that certain of its waters were flood or freshet waters not subject to riparian rights, as a general proposition such does not seem to be the situation, and, since we are dealing primarily with streams of a different character, it would seem that this doctrine can not be considered as offering any satisfactory solution of the problem before us. However, as a practical matter, it will be found that where most of the land along a stream is reclaimed and the maintenance of levees becomes important, there will be less likelihood of objections to the storage and diversion of waters that would menace the works of reclamation.

In some portions of the state, particularly the semiarid regions, problems of flood and freshet waters are no doubt of considerable importance in connection with flood control and water spreading projects, but detailed consideration of these matters would seem to be out of place in a general report dealing primarily with the major streams of the state.

DEDICATION TO PUBLIC USE AND PRESCRIPTION

There is no doubt that where water has been taken from a stream and used for five years adversely to the lower riparian owners a prescriptive title to the water thus taken is obtained as against them. It is also established that, in case water is taken for a shorter period and applied to a public use with the knowledge and apparent acquiescence of the riparian owners and the rights of the public have intervened, the continuance of the use cannot be stopped, but it may continue, subject to the payment of compensation if demanded within the statutory period.

As a practical proposition, these doctrines have operated to avoid the claims of riparian owners on a great many streams, for it is a well known fact that huge irrigation developments, as well as water power developments, have been successfully carried out both by public, *quasi*-public and private interests, without any objection whatever from riparian owners who might have claimed the right to the full flow of the stream. Generally speaking it seems to be the fact that where these developments do not deprive persons of water which they actually need for beneficial purposes, they make no objection to such developments However, our present investigation is being conducted on the

theory that objection may arise to any project of the state, as it has in individual cases arisen with respect to other projects, and we must advise as to the best way to obviate such objection, if made.

It is proper to state that claimants of the right to appropriate for use on nonriparian lands water that is not needed on riparian lands point, in justification of their claims, to the establishment of the custom of appropriation by the miners and to the recognition of the doctrine of appropriation in the Civil Code by the Legislature in 1872. They insist that the provision, inserted when the codes were adopted, that the rights of riparian owners should not be affected by the sections providing for the filing of notices of appropriation, was intended to preserve to the riparian owners only the right to so much water as they might actually need, and in support of this they emphasize the fact that in 1887, at the next session of the Legislature after the final disposition of the case of *Lux* vs. *Haggin* in 1886, the Legislature repealed this saving provision. Furthermore, they direct attention to the fact that in 1913, the Legislature passed the Water Commission Act, which was approved by the people on referendum in 1914, and by this act all water not appropriated or reasonably needed for use on riparian lands was declared to be subject to appropriation, and rules for obtaining permits and licenses for the appropriation of water were established.

POLICE POWER

Naturally, one of the suggestions which occur in this respect is that in some manner the desired result could be accomplished by the exercise of the police power. In connection with this, it should be noted that the courts, in deciding riparian rights as between individuals, have not generally been called upon to pass upon the right of the state in case it asserted it under the police power. The courts have had occasion to refer to certain acts of the Legislature which merely undertook to permit private persons to appropriate and take water away from the riparian owners on the theory that the state had a proprietary interest in the water, and to hold that this could not constitutionally be done.

The courts have passed upon certain acts passed under the police power, such as acts to prevent the waste of water, and held them constitutional, and the act limiting land to a definite quantity of water, and held it unconstitutional, but the courts have never deemed that they have been called upon to pass in a broad way upon the question as to the power of the Legislature to deal with or regulate riparian rights for the public good, under what is generally known as the police power.

Specifically, therefore, the question presented is whether the Legislature under the police power could limit the right of a riparian owner to such water as he requires when economically diverted and applied, and whether, if it could do so, that would prevent the riparian owner from objecting to a diversion which deprived him of the right to the full flow, but did not deprive him of the amount economically required. This question presents the broadest field for philosophical discussion. The leading cases by the supreme court of the United States involving the police power are, in fact, philosophical discussions, and the conclusions arrived at, even by a four to five decision, are controlled

by the peculiar philosophy of the individual justices pronouncing the conclusion of the court and the consequent dissenting opinions. Many generalizations have been attempted in regard to the police power, but it will be found that almost all of them break down when put to the test of judicial decision. It has frequently, for instance, been said that there is a clear and marked distinction between the regulation of property under the police power and the taking of property under the power of eminent domain, but under the latest pronouncements of the supreme court of the United States, there is no such clear demarcation. On the contrary, it has recently been pointed out that when the Legislature forbids a man from erecting more than a five-story building on his property, it does, to the extent that it forbids the use of his property, take it from him. Still, in a proper case, this may be fully justified under the police power without compensation.

It, of course, is deemed that the very nature of water makes it peculiarly a subject of the exercise of the police power. There can not be much serious question that the Legislature has full power to require such economy in the use of water as is necessary, at all events, in order that all those entitled to use the water may enjoy it. But, whether it can make like regulations for the purpose of making a more extended use of the water by a general plan for the conservation and use of the waters of the state in the interest of the public presents a different question. We believe, that in view of the latest decision of the Supreme Court of California that it did not intend to prejudice the question as to the rights of the state under the police power, this committee should not assume that the Legislature could not so provide by the exercise of that power. On the other hand, we believe that it would be an unfounded assumption of knowledge for this committee to presume to decide that the Legislature could under the police power solve the problem before us, in view of the absence of any controlling decision on the question. We know that the Legislature could not, by the exercise of the police power, take away from the riparian owners waters which they reasonably require for their needs when reasonably and economically applied, and, we presume, it would be equally recognized that from the standpoint of fairness and justice the Legislature would not desire to do so if it could. Whether it could limit, so to speak, the riparian owners to a quantity of water economically needed by them, is a question which should not be foreclosed by us, nor should we attempt to advise that the Legislature has or has not such power. If the state should determine to attempt such a regulation of riparian rights, there is adequate machinery in the law for the determination of its validity.

NAVIGABLE WATERS

The principal rivers of the state, the waters of which the state desires to take for public use, are navigable streams. In the decisions of the courts regarding water rights between private individuals, the courts have had little or no occasion to consider the nature of the rights of the state in navigable waters. The suggestion has been made that the state has a right to use the navigable waters of the state either for navigation or other public uses, and that any rights of riparian owners must be held subject to the superior right of the state. The far-reaching effect of this contention can readily be seen.

Assuming that the state had any such power, it is inconceivable that it would desire to exercise it so as to interfere in any way with the navigation interests of the state or the enjoyment by riparian owners of the waters of streams, so far as the same are reasonably necessary for their lands. It is equally inconceivable that it would desire to exercise it so as in any way to question the right of appropriators to continue to enjoy waters appropriated by them and reasonably needed for the purposes for which the appropriation was made. Whether it might desire to exercise the right as against the claim of a riparian owner to the full flow of the stream, although such flow is not reasonably necessary for his use, presents a question of public policy on which this committee could not well pass. The attitude, however, of the Legislature on Assembly Constitutional Amendment No. 27, submitted to the people by the Legislature at its last session, might be construed as indicating that it did not have a high regard for this claim.

Here, again, we have no authoritative decision by the courts of this state on the subject. Examining the decisions of the courts of other states, we find, first, that the courts of some states have held that the state is the owner of all navigable waters and is entitled to take them in aid of navigation or for any other public use, and that the rights of riparian owners are entirely subordinate to the right of the state; second, in other states the courts have held that the state only owns the navigable waters for the purpose of navigation, and that it can not take, or authorize the taking of, the water for other public purposes as against riparian owners; third, it is held that whether or not the state may take the water as against the claims of riparian owners, depends on the question whether the state or the riparian owner owns the bed of the navigable streams; and fourth, in many states it is held that even where the state owns the navigable waters for all public purposes, it may grant rights therein which would become superior to any right of the state, and the question as to whether such rights have been granted, of course, involves many considerations of law and fact.

In attempting to apply these decisions to this state, we find many difficulties. By section 670 of the Civil Code it is provided that the state is the owner of all land below tide water and below ordinary high-water mark bordering upon tide water within the state; and of all land below the water of a navigable lake or stream. By section 830 of the same code it is provided that a grant of land bordering on tide water extends to *high*-water mark, while a deed to land bordering on a non-tidal navigable lake or stream extends to *low*-water mark. Whether the effect of this would be to limit the title of the *state* in the bed of a navigable lake or stream to the land below *low*-water mark, does not appear to have been decided, and a decision on that point might materially affect its title to the *water* of non-tidal streams above the low-water mark.

We find that, as between private individuals, our courts have recognized the rights of riparian owners on navigable streams, but have had no occasion to determine whether such rights are subordinate to the superior rights of the state for purposes other than navigation. In view, therefore, of the fact that the courts of different states have come to different conclusions on this subject, we do not believe that it would be of any benefit for this committee to attempt to express an opinion

on this very important question. All that we can say is that the contention does exist, and it can not be said to be without merit, nor can it be, with any degree of certainty, said to be well founded.

There is also some doubt as to how far a decision in favor of the state on this question would solve the present difficulty. The decisions in other states seem very generally to hold that even where the state has a right to use the waters of navigable streams for any public purpose as against the claims of riparian owners, the state can not do so to the injury of riparian owners on non-navigable portions of the stream, or upon non-navigable branches or tributaries. Undoubtedly in certain cases the riparian owners claiming the right to the full flow of the stream would own land upon non-navigable branches of the river, and it might be those very branches that were most affected by the taking of the water.

For these reasons, we feel that no definite opinion can be expressed as to the right of the state in this particular, or how far a decision favorable to it would solve the difficulty in any particular case.

EMINENT DOMAIN AND COMPENSATION

Of course, it is elementary that the state, under its inherent power of eminent domain, has a right to take water for public use, just as it has the right to take any private property in condemnation proceedings, subject to the constitutional requirement that just compensation be paid for the property taken. So that, in all events, the state has in its hands one method by which it can effectively remove the obstacle which we have been considering.

This principle is so elementary that it is needless to enlarge upon it, and the only suggestions which this committee could make would be with regard to the procedure by which riparian rights might be condemned and compensation fixed In this regard three distinct procedures have been considered, as follows:

First, the present statutory method of a proceeding in the superior court, in which the judge decides all questions except the amount of compensation, which is fixed by a jury, unless a jury is waived by the parties. This procedure, of course, has the advantage of being the procedure in vogue, and it also has the advantage that it would only be invoked when and if a riparian owner insisted on his right to the full flow of the stream. Under this procedure, as well as under the others hereinafter considered, the court can decide all conflicting claims of the parties with regard to the water of the stream, as well as the compensation to be paid for the rights taken, subject, of course, to the right of appeal. If there should be any doubt on this latter point, a simple amendment of the Code of Civil Procedure could confer power upon the court, in any eminent domain proceeding, in which there was doubt as to the title of the property to be condemned, to determine first the relative rights of the parties in and to the property and then to fix the amount of compensation to be paid for the property necessary to be taken for public use.

There is now a statute which provides that the court may appoint competent persons for the purpose of investigating without prejudice to either party the facts of the case and reporting to the court their conclusions, subject, of course, to cross-examination by the litigants and to

the right of the litigants to produce witnesses in their own behalf. There is a provision in the State Water Commission Act whereby the court may refer to the State Water Commission (now the Division of Water Rights) as referee litigation affecting water rights. The Division of Water Rights and the Division of Engineering and Irrigation are both equipped to gather data that would be useful in an eminent domain proceeding of the character under consideration, and one or the other of these divisions might be made available by law for the assistance of the courts in such cases.

Second, it has been suggested that an administrative proceeding be provided for by act of the Legislature whereby some administrative tribunal would inquire into the damage which would result to riparian owners by the taking of water for public use and that the findings of such administrative body should be subject to recourse in the courts, in which they would be *prima facie* evidence as to the amount of damages. Some have suggested that the present Division of Water Rights could act as such administrative tribunal, while others have urged that this division is too closely connected with the program of the state in the working out of a comprehensive program for the conservation and use of our water resources to be deemed an impartial tribunal. Consequently it has been suggested that a new commission be created for this particular purpose or the State Water Commission be revived as an independent branch of the state government.

In this connection it has been suggested that in connection with the appropriation of water the Division of Water Rights could be given authority to hear any protest on the ground that such appropriation would damage riparian land, and determine, in an administrative way, the extent of such damage, leaving the parties the right to judicial recourse with a jury trial if the administrative award should not be accepted.

Those who advocate such an administrative tribunal argue that the results of its work would be much like those of a board of viewers in the laying out of a public road, and that in the great majority of cases the award made by the tribunal would be accepted without question, and that if in some cases an award was not satisfactory and the matter was taken into court, the work done before the administrative tribunal would all be available in the trial before the court. It is pointed out that the Water Commission Act now provides for a somewhat similar procedure in stream adjudications, and that similar provisions are found in the statutes of other states, and that the history of such proceedings is that the administrative determination is accepted in a vast majority of cases.

On the other hand, it is obvious that if the award of the administrative tribunal is not satisfactory, it will be necessary for the land owner to incur the expense and trouble of an additional proceeding in court in order to obtain what he considers to be his rights.

Third, neither of the two foregoing procedures would require any modification of the constitution. It has also been suggested that a constitutional amendment be prepared for the establishment of a judicial tribunal to determine conflicting claims to water rights and the compensation to be paid in case of the condemnation of such rights, such tribunal to function as in the case of the State Railroad Commission and the Industrial Accident Commission, when exercising judicial

functions. It is pointed out that the determination of such a tribunal as to matters of fact could be made conclusive, and its decisions subject to review only by the appellate courts on questions of law.

It is obvious that much can be said in favor of and against each of these proposals. They involve largely a question of policy, and partiality for one or the other depends largely upon the point of view of the individual. It is hardly within the purview of the duties of this committee to express any preference on the subject.

In determining, however, which, if any, of these suggestions adequately meets the situation, this controlling feature should not be overlooked, namely, that as a general rule the state does not desire to condemn all of the rights of riparian owners, but that in most cases it will be desired to leave to the riparian owners the quantity of water which they reasonably require for economical use. One great difficulty in any condemnation proceeding, whether strictly judicial or administrative, is in devising a procedure which will take away from the riparian owner only that excess of water which is desired to be taken. In the ordinary proceeding in condemnation, the plaintiff states what water he wishes to take, and the question is to what extent will that damage the riparian owner. The difficulty is that it is impracticable in such a proceeding to ascertain whether such a taking will only deprive the riparian owner of the excessive quantity of water which he really does not need or whether it will deprive him of water which he requires for his uses. This will readily be seen when we consider that the right of a riparian owner on one of our great rivers is entirely correlative with the rights of many other riparian owners, and unless there is sufficient water left in the stream after the condemnation to supply the reasonable needs of all riparian owners on the stream, the defendant in the condemnation suit may be deprived, as a result of the proceeding, of water which he absolutely requires for his needs. Thus, if a stream is flowing 10,000 second-feet, the taking of 500 second-feet might not injure, or even inconvenience any riparian owner, but if the flow of the stream drops to 1,000 second-feet, the condemnation of 500 second-feet might result in serious loss to a riparian owner who would have to share the remaining 500 second-feet with a large number of other riparian owners. The effect of the taking of any given amount of water from a stream can best be determined by an investigation of the entire stream and the needs of all parties upon it. Such an investigation in each individual condemnation proceeding would be impracticable, unduly expensive and place a burden upon the parties that would be unbearable, and this would be true, whether the proceeding was before the court or before an administrative body. Whatever procedure, therefore, is adopted, it should be adequate in some way to ascertain the amount of water which the riparian owner does require and in some way assure him of that quantity, and then, if necessary, condemn the right to take the surplus as against the legal right to the full flow of the stream. Of course the right of the state, if necessary, to condemn the entire riparian right, would remain as at present, and, undoubtedly, in some cases the condemnation of the entire right would be necessary, but, generally speaking, it would not be necessary or desirable.

The suggestion has been made that the damages which the riparian owner claiming the full flow of the stream would recover would generally be small. This entirely overlooks the difficulty which has just been pointed out. If the trier of the facts, whether it be a jury or an administrative tribunal, is left in doubt as to whether the condemnation will leave the riparian owner with a clear right to a sufficient quantity of water for his reasonable economical uses, the damages awarded must, in the nature of things, be large, and not small. If, therefore, justice is to be done to the riparian owner and at the same time to the public in its desire to take the surplus water, some procedure must be devised which will assure to the riparian owner water for his reasonable needs and limit his damages to such amount, if any, as will compensate him for any loss he may sustain by the appropriation of the surplus.

It has been suggested that this difficulty may be met by the condemnation of the entire riparian right of the defendant, with a guarantee by the condemning party, in lieu thereof, of a certain definite supply of water, to be taken from the appropriation of the condemning party. This would put upon the condemning party the duty to protect the appropriation, both for itself and for the riparian owners whose rights were condemned, against any demands of other riparian owners on the stream who were not parties to the condemnation proceedings; and on the other hand, it would give the riparian owner a definite supply of water, which could be determined by the court to be sufficient for the needs of the riparian land.

It has also been suggested that provision be made for a proceeding *in rem* in the superior court or one of the other tribunals hereinbefore suggested, to settle and determine all rights in a particular stream, with a provision that each riparian owner might, in lieu of his riparian rights, accept a certain quantity of water with a priority over all persons except those who had already acquired better rights against him. In case any riparian owner refused to do this, his riparian rights over and above such quantity of water as might be found to be necessary on his land would be valued and condemned in such proceeding, and their value paid to him, and then all the rights on the stream would be fixed in the final judgment in the proceeding. The result would be an assurance to the riparian owners of enough water for their land, and no more, and an assurance that the balance of the water would be available for other purposes, and finally at the same time the rights of all persons in the stream would be settled, and the stream would be in a condition to have the water actually measured and delivered to those entitled to it under the direction of a water-master, if that were found necessary.

A proceeding of this nature is now provided for in the Water Commission Act, but it is limited to rights by appropriation and there is no provision for determining the rights of riparian owners in that proceeding, or for condemning rights of any character.

No matter what course of procedure may be followed, the committee recommends that consideration be given to the following proposals for changes in the law of eminent domain:

First. One suggestion is that, unless a tribunal having state-wide jurisdiction is provided for, the law should be changed to allow a condemnation proceeding to be brought in the county in which any part

of the riparian land is situated. At present, a separate suit must be brought against owners in different counties, whereas the effect on these lands should be determined in the same proceeding. This suggestion is not based merely on considerations of convenience, but is made in view of the fact that many streams flow through more than one county and that for reasons hereinbefore pointed out it may, in many cases, be essential that the correlative rights of all riparian owners and appropriators on a stream be ascertained in the same proceeding.

Second. The constitution originally provided that private property should not be taken until compensation was first made and paid, and this was held to prohibit the Legislature from providing that the public might take possession upon giving security for damages. This resulted in amendments providing that in any action of eminent domain brought by the state or a county, or a municipal corporation, or a drainage, irrigation, levee or reclamation district, the aforesaid state or political subdivision thereof, or district, may take possession and use of any right of way upon giving security for damages. It will be noticed that the amendment does not include all public districts or public utilities, nor does it include quasi-public corporations, and the words "right of way" are quite indefinite. We see no reason why this section should not be again amended so as to generally permit possession of any property to be taken by anybody exercising the right of eminent domain upon making deposit for the owner. At all events, it should be amended so as to include water.

Third. Another change in the law of eminent domain which might be of great importance, but which should receive critical study before it is put in definite form, would be the adoption of Legislation or constitutional amendment providing for compensation by substitution based on the recognition of the fact that compensation wholly in money does not always adequately meet the situation, and that physical adjustments are often required by the facts of a particular case. For example, the construction of a reservior may flood a private road essential to the use of nearby lands, and if the proceedings for the condemnation of the private road must, as at present, take the form of fixing the compensation for what is taken, the award may have to be a very large one. The utility constructing the reservoir may, however, be perfectly willing to, and could at far less expense, provide a private road across the dam which creates the reservoir, which would be equally as good as, or even better than, the existing road, and thereby completely eliminate the damages resulting from the destruction of the road, but there is no way, under the present law, in which the utility could compel the owner of the private road to accept the new road in lieu of cash compensation based on the destruction of the old, nor, on the other hand, can the owner of the road insist that the utility give him the right of way across its dam.

Another illustration may be found in the case of a power company desiring to divert the flow of a stream above a point where an irrigator diverts say, 100 inches of water into a ditch for irrigating his land. The power company may be perfectly willing to construct a pipe or ditch from its conduit, which will deliver to the lands of the irrigator

the full 100 inches to which he is entitled, and may be able to construct the necessary works at a cost of say $1,000. Under the present procedure, however, the land owner could insist on compensation for the taking of his entire water right and might be legally entitled to say $100,000 damages.

Cases of this kind are often adjusted by mutual agreement. Serious consideration might well be given to the question of the possibility of making changes in the law which would permit a plan for compensation by substitution of physical adjustment to be suggested by the parties to an eminent domain proceeding, and if found by the court to be compatible with the greatest public good and the least private injury, and to afford just compensation, to be carried into effect by judgment, either with or without monetary compensation.

Some steps in the direction mentioned have already been taken by the inclusion in the Code of Civil Procedure of provisions for the relocation of structures or improvements and the making of crossings and the construction of fences; but although they seem to recognize the principle of physical adjustments they are far from adequate to meet the exigencies which may arise in connection with any state-wide plan.

Fourth. Another subject requiring detailed and careful consideration is found in the fact that the present statutory provisions on the subject of eminent domain contain many illogical and impracticable provisions Numerous amendments to meet specific cases have been adopted from time to time until the portion of the code relating to eminent domain has become not only illogical but even self-contradictory. There has been no systematic revision of these provisions since 1872. Other states, notably New York, have, in recent years, adopted revised statutes on the subject of eminent domain to meet present day conditions. The subject is, of course, much broader than the subject matter of this committee's activities, but it is obvious that the adoption of any state-wide plan with reference to waters must involve extensive resort to the powers of eminent domain, and the consummation of any such plan might be seriously hampered by the inadequacy of the present law and the absurdities it contains.

Fifth. In several of the western states the Legislature has declared irrigation to be so essential to the well being of the state as to constitute a public use, whether the use is for the general benefit of the public or for the private benefit of the irrigator. The validity of such legislation has been very generally upheld by the courts, including the Supreme Court of the United States, and if such a law were enacted in California it would enable any appropriator to take advantage of any statutes which the Legislature might pass for the condemnation of riparian rights in order to permit the irrigation of nonriparian lands. There seems to the committee to be no objection to such legislation, and that considerable advantages might flow therefrom.

HYDRAULIC POWER OF STREAM

There are several circumstances under which the hydraulic force of the stream as a valuable right might be claimed by the riparian owner, and we will therefore consider them separately.

1. *Production of power.* The right of the riparian owner to use the stream for the production of power is a well established one. In

early days the power of the stream was directly applied to the operation of machinery, but under present conditions that method is but little used. The modern method is the use of the stream for the production of hydro-electric power. So far as the valley lands are concerned, the use of the streams for this purpose may for practical purposes be disregarded. Abstractly, the owner of a piece of riparian land near the mouth of one of our great rivers is entitled to the full flow of the stream for the propelling of machinery. But the stream is of little value for that purpose, is practically never utilized for that purpose and could not economically be maintained for such purpose. On the other hand, in the mountain regions the production of power is the important factor.

In those cases where the natural flow of the stream is used for generating power and the water is returned to the stream above the irrigated areas, the power use does not conflict with the irrigation use. In many cases, however, the economical utilization of the stream for generating power requires the use of large reservoirs, to store the summer flood flows for use at other seasons of the year, and particularly in the winter when in general the maximum power demand occurs. On the other hand, the maximum demand for water irrigation in general is in the early summer months. A conflict thus arises in many cases between power uses and irrigation uses. In such cases the manner in which the conflicting interests can be reconciled must of necessity be determined in the light of the particular facts of each case. Occasionally it is practicable to construct reregulating reservoirs below the power works and reestablish the natural flow, or even to create a condition more favorable to the irrigators than the natural flow. In other cases the rights must be adjusted by amicable agreement or resort to the power of eminent domain.

2. *Use of hydraulic forces as a means of diversion.* In a state of nature the hydraulic force of the full flow of the stream undoubtedly at times either directly diverts water by way of overflow onto the adjoining land, or indirectly does so by raising it into high-water channels and thence over the land. Obviously, this condition can not ultimately be maintained. At the same time the owners of land benefited thereby will naturally oppose any deprivation thereof. Undoubtedly in certain cases this could be avoided by the construction of proper means of artificially diverting the water. Whether that could be accomplished under the police power or whether the party desiring to take the water would be compelled to furnish such appliances is a matter comprehended in the general question of the extent of the police power, which we are not attempting to pass upon. However, if the right to construct such appliances, if necessary by means of the power of eminent domain, were granted, the situation could be satisfactorily handled. The question whether in any given case it would be better to condemn the overflow right entirely or substitute for it a more up-to-date method of irrigation would be a question of economics in any given case.

3. *Use of hydraulic power to force water into underground channels.* There are cases where the high flow of the stream forces water into underground channels or permeable strata from which the water is later abstracted by means of pumps for irrigation. The best illustration of

this situation is the Coyote Creek in Santa Clara County. Such a use of the water is of course of substantial value. Economically such areas could not well be deprived of the quantity of water naturally coming to the land. The water, however, which serves this hydraulic purpose, and then flows to the sea, never reaches the land, and if the construction of artificial structures would cause the same quantity of water to naturally flow to the land, and at the same time conserve the surplus which would otherwise be lost, there would seem to be no substantial objection to such a procedure. We understand that some such solution was applied to a like situation on Alameda Creek. At all events, the situation does not seem to be one that could not be solved in most cases in some manner so as to preserve the water which under natural conditions is lost.

4. *Use of hydraulic force to protect land from encroachment of salt water.* This situation presents itself on the delta of the Sacramento and San Joaquin rivers. There is some dispute as to whether or not lands thus situated have riparian rights. There is also some dispute as to whether the use of the water for the purpose mentioned is a riparian right. Without attempting to pass on those disputed questions, there is no doubt that from an economical standpoint the lands should be assured of the reasonable quantity of water needed for irrigation. The exact method by which the saline situation might best be handled is one upon which many persons are now working who are probably better advised than we are as to the physical situation. Of course the construction of some artificial barrier against the salt water is the method that naturally first suggests itself, and that is being seriously considered by both the state and federal governments. Others have suggested that it would be feasible to supply to these lands a sufficient quantity of water to hold back the salt water. Of course this would result in some loss of water, and the question would simply present itself as an economic one whether that were cheaper than building a barrier to keep the salt water out. The problem is a large one, and whether the owners of these lands are entitled to insist that anyone taking the surplus water must protect them, or whether they must protect themselves against the salt water, presents legal problems which are difficult of solution and which will probably disappear in view of the economic problems involved. In other words, as a practical proposition, the state may not find it advisable to permit damage to such lands in order to permit the irrigation of additional areas. At all events, the quantity of water needed to protect those lands could be ascertained and determined, and become a limiting factor in determining the surplus available for diversion and use.

CONCLUSION

In this report we have assumed that any proposed legislation concerning the conservation and use of water would recognize, frankly and fairly, all existing rights to water or its use. These rights include: first, the rights of owners of riparian lands and lands containing percolating waters or other underground sources of water supply, and second, rights based on appropriation, diversion or use of water by others than riparian owners or owners of so-called overlying lands. If any proposed appropriation, diversion or use of water, to be authorized by or under authority of the law of the state, should violate or

prejudicially affect such existing rights, then the owners of such rights should be awarded just compensation for any damage which they may suffer.

In the foregoing we have not attempted any technical statement of water rights or any nice distinctions, but have sought in a broad way to call your attention to the nature of the problem and the rights involved, and made our suggestions as to how the state might proceed with due deference to private rights and constitutional principles, and trust that our suggestions may prove of some value to you in the performance of your duties.

Dated, October 27, 1928.

Respectfully submitted.

HENRY E. MONROE,
Chairman.
F. G. ATHEARN,
LOUIS BARTLETT,
W. B. BOSLEY,
SPENCER BURROUGHS,
A. L. COWELL,
HOMER J. HANKINS,
S. B. ROBINSON,
EDWARD F. TREADWELL,
Committee.

I concur in such parts of the foregoing report as are consistent with a separate report filed by me herewith.

SAMUEL C. WIEL.

EXHIBIT "B"

REPORT ON KENNETT RESERVOIR DEVELOPMENT

AN ANALYSIS OF METHODS AND EXTENT OF FINANCING BY ELECTRIC POWER REVENUE

By LESTER S. READY,
Consulting Engineer

A REPORT TO THE JOINT LEGISLATIVE COMMITTEE OF 1927 ON WATER RESOURCES

October, 1928

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS

REPORTS OF THE
DIVISION OF ENGINEERING AND IRRIGATION
EDWARD HYATT, State Engineer

BULLETIN No. 20

REPORT

on

KENNETT RESERVOIR DEVELOPMENT

An Analysis of Methods and Extent of Financing by Electric Power Revenue

By LESTER S. READY, Consulting Engineer

A Report to the Joint Legislative Committee
of 1927 on Water Resources

Kennett Dam Site in Sacramento Canyon

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An Analysis of Methods and Extent of Financing by Electric Power Revenue.

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LETTER OF TRANSMITTAL, STATE ENGINEER TO CHAIRMAN OF JOINT LEGISLATIVE COMMITTEE ON WATER RESOURCES

MR. B. S. CRITTENDEN, Chairman,
Joint Legislative Committee on Water Resources,
Tracy, California.

SUBJECT: WATER RESOURCES INVESTIGATION

SIR: In accordance with request of your committee there has been prepared and is being transmitted herewith, a report on certain phases of the Kennett reservoir, a unit of the "Coordinated Plan" for the development of the water resources of California. This report, prepared under the direction of Mr. Lester S. Ready, consulting engineer, deals particularly with the method and extent of financing this unit by revenues from electric power and is based upon estimates set forth in Bulletin No. 13 entitled "The Development of the Upper Sacramento River," published by this Division.

In the preparation of Bulletin No. 13, the basic consideration under the statute (chapter 477, Statutes of 1925) directing such report, was that of maximum utilization of the water resources of the State. The electric power installation was determined in accord with this mandate. In the following report, however, the consideration is one of economic immediate installation from present commercial viewpoint. Therefore, the conclusions of Bulletin No 13 have been altered somewhat in this respect The exact desirable installation can not be accurately stated until the manner of the disposition of the power is known. Whatever size is decided upon, provision should be made for future enlargement to that described in Bulletin No. 13, so that the maximum use of the water resources may be utilized.

Very truly yours,

State Engineer

Sacramento, California, January 4, 1929.

LETTER OF TRANSMITTAL, AUTHOR TO STATE ENGINEER

MR. EDWARD HYATT,
State Engineer,
Sacramento, California.

SIR: Submitted herewith is a report on "Kennett Reservoir Development, an Analysis of Methods and Extent of Financing by Electric Power Revenue," prepared in compliance with your request.

Although the analysis and conclusions are set forth in fairly concise manner in the report, matters of outstanding importance are summarized in this letter.

SUBJECT OF REPORT.

The Kennett reservoir was selected from several considered in the "Coordinated Plan" of water development in the Sacramento and San Joaquin valleys as being one of the principal units in that plan and in many respects typical of the various units. The analysis made, data submitted and deductions set forth will be applicable in general to other units of the plan with modifications, however, for operating characteristics and geographic location.

The specific Kennett development considered was that contemplating a 420-foot dam, a 2,940,000 acre-foot reservoir and a power plant of 275,000 kilovolt-amperes (220,000 kilowatts) capacity, costing in total $70,000,000. The figures for the power plant capacity and total cost differ from those under Bulletin No. 13, "The Development of the Upper Sacramento River," issued by Division of Engineering and Irrigation, where they are given as 400,000 kilovolt-amperes and $80,000,000, respectively. The power plant capacity was reduced to 275,000 kilovolt-amperes after a study of power values revealed that the latter was the more economic commercial installation under present conditions. The difference in cost is due to this change and to a reduction of interest rate during construction, from 6 per cent to 4.5 per cent.

The development has been analyzed as suggested by you, based upon the operation of the reservoir coordinately for:

1. Control of salinity to Antioch in the delta of the Sacramento and San Joaquin rivers.
2. Control of floods on the Sacramento River to 125,000 second-feet maximum, measured at Red Bluff.
3. An irrigation supply for San Joaquin Valley (330,000 acre-feet per season; 1000 second-feet maximum rate of flow) and additional water for Sacramento Valley.
4. Generation of power consistent with the primary uses of the reservoir as above set forth.

Five plans of financing suggested have been studied, the plans being:

1. Reservoir, dam and power plant financed and operated by private capital.
2. Reservoir and dam financed and operated by the state; power plant financed and operated by private capital; use of water for

power generation sold by State to private interests financing the power plant.

3. Reservoir, dam and power plant financed and operated by State; the power output wholesaled at the power plant

4. Reservoir, dam and power plant and main trunk transmission lines to important load centers in northern California, financed and operated by the State; power wholesaled at substations to political subdivisions and privately-owned public utilities.

5. Reservoir, dam and power plant, main trunk transmission lines and substations, steam standby plants and general secondary transmission and distribution systems financed and operated by the State; power retailed to the general public.

In each of these plans the State is to retain control of the operations of the dam and reservoir in so far as it affects release of water for salinity or flood control and irrigation supply.

CONCLUSIONS FROM INVESTIGATION.

Ability of the market to absorb Kennett output.

1. The power market tributary to the Kennett development is that existing generally north of Stanislaus County within a distance of approximately 300 miles of Kennett.

2. This market required the production in 1927 of 3,219,000,000 kilowatt hours, and by 1936, the earliest that Kennett may be expected to be completed, will require approximately 5,328,000,000 kilowatt hours annually.

3. Over 65 per cent of the tributary power market is located within 50 miles radius of San Francisco

4. The tributary market at present is served through two main systems; one including the Pacific Gas and Electric Company and connecting companies supplying 75 per cent; the other, the Great Western Power Company of California supplying 25 per cent of the requirements.

5. The average annual power output of Kennett based upon a plant installation of 275,000 kilovolt-amperes is estimated at 1,217,000,000 kilowatt hours, varying from 990,000,000 to 1,314,000,000 kilowatt hours

6. The present development of power in northern California is almost entirely from hydro-electric plants, steam-electric plants being used for standby purposes primarily. A greater proportion of the energy required should be developed by steam-electric plants before Kennett is completed.

7. The output of Kennett represents the growth of load for the entire northern market for 4 years Approximately 5¼ years would be required for the growth of load on the system of the Pacific Gas and Electric Company and connecting companies to absorb the entire output.

8. With coordination of future developments between the State and the existing agencies, the growth in load prior to the completion of Kennett could be carried by steam-electric plants, thus materially reducing the burden of absorption of Kennett output.

9. With reasonable cooperation between the State and the existing agencies, absorption of Kennett output will present no serious diffi-

culties under Plans 1, 2, 3 and 4. The existing utilities have met problems relatively greater than the absorption of the output of Kennett presents. The Pacific Gas and Electric Company in 1925 brought in its own Pit No 3 plant and took delivery from the City of San Francisco and the California-Oregon Power Company, a total representing over 40 per cent of its then existing load. This compares with Kennett output which represents approximately 25 per cent of the load that would be tributary in 1936 A similar condition was met by the Great Western Power Company in 1921.

Cost of Kennett Development

The estimated cost of Kennett reservoir, dam and power plant is:

Land and improvements flooded	$22,882,000
Dam	30,118,000
Total	$53,000,000
Power plant	17,000,000
Total	$70,000,000

The annual cost of Kennett reservoir, dam and power plant, which is set forth in detail for Plans 1, 2 and 3, varies depending upon the basis of treatment of taxes on private capital and amortization of State bonds The limits of the estimated costs are as follows·

	Total	*Mills per kwh of output*
Plan 1. Complete private ownership:		
(a) *Including* state taxes	$6,867,000	5.64
(b) Excluding state taxes	6,231,000	5 12
Plan 2. State ownership of reservoir and private ownership of power plant·		
(a) With 40-year straight line amortization of state bonds and state taxes on private capital	5,983,000	4 91
(b) With 40-year sinking fund amortization of state bonds and state taxes excluded	4,985,000	4.09
Plans 3, 4 and 5. State ownership:		
(a) With 40 year straight line amortization of bonds	5,663,000	4 66
(b) With 40-year sinking fund amortization of bonds	4,652,000	3 82
(c) Excluding bond amortization	3,918,000	3 22

Plan 4 will require additional capital for transmission lines and substations by the State, amounting as a minimum to $9,600,000. The added cost assuming wholesaling of power to the main utilities at a point near the center of load based on 4 per cent sinking fund amortization is estimated at $784,000 per annum.

Value of power.

The value of power delivered from Kennett power plant to transmission as indicated by the cost of power from other hydro-electric plants is from 2.7 to 3.3 mills per kilowatt hour of power plant output; as indicated by steam power development, the value is from 3.45 to 3.68 mills per kilowatt hour; and as indicated from comparison with existing contracts, approximately 3.45 mills per kilowatt hour.

Revenue from power.

The revenue that may be obtained from the sale of power output at Kennett plant may not be expected to exceed $4,250,000 per annum, and at the terminal of transmission near the Bay district, not to exceed $5,300,000, or approximately 3 5 and 5 mills per kilowatt hour delivered, respectively. Under complete control and operation of Kennett reservoir for irrigation the value of power output will be reduced to approximately $2,000 000 per annum based upon plant delivery.

Plan 5.

Plan 5, contemplating distribution of the total power output by the State, will require duplication of existing systems or condemnation of at least one-quarter of the distribution systems of northern California and the added capital expenditure of over $110,000,000.

It is doubtful if this action would assist the State in the carrying of the costs of Kennett development beyond which would be possible under Plan 3 or 4.

Other revenue required.

By comparison of the cost of Kennett with the revenue from power at the plant of $4,250,000, or to substation delivery of $5,300,000, probable maximum, it is apparent that power can not carry much more than the cost of interest, depreciation and operating expenses of Kennett even under State development. Other sources of revenue such as State or Federal aid, sale of water for irrigation or payments by other beneficiaries would be needed to cover the full amortization requirements of State bonds The amount of aid required would be minimized by extending the amortization period of State bonds beyond the period of forty years assumed in this report.

Very truly yours,

Consulting Engineer.

San Francisco, California, October 23, 1928.

REPORT ON

Kennett Reservoir Development

An Analysis of Methods and Extent of Financing by Electric Power Revenue

AUTHORITY FOR REPORT.

This report is prepared in compliance with request of Mr. Edward Hyatt, State Engineer, and of the Joint Legislative Committee on Water Resources for the State of California, that a study and analysis be made of the financial and economic phases of the proposed Kennett reservoir.

SUBJECT OF REPORT.

The "Coordinated Plan" for water development in the Sacramento and San Joaquin valleys contemplates several large reservoirs for the storage of water for flood and salinity control and irrigation. Considerable electric power can be developed incidental to and in connection with these reservoirs. The Kennett reservoir has been selected for analysis as being one of the principal units of the "Coordinated Plan," and typical in many respects of the several units of this plan. The analysis made, data submitted and deductions set forth will in general be applicable to the other units of the plan with modifications, however, for operating characeristics and geographic location.

This study and report deals with the relative value of several plans of financing the Kennett unit and the extent to which it can be financed by revenue from electric power that can be generated at the dam.

The analysis is based on the operation of the reservoir coordinately for:

1. Control of salinity to Antioch in the delta of the Sacramento and San Joaquin rivers.
2. Control of floods on Sacramento River to 125,000 second-feet maximum, measured at Red Bluff.
3. Irrigation supply for San Joaquin Valley (330,000 acre-feet per season: 1000 second-feet maximum rate of flow) and additional water for Sacramento Valley.
4. Generation of power consistent with the primary uses of the reservoir as above set forth

Although the primary purposes of this reservoir are for flood and salinity control and irrigation, the requirements for irrigation during the early period of use, apparently, will not seriously interfere with the power output, which will be relatively large. Therefore, an important element to be considered in connection with the financial analysis is the value of the power output and the extent to which it may carry the financial burden of the development.

Five different plans for the financing of the development have been suggested for special consideration. In each plan the State is to retain control of the operation of the dam and reservoir in so far as it affects

the release of water for salinity control, flood control and irrigation supply for San Joaquin Valley.

The five plans suggested are:

1. Reservoir, dam and power plant financed and operated by private interests.
2. Reservoir and dam financed and operated by the State. Power plant financed and operated by private interests; use of water for power generation sold by State to private interests financing the power plant.
3. Reservoir, dam and power plant financed and operated by State, power output wholesaled at the power plant.
4. Reservoir, dam and power plant, and main trunk transmission lines to important load centers in northern California financed and operated by the State. Power wholesaled at substations to political subdivisions and privately-owned public utilities.
5. Reservoir, dam and power plant, main trunk transmission lines and substations, steam-electric standby plants and general secondary transmission and distribution systems financed and operated by the State. Power retailed to general public.

A modification of Plan 3, considered herein as Plan 3a, has also been suggested. This plan contemplates the disposition of part of the power at the power plant by sale to municipalities and resale companies. It is suggested that the large private power company or companies purchasing the bulk of the power be required under contract to act as common carriers transmitting the power for compensation from the power plant to the respective municipalities or resale companies.

The general benefits to central and northern California resulting from irrigation, flood control and salinity control, and to San Joaquin Valley for irrigation, are not considered in this report, the report being limited primarily to an analysis of the financial, economic and engineering phases of the development as affected by the disposition of power which may be produced.

SCOPE OF INVESTIGATION.

The investigation carried on in connection with this report has consisted of a study and analysis of the Kennett development with reference to annual cost, potential output and characteristics of the power to be produced, both when operated as suggested and when ultimately operated primarily for irrigation demands. This latter condition must be given some consideration in order that a clear perspective of the future financial situation may be obtained.

Study and analysis of the power market tributary to Kennett and the present and future ability of the market to absorb the output under the different plans presented have been made. The value of the power output has been determined from study of cost of power from other sources, both steam-electric and hydro-electric, and the price for power as indicated by wholesale purchase contracts. The probable power revenue to be obtained from Kennett has been estimated. An independent check of the estimated cost of Kennett development as set forth in Bulletin No. 13, "The Development of the Upper Sacramento River," issued by Division of Engineering and Irrigation, has not been

made. The estimate therein has been revised, however, in two particulars. The interest rate has been reduced to the basis of State financing. The size of the power plant has been reduced from 400,000 kilovolt-amperes (the figure used in Bulletin No. 13) to 275,000 kilovolt-amperes. The latter size would appear the more economical development, for the potential power output as viewed from the standpoint of present and probable future cost of power. The basic considerations, in the preparation of Bulletin No. 13, were that of maximum utilization of the water resources of the State rather than the most economic power development considered herein. No detailed layout of a system for complete distribution of power output of Kennett has been made. This matter has been analyzed from a broad consideration of the problem and the determining factors involved.

COOPERATION.

In connection with the investigation and preparation of this report, I have had the full assistance of the engineers of the State Division of Engineering and Irrigation under the direction of Mr. A. D. Edmonston, and the cooperation of the Railroad Commission of the State of California and its engineering department; also of Mr. F. E. Bonner of the Federal Power Commission, and the power companies and municipal electric utilities. I wish to express herein my appreciation of the assistance received.

PROPOSED KENNETT DEVELOPMENT.

The Kennett dam and reservoir as contemplated in Bulletin No. 13 is to be located on the Sacramento River near Kennett, Shasta County, approximately two hundred miles due north of San Francisco. The development includes a dam, 420 feet in height, a reservoir of 2,940,000 acre-feet capacity and a power plant of 275,000 kilovolt-amperes capacity with a potential output of 1,217,600,000 kilowatt hours annually. The reservoir will flood 23,000 acres of land. The main line of the Southern Pacific Company and a portion of the State highway will have to be relocated. The estimated cost of the development, including the dam, reservoir, flood control features and power plant, is $70,000,000. This estimate of cost includes interest during construction on basis of State financing. Though under private development interest rates would be higher, the analysis for clarity has been based upon equal capital cost, the difference being within the accuracy of the estimate.

The above covers the development as outlined in Bulletin No. 13, except as to change in power plant capacity, and is the development contemplated in Plans 1, 2 and 3 listed herein. Under Plan 4, State construction of a 220,000-volt transmission line would be added, and, under Plan 5, extensive purchase of existing electric transmission and distribution systems or duplication thereof would be necessary to dispose of the power.

IMPORTANT QUESTIONS INVOLVED.

Following are certain of the important features to be considered in the analysis:

1. The ability of the electric power market to absorb the output of the development when completed.
2. The investment and annual cost of the development under the several plans proposed.

3. The value of power and the amount of revenue from power which may be obtained by the sale of the output of the Kennett development.

4. The effect of the ultimate operation of the reservoir primarily for irrigation on the value of power output.

The first four of the five proposed plans of financing Kennett involve in general the same conditions with reference to the ability of the market to absorb the power output. The power would be delivered to the main existing agencies. Investment costs would be practically the same in total and the annual costs and revenues are subject to definite comparisons. The fifth plan contemplates a material departure from the other four and would be subject to special and separate consideration.

ABILITY OF POWER MARKET TO ABSORB OUTPUT OF KENNETT

DESCRIPTION OF PRESENT POWER DEVELOPMENTS OF THE STATE

A. Extent and grouping of systems

The electric power development of the state has experienced a rapid and steady growth during the past twenty-five years. During this period, interconnections and consolidations have occurred until at the present time, the supplying of electric power is through four main networks or groupings of systems. These are set forth on Plate I, "Electric Power Production and Transmission Systems in California, December 31, 1927," which shows the location of the hydro-electric and steam-electric plants and the main transmission systems in the State:

System I—Includes Pacific Gas and Electric Company and its subsidiary companies; The California-Oregon Power Company; Snow Mountain Water and Power Company; City of San Francisco and Coast Counties Gas and Electric Company.

This network, extending from the northern boundary of the State to the Salinas Valley, represents the largest northern system and has transmission lines nearest Kennett.

System II—Includes Great Western Power Company of California and its allied companies, San Joaquin Light and Power Corporation and Midland Counties Public Service Corporation; also the Modesto and Turlock Irrigation Districts and the Merced Irrigation District.

System III—Consists mainly of the Southern California Edison Company, the City of Los Angeles and the City of Pasadena.

System IV—Includes Southern Sierras Power Company, Los Angeles Gas and Electric Corporation, and San Diego Consolidated Gas and Electric Company, operating in the southern and eastern portions of the State, which, although not fully connected at this time, will be a connected system within the near future.

It is to be noted that System I is nearest in distance to the Kennett reservoir, which is shown in "black" on Plate I. System II is somewhat further south, although the Great Western Power Company serves a territory generally the same as that served by the Pacific Gas and Electric Company and its connecting companies. Systems III and IV serve the southern part of the State, the market supplied being from 456 to 600 miles from Kennett. This distance is such that from an economic standpoint the market served by these companies is not available to absorb the power from Kennett. This is also largely true of the market served by the San Joaquin Light and Power Corporation.

B. Extent and distribution of present load or power market

Plate II, "Geographic Location of Electric Power Production and Load in California, 1927," sets forth graphically the location and extent of the power production and market throughout the State for the year 1927 as indicated by existing utility power plant and substation outputs, respectively. The magnitude of the production by dis-

tricts or groups of plants and the load by counties is indicated by "dots." Each "full dot" represents 25.000.000 kilowatt hours and each "half dot" an amount less than 25,000,000 kilowatt hours annual output The potential output of Kennett is also delineated. This plate indicates where kilowatt hours were produced and where used in 1927. It does not show the extent of plant capacities. It is to be noted that the main location of power production is along the Sierra Nevada Mountains from the California-Oregon line to the Kern River, the larger developments being on the Pit, Feather, Tuolumne and San Joaquin rivers Plates I and II together indicate the general transmission of power southward from the power plants in the Sierra Nevadas to the power load which centers around San Francisco Bay for northern California, and Los Angeles for southern California, with general but much less dense use throughout the Sacramento and San Joaquin valleys Study of Plate II and the data supporting it indicates that in excess of 65 per cent of the power market of northern California is within a radius of fifty miles of San Francisco; also a like percentage for southern California is located within the same radius of Los Angeles

DIVISION OF POWER MARKET AND SYSTEMS FOR STUDY OF PROBLEM.

A general study of the sources of power in the State, the systems and the market indicates that for this analysis, the State should be divided into a northern district, comprising generally that portion served by System I and the Great Western Power Company of System II, hereafter referred to as "Northern Group," and a southern district. The southern district comprises that portion of the State generally south of Stanislaus County and served by San Joaquin Light and Power Corporation of System II, and System III and System IV, referred to as "Southern Group."

The two districts or groups are connected for interchange of power by the transmission line between the Great Western Power Company and the San Joaquin Light and Power Corporation This tie-line is available for the shifting of power between the two sections of the State

Table 1 sets forth by companies the production of power in millions of kilowatt hours and in per cent of the total for the northern and southern groups, respectively. There is also set forth by companies the total substation output in millions of kilowatt hours and in per cent of the totals for the respective groups, eliminating intercompany deliveries This represents, measured in substation output, the power market served directly by the respective companies

Table 1 also shows for the Northern Group that System I produced 79 per cent and served directly 75 2 per cent of the entire load in the Northern District: for the Southern Group, the San Joaquin portion of System II produced 18 2 per cent; System III, 66 5 per cent; and System IV, 15 3 per cent of the total power requirements of the Southern District. The San Joaquin system directly serves 16.3 per cent; System III, 67.6 per cent; and System IV, 16 1 per cent of the market of the Southern District

TABLE 1

Electric Power Production and Substation Delivery by Companies, 1927

Name of company	*Production*		*Substation delivery*	
NORTHERN GROUP. *System I*	*Millions of kilowatt hours*	*Per cent of total*	*Millions of kilowatt hours*	*Per cent of total*
California-Oregon Power Co	290 3	9 0	24.2	0.9
Pacific Gas and Electric Company and its subsidiary companies	1,624.6	50 5	1,876 5	72.2
City of San Francisco	538.4	16 7	0	0
Snow Mountain Water and Power Co.	53 0	1 7	11.9	0 5
Utica Mining Co	19 0	0 6	----	---
Coast Counties Gas and Electric Company	4 2	0 1	36.7	1.4
Melones Mining Company	4.7	0 1	0	0
West Side Lumber Company	1 6	0 1	----	---
Truckee River Power Co	7.6	0 2	4.1	0 2
Total, System I	2,543 6	79 0	1,953.4	75 2
System II-a.				
Great Western Power Co of California	675.4	21 0	645 6	24.8
Total, northern group	**3,219.0**	**100.0**	**2,599.0**	**100.0**
SOUTHERN GROUP				
System II-b.				
San Joaquin Light and Power Corporation	504 4	12.4	515 2	15.0
Merced Irrigation District	126 6	3 1	0	0
Turlock-Modesto Irrigation Districts	104 3	2.5	43.7	1.3
U. S. National Park Service	7 7	0 2	----	---
Total, System II-b	743 0	18 2	558 9	16.3
System III.				
Southern California Edison Company	2,419 5	59 1	1,711.6	49.7
City of Los Angeles	268 8	6 6	567.9	16 5
City of Pasadena	31 6	0 8	49 4	1 4
Total, System III	2,719 9	66 5	2,328 9	67.6
System IV.				
Los Angeles Gas and Electric Corporation	247 1	6.0	247 2	7.2
Southern Sierras Power Co	265 1	6 5	178 1	5 2
San Diego Consolidated Gas and Electric Co.	109 9	2 7	126 8	3.7
Yuma Project—United States Reclamation Service	5 2	0.1	----	---
Total, System IV	627.3	15.3	552 1	16.1
Total, southern group	**4,090.2**	**100.0**	**3,439.9**	**100.0**
Northern group	3,219 0	44	2,599.0	43
Southern group	4,090 2	56	3,439 8	57
Grand total, entire State	**7,309 2**	**100**	**6,038.8**	**100**

The following table summarizes for the state the distribution of production and load among the four systems:

Electric Production and Load in California, 1927

	Millions of kilowatt hours output		*Per cent of total*	
	Production	*Substation output*	*Production*	*Substation output*
System I	2543.6	1953.3	34 8	32.3
System II-a	675 4	645 6	9 2	10.7
Total, northern group	3219 0	2599 0	44 0	43 0
System II-b	743 0	558 9	10 2	9 3
System III	2719 9	2328.9	37 2	38 6
System IV	627 3	552 1	8 6	9.1
Total, southern group	4090 2	3439 9	100.0	100 0
Total State	7309 2	6038 8	56 0	57.0

DISTRIBUTION OF POWER MARKET BY COUNTIES.

Tables 2, 3-A and 3-B, and Plate III, "Distribution of Electric Power Load by Counties in California, 1927," set forth by counties the distribution of the power load throughout the State. These, together with Plate II, indicate for the market of northern California that 13 8 per cent of the market is located north of Sacramento County; 18.8 per cent in the counties surrounding Sacramento, including the mountain counties as far south as Tuolumne County; 62.7 per cent in the Bay counties; and 4.7 per cent in the counties south of Santa Clara County. The total substation output of this entire part of the State for 1927 was somewhat in excess of twice the potential development of Kennett.

TABLE 2

California Electric Power Load or Market by Counties Measured by Substation Delivery, 1927

County	*Substation delivery thousands of kilowatt hours*	County	*Substation delivery thousands of kilowatt hours*
Alameda	449,920	Orange	138,361
Alpine	------	Placer	19,858
Amador	22,846	Plumas	31,523
Butte	35,516	Riverside	132,809
Calaveras	12,802	Sacramento	172,146
Colusa	20,175	San Benito	20,823
Contra Costa	244,397	San Bernardino	239,016
Del Norte	------	San Diego	126,801
El Dorado	2,449	San Francisco	685,775
Fresno	171,885	San Joaquin	123,287
Glenn	21,161	San Luis Obispo	16,423
Humboldt	14,451	San Mateo	91,031
Imperial	40,257	Santa Barbara	57,766
Inyo	8,188	Santa Clara	131,575
Kern	256,869	Santa Cruz	50,591
Kings	43,863	Shasta	16,162
Lake	------	Sierra	------
Lassen	------	Siskiyou	20,584
Los Angeles	1,859,426	Solano	68,792
Madera	33,457	Sonoma	24,306
Marin	32,073	Stanislaus	67,451
Mariposa	3,000	Sutter	22,236
Mendocino	5,535	Tehama	8,351
Merced	69,341	Trinity	6,899
Modoc	------	Tulare	157,694
Mono	------	Tuolumne	18,824
Monterey	50,271	Ventura	56,814
Napa	4,884	Yolo	21,683
Nevada	33,901	Yuba	52,313
Total—Substation delivery by counties			6,016,561
Not segregated—Southern California Edison Co, interdepartmental			22,295
Entire State			6,038,856

GROWTH OF POWER LOAD.

Plate IV, "Electric Power Installation in California, 1911–1927," sets forth for the northern and southern groups and for the entire State, the growth in power developed by plant capacities, both hydro-electric and steam-electric, for the period 1911 to 1927. It is to be noted that in the Northern Group, up to the present time, the amount of hydro-electric capacity in per cent of total is considerably greater than in the Southern Group. Table 4 sets forth statistically the data indicated in Plate IV.

Plate V, "Electric Power Production in California, 1913–1927," presents for the period 1913 to 1927 and for the two groups and the State, the power output by months in thousands of kilowatts (average) for steam-electric and hydro-electric plants, respectively. The fluctuation in steam-electric production should be noted, as the amount is an important factor in the absorption of new hydro-electric developments

This fluctuation has occurred partly on account of variation of hydro-electric power production between wet and dry years and partly as a result of the bringing in of new hydro-electric plants. The heavy demand for steam-electric power as a result of the 1924 drought is clearly indicated. The material reduction in steam-electric power in the northern part of the State in the past three years has been the result mainly of bringing in three large hydro-electric projects in 1925: Copco No. 2 of The California-Oregon Power Company, Pit No. 3 of the Pacific Gas and Electric Company, and Moccasin Creek plant of the City of San Francisco. The result of bringing in these three developments, having an annual output of approximately 1,000,000,000 kilowatt hours, has been to reduce the steam-electric power production to less than 1 per cent of the total and to create a condition of temporary oversupply.

TABLE 3-A

Substation Delivery by Counties Grouped Geographically

(District Served by Northern Group of Companies)

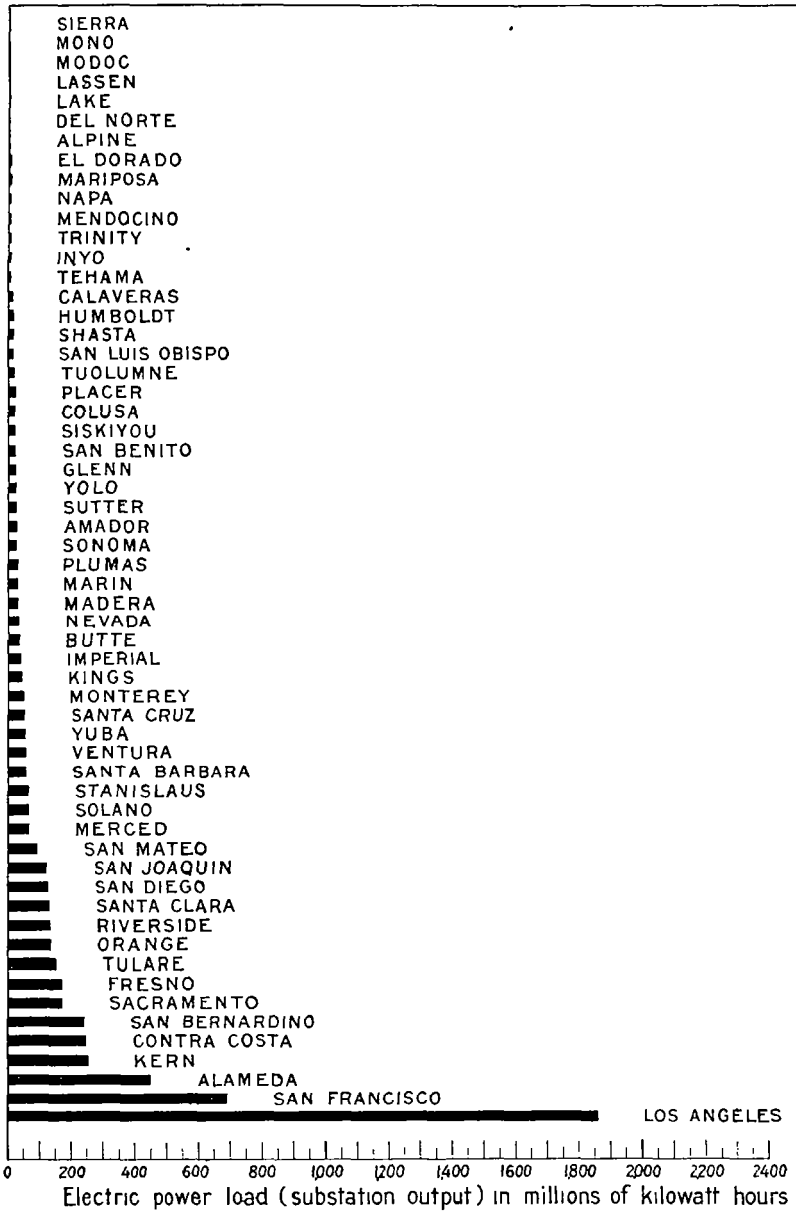
County	*Substation delivery* *Thousands of kilowatt hours*	*Per cent of total northern group*
DISTRICT 1		
Butte	35,516	
Colusa	20,175	
Del Norte	-----	
Glenn	21,161	
Humboldt	14,451	
Lake	-----	
Lassen	-----	
Mendocino	5,535	
Modoc	-----	
Napa	4,884	
Nevada	33,901	
Placer	19,858	
Plumas	31,523	
Shasta	16,162	
Sierra	-----	
Siskiyou	20,584	
Sonoma	24,306	
Sutter	22,236	
Tehama	8,351	
Trinity	6,899	
Yolo	21,683	
Yuba	52,313	
Total, District 1	359,538	13 8
DISTRICT 2.		
Alpine	-----	
Amador	22,846	
Calaveras	12,802	
El Dorado	2,449	
Sacramento	172,146	
San Joaquin	123,287	
Solano	68,792	
Stanislaus	67,451	
Tuolumne	18,824	
Total, District 2	488,597	18 8
DISTRICT 3.		
Alameda	449,920	
Contra Costa	244,397	
Marin	32,073	
Santa Clara	131,575	
San Francisco	685,775	
San Mateo	91,031	
Total, District 3	1,634,771	62 7
DISTRICT 4.		
Monterey	50,271	
San Benito	20,823	
Santa Cruz	50,591	
Total, District 4	121,685	4 7
Total Northern California	2,604,591	100 0

TABLE 3-B

Substation Delivery by Counties Grouped Geographically
(District Served by Southern Group of Companies)

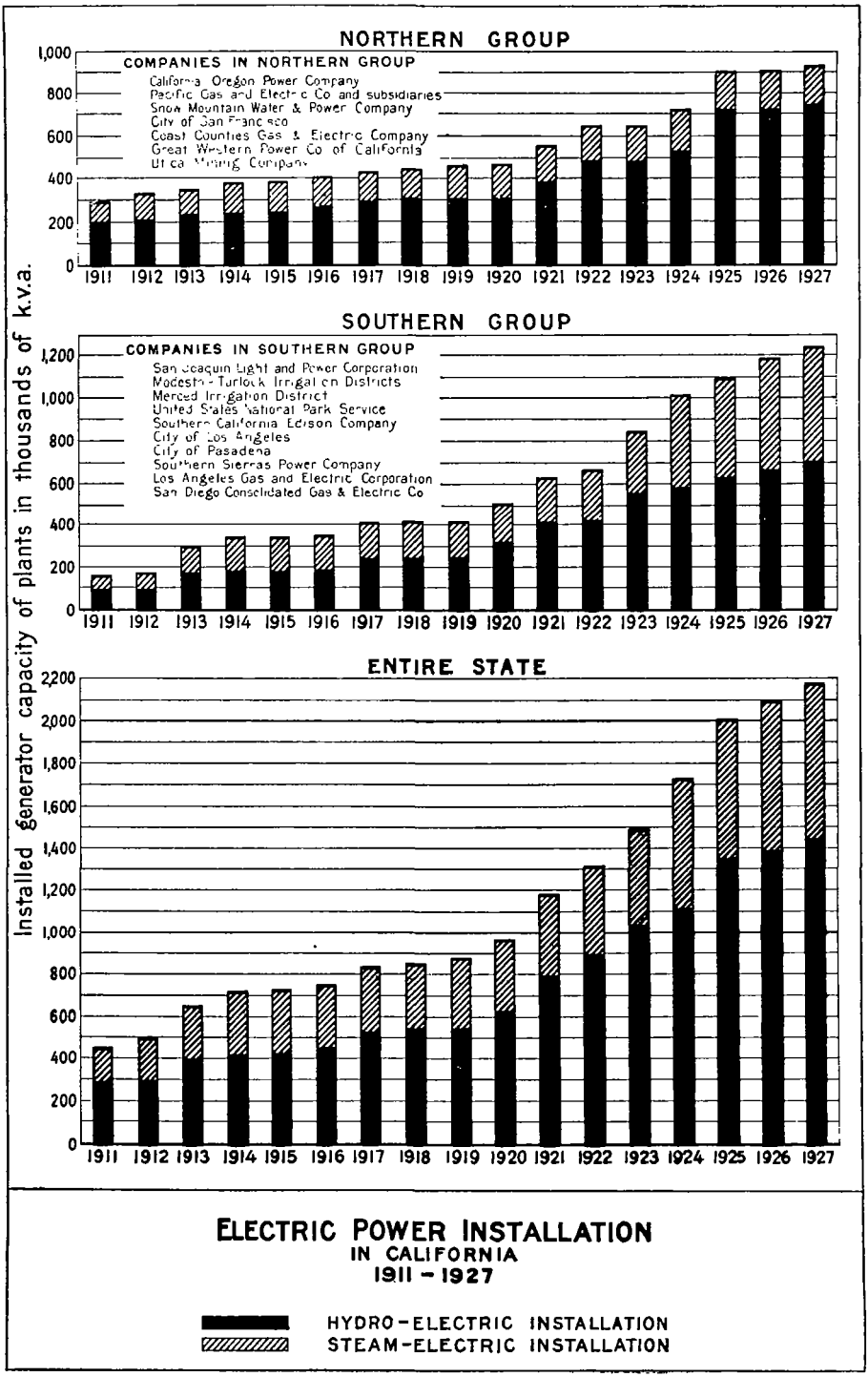
County	*Substation delivery* *Thousands of kilowatt hours*	*Per cent of total southern group*
DISTRICT 1		
Fresno	171,885	
Inyo	8,188	
Kern	256,869	
Kings	43,863	
Madera	33,457	
Mariposa	3,000	
Merced	69,341	
Mono	-----	
San Luis Obispo	16,423	
Santa Barbara	57,766	
Tulare	157,694	
Total, District 1	818,486	24.0
DISTRICT 2.		
Los Angeles	1,859,426	
Orange	138,361	
Ventura	56,814	
Total, District 2	2,054,601	60 2
DISTRICT 3		
Imperial	40,257	
Riverside	132,809	
San Bernardino	239,016	
San Diego	126,801	
Total, District 3	538,883	15 8
Total South San Joaquin Valley and southern California	3,411,970	100.0

PLATE III.



DISTRIBUTION OF ELECTRIC POWER LOAD BY COUNTIES IN CALIFORNIA 1927

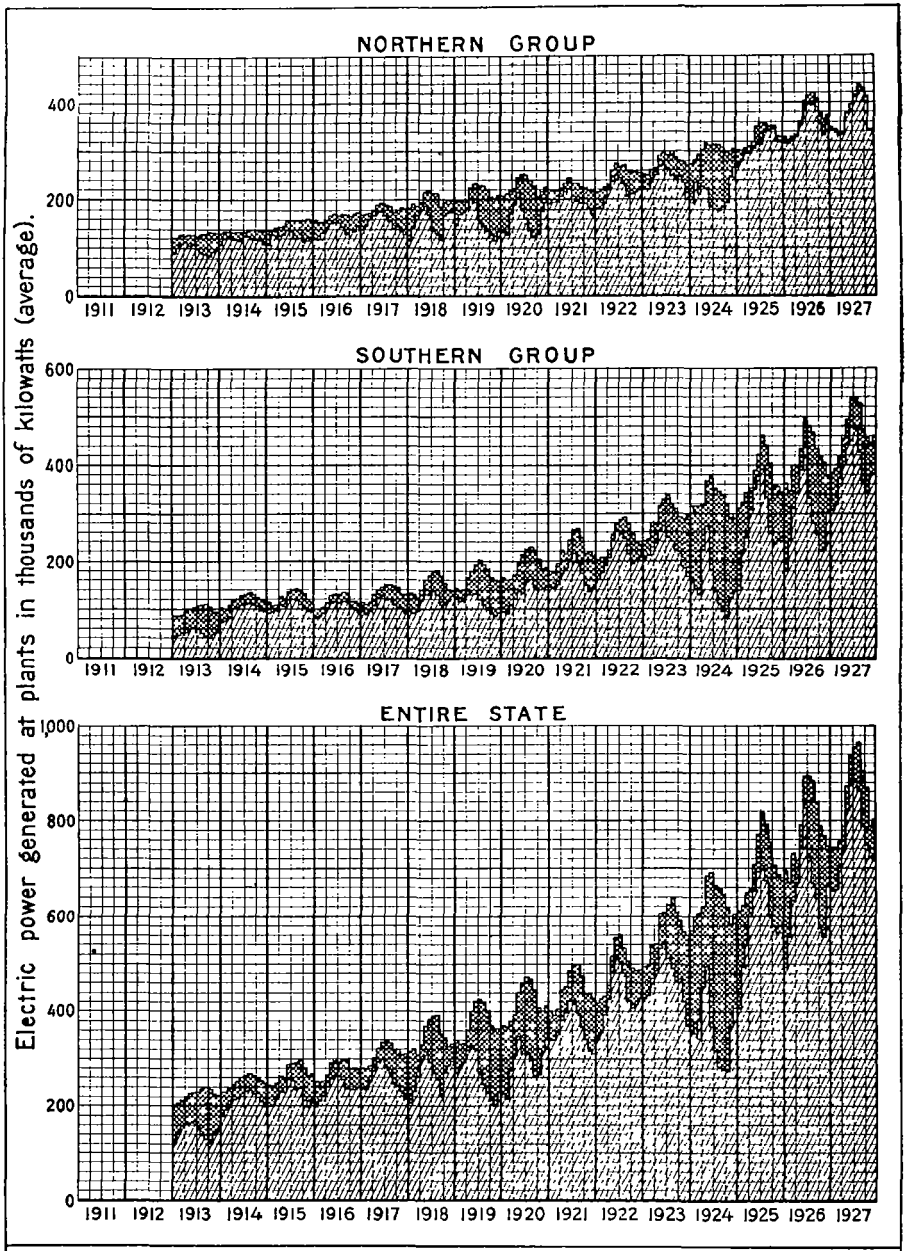
PLATE IV.



ELECTRIC POWER INSTALLATION
IN CALIFORNIA
1911 – 1927

HYDRO-ELECTRIC INSTALLATION
STEAM-ELECTRIC INSTALLATION

PLATE V.



ELECTRIC POWER PRODUCTION
IN CALIFORNIA
1913 – 1927

POWER PRODUCED BY HYDRO-ELECTRIC PLANTS

POWER PRODUCED BY STEAM-ELECTRIC PLANTS

TABLE 4

Electric Power Installation in California, December 31 of each year, 1911–1927

Year	NORTHERN GROUP			SOUTHERN GROUP			ENTIRE STATE		
	Hydro-electric installation kva	Steam-electric installation kva	Total electric installation kva	Hydro-electric installation kva	Steam-electric installation kva	Total electric installation kva	Hydro electric installation kva	Steam-electric installation kva	Total electric installation kva
1911	196,795	94,575	291,370	85,585	69,577	155,162	282,380	164,152	446,532
1912	202,795	126,575	329,370	85,585	79,977	165,562	288,380	206,552	494,932
1913	226,795	121,375	348,170	167,835	130,217	298,052	394,630	251,592	646,222
1914	239,295	136,375	375,670	173,835	166,967	340,802	413,130	303,342	716,472
1915	241,170	141,675	382,845	174,435	166,367	340,802	415,605	308,042	723,647
1916	268,475	132,950	401,425	179,935	166,212	346,147	448,410	299,162	747,572
1917	286,725	141,950	428,675	236,616	168,946	405,562	523,341	310,896	834,237
1918	302,075	141,810	443,885	236,616	168,946	403,562	538,691	310,756	849,447
1919	300,575	156,810	457,385	241,466	168,547	410,013	542,041	325,357	867,398
1920	301,725	156,810	458,535	320,066	183,647	503,713	621,791	340,457	962,248
1921	378,822	169,310	548,132	409,916	216,097	626,013	788,738	385,407	1,174,145
1922	472,872	169,310	642,182	417,666	248,247	665 913	890,538	417,557	1,308,095
1923	471,972	175,200	647,172	551,824	288,697	840,521	1,023,796	463,897	1,487,693
1924	527,320	187,625	714,945	577,824	432,097	1,009,921	1,105,144	619,722	1,724,866
1925	718,320	187,625	905,945	627,324	467,645	1,094,969	1,345,644	655,270	2,000,914
1926	720,820	187,625	908,445	661,074	522,245	1,183,319	1,381,894	709,870	2,091,764
1927	744,445	187,625	932,070	699,024	540,995	1,240,019	1,443,469	728,620	2,172,089

Table 5 sets forth by years the production of power, both hydro-electric and steam-electric in millions of kilowatt hours for the years 1913 to 1927. The figures include a relatively small production of power by plants of the California-Oregon Power Company and the Truckee River Power Company outside the State.

TABLE 5

Electric Power Production in California, 1913–1927

Year	*Annual power plant output in millions of kilowatt hours*			*Steam-electric in per cent of total*
	Hydro-electric	*Steam-electric*	*Total*	
*Northern group**				
1913	852	266	1118	23 8
1914	1028	146	1174	12 4
1915	1072	220	1292	17 0
1916	1219	208	1427	14.6
1917	1332	242	1574	15.4
1918	1350	386	1736	22 2
1919	1343	473	1816	26 0
1920	1409	576	1985	29 0
1921	1719	253	1972	12 8
1922	1905	268	2173	12.3
1923	2118	302	2420	12 5
1924	1833	812	2645	30 7
1925	2721	162	2883	5 6
1926	3102	130	3232	5 0
1927	3266	32	3298	1.0
Southern group				
1913	439	414	853	48.5
1914	858	173	1031	16 8
1915	911	170	1081	15.7
1916	894	137	1031	13 3
1917	930	242	1172	20.6
1918	1014	319	1333	23 9
1919	994	491	1485	33 1
1920	1163	543	1706	21.8
1921	1485	449	1934	13 2
1922	1886	287	2173	13 2
1923	1995	627	2622	13 9
1924	1335	1561	2896	53.5
1925	2462	836	3298	25.3
1926	2577	1091	3668	29 7
1927	3443	644	4087	15 8
*Entire State**				
1913	1291	680	1971	34 5
1914	1886	319	2205	14.5
1915	1983	390	2373	16.4
1916	2113	345	2458	14 0
1917	2262	484	2746	17 6
1918	2364	705	3069	23.0
1919	2337	964	3301	29 2
1920	2572	1119	3691	30 3
1921	3204	702	3906	18 0
1922	3791	555	4346	12 8
1923	4113	929	5042	18.4
1924	3168	2373	5541	42.8
1925	5183	998	6181	16.1
1926	5679	1221	6900	17 7
1927	6709	676	7385	9.2

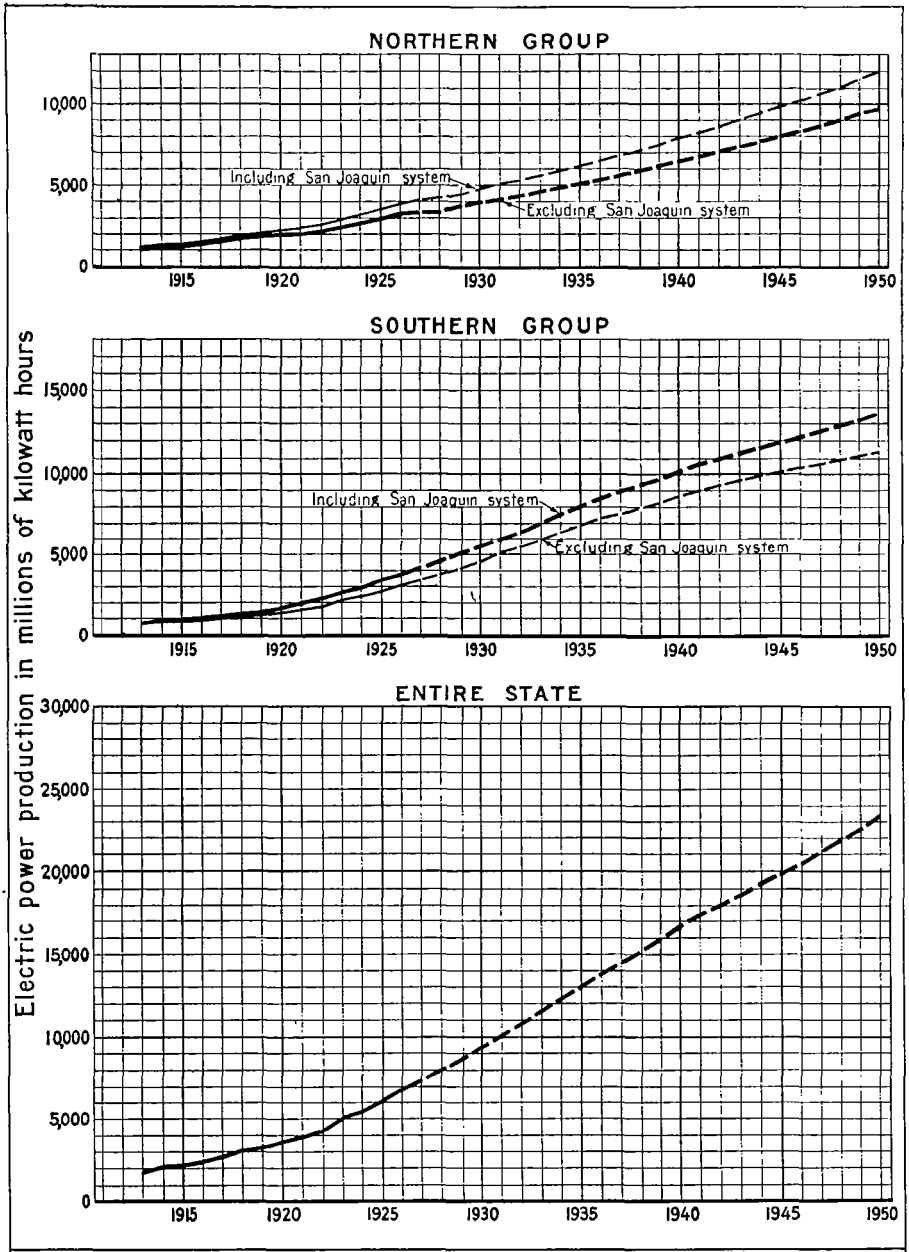
* Limited production outside of State included

ESTIMATED FUTURE GROWTH OF POWER REQUIREMENTS.

An important factor in determining the ability of the market to absorb the output of the Kennett development is the extent of the market and the rate of growth, especially just prior to and following the completion of such a plant.

Numerous estimates have been made of the future growth of power in the State of California. The past growth in northern California has been steady, though not as rapid as in southern California. There has been apparently some slowing up of the growth in southern California during the past few years. Studies of estimates of growth of power requirements prepared by Mr. F. E. Bonner of the Federal

PLATE VI.



PAST AND ESTIMATED FUTURE GROWTH OF ELECTRIC POWER PRODUCTION IN CALIFORNIA 1913 – 1950

ELECTRIC POWER PRODUCTION FOR PAST YEARS

ESTIMATED ELECTRIC POWER PRODUCTION FOR FUTURE YEARS

Power Commission, together with other analyses of past and estimated future growth, have been made in connection with this report The resultant conclusions are set forth in Plate VI, "Past and Estimated Future Growth of Electric Power Production in California, 1913–1950," and in Table 6 for the two sections of the State. The past growth of power in northern California has been at a compound rate approximating 8 per cent. The estimates herein, however, contemplate the future growth at a reducing percentage, ranging from approximately 7 per cent in 1928, to as low as 4 per cent about 1950.

DATE OF BRINGING IN KENNETT.

The date of completion of Kennett development will have an important bearing on the ability of the market to absorb its potential power output. The construction program contemplates a period of four and one-half years for completion. Allowing for preliminaries and financing, it may be concluded that the earliest time for bringing in this development would be 1935. For the purposes of this discussion, however, completion by 1936 has been assumed. Should the completion occur at a later date, the market could more readily absorb the power output.

POWER OUTPUT OF KENNETT.

The power output of Kennett, when operated for flood and salinity control, and limited irrigation, is estimated at an average of 1,217,600,000 kilowatt hours annually This output is based on a 275,000 kilovolt-ampere plant operating at 80 per cent power factor and with an output equivalent to approximately 70 per cent plant load factor.

TABLE 6

Estimated Future Power Requirement, 1927–1950

(Power Plant Output)

Year	*Northern Group, millions of kilowatt hours*	*Southern Group, millions of kilowatt hours*	*Entire State, millions of kilowatt hours*
1927	3,219	4,090	7,309
1928	3,433	4,572	8,005
1929	3,668	5,054	8,722
1930	3,919	5,492	9,411
1931	4,125	6,017	10,142
1932	4,343	6,499	10,842
1933	4,570	6,981	11,551
1934	4,811	7,507	12,318
1935	5,063	8,032	13,095
1936	5,328	8,470	13,798
1937	5,606	8,908	14,514
1938	5,897	9,346	15,243
1939	6,205	9,740	15,945
1940	6,539	10,178	16,717
1941	6,806	10,573	17,379
1942	7,083	10,923	18,006
1943	7,372	11,273	18,645
1944	7,673	11,624	19,297
1945	7,984	11,930	19,914
1946	8,310	12,237	20,547
1947	8,647	12,587	21,234
1948	8,997	12,938	21,935
1949	9,362	13,201	22,563
1950	9,728	13,551	23,279

These bases of estimates are somewhat conservative. The output under the conditions as set forth will vary from a minimum of 990,400,000 kilowatt hours to a maximum of 1,314,000,000 kilowatt hours annually. Table 7 sets forth the estimated output which could have been developed under the water supply conditions of 1896–1927 had Kennett been installed. The relative variation of output both annually and

monthly, compared with other typical plants, is presented graphically on Plate VII, "Variation of Annual and Monthly Power Output of Kennett Reservoir Compared with Typical Hydro-electric Plants." The Kennett output for the minimum year has been estimated to meet the normal variation of power demand on the main power systems and is under these conditions more valuable than that from the other plants. Although shown as uniform throughout the maximum year, the output could be varied to follow more closely the power demand.

The output characteristics under condition of practically complete control for irrigation, which will ultimately occur, are very different and will materially reduce the value of the power available. An estimate of the conditions under such control based on a use of water to the level of two hundred feet above the stream bed indicates an average annual output of 767,000,000 kilowatt hours with a variation in output from 46 per cent to 138 per cent of the average. Unless such a limit on the minimum head is provided much less power could be produced in the dry years and the value of the output would be materially reduced.

TABLE 7

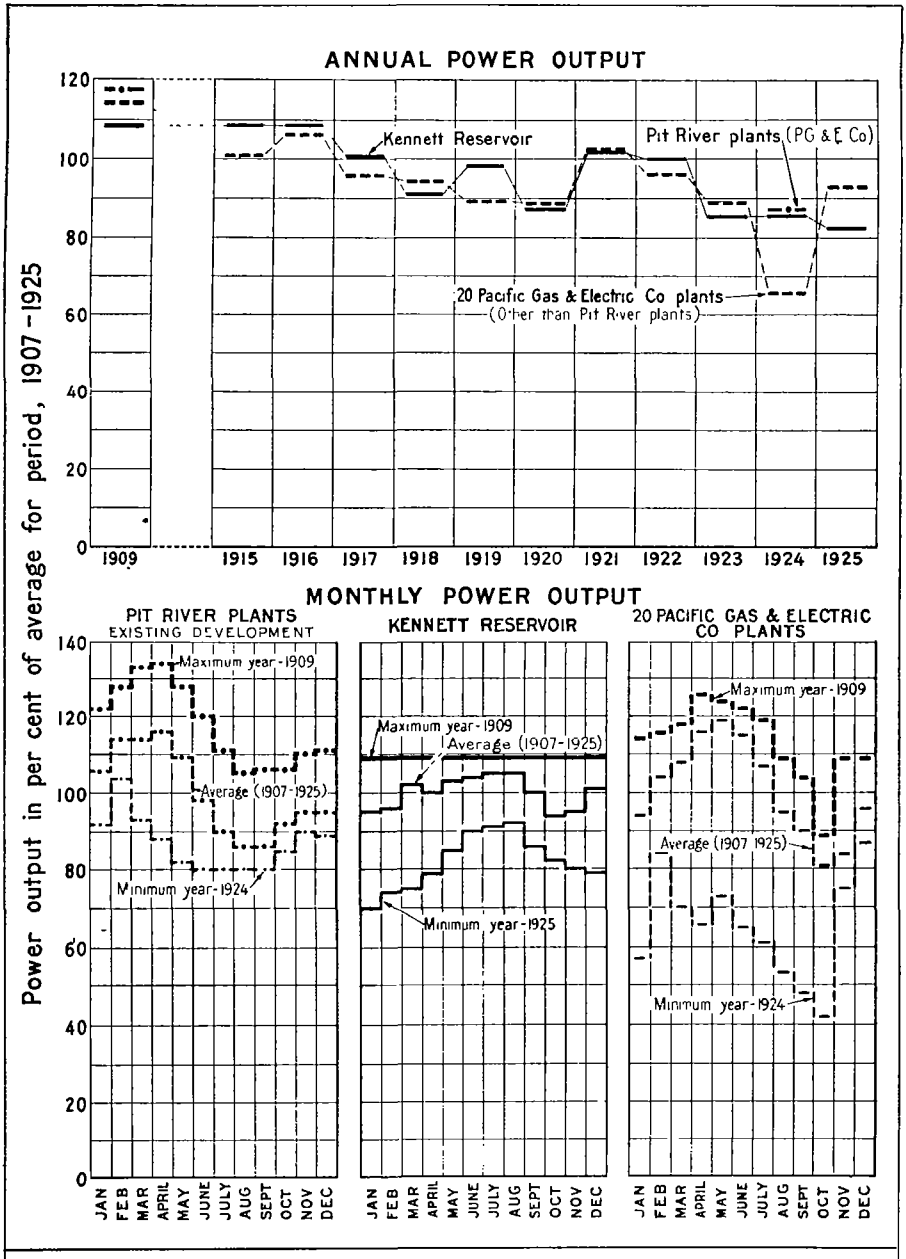
Estimated Power Output, Kennett Reservoir—420 foot dam

Operated for Flood Control, Saline Control and an Irrigation Supply to San Joaquin Valley.

Installed Capacity of Plant, 275,000 k.v.a. Power Factor = 0.80 Load Factor = 0.75

Year	*Power output in millions of kilowatt hours*
1896	1310.7
1897	1287.9
1898	1074.7
1899	1104.0
1900	1242.9
1901	1192.5
1902	1288.5
1903	1252.5
1904	1314.0
1905	1288.6
1906	1314.0
1907	1314.0
1908	1291.2
1909	1314.0
1910	1283.8
1911	1308.7
1912	1240.0
1913	1229.7
1914	1314.0
1915	1314.0
1916	1314.0
1917	1215.8
1918	1098.6
1919	1186.3
1920	1054.5
1921	1227.7
1922	1208.0
1923	1031.7
1924	1035.4
1925	990.4
1926	1049.6
1927	1271.5
Average: 1896-1927	1217.6

PLATE VII.



VARIATION OF ANNUAL AND MONTHLY POWER OUTPUT OF KENNETT RESERVOIR COMPARED WITH TYPICAL HYDRO-ELECTRIC PLANTS

MARKET AVAILABLE AT TIME OF COMPLETION.

Upon completion of Kennett, assumed as occurring in 1936, its power output of 1,217,600,000 kilowatt hours annually would be entering the market of northern California, estimated as requiring the production of 5,328,000,000 kilowatt hours annually. The demands of the territory at that time must and will be fully served by existing agencies. These agencies are at present grouped in two systems, one supplying approximately 75 per cent, and the other 25 per cent of the market. The market will face the absorption of an added supply of approximately 23 per cent of the then existing production, assuming complete coordination of the existing agencies. If the larger of the two systems is to absorb the output it will face the absorption of 31 per cent added supply.

The estimated growth of the market of northern California during the period 1935 to 1940 is at a rate of approximately 300,000,000 kilowatt hours per annum or one-fourth of the total estimated output of Kennett. The market will take, therefore, from four to five years for the growth of load to absorb the entire output, depending upon the extent of cooperation and coordination obtained.

IMPORTANCE OF COORDINATED DEVELOPMENT.

From a standpoint of economic absorption of power output, such as Kennett, the amount of steam-electric power produced at the time of completion of the project is important.

It is economic, also the general practice of utilities in bringing in any large hydro-electric plant, to carry the growth of load for one or two years prior thereto on steam-electric plants so that a considerable load may be immediately shifted to the hydro-electric plants and thus reduce expenses as fixed charges are increased. At present the most economic balance between hydro-electric and steam-electric power production does not exist, there being too small a percentage of steam-electric power produced.

The Pacific Gas and Electric Company has under construction added power plants on the Mokelumne River and plans for development on the Bear and Pit rivers in addition to steam-electric plants. Further development on the Feather River by the Great Western Power Company may be expected as needed by that system. Other private and public enterprises are urging developments on other streams so that, at present, the tendency is toward further development of hydro-electric plants where a more economic procedure would be to meet the growth of load by steam-electric power installation. It is, therefore, important that, through cooperation with the agencies serving the public, their developments be coordinated to make possible the ready absorption of Kennett power output if it is to be wholesaled to them, otherwise the output of Kennett would enter a market not ready for the absorption of such a large added production

Under Plans 1, 2, 3, and in general, Plan 4, as suggested for consideration, the entire market of northern California tributary to Kennett power may be considered available for absorption of the output through the system of the existing utility agencies. These agencies, through the extent and diversity of their load, have developed a market fully interconnected through their systems with a load factor in excess of 60 per cent and a flexibility such that the power output could be readily

absorbed. If definite obligations for sale and purchase are entered into, under Plans 2, 3 and 4, other developments may be adjusted sufficiently in advance to make possible a minimum period of absorption. Much more extreme problems have been faced and overcome in the past than are presented by Kennett. In 1921, the Great Western Power Company brought in on its own system the first units of the Caribou development, the output of which represented in excess of 40 per cent of the then existing load on that system. In 1925, the Pacific Gas and Electric Company completed its Pit No. 3 plant, commenced the purchase of additional power from the California-Oregon Power Company and the City of San Francisco, the total amount exceeding 40 per cent of its then existing load. Kennett output will represent from 23 per cent to 31 per cent of the load at the time it is available.

With reasonable coordination and cooperation between this development and existing agencies no serious difficulty should arise in the absorption of power produced by Kennett development.

The problem of obtaining a market for the output of Kennett plant were the market to be developed through state-owned and operated distribution systems as suggested in Plan 5, is one to be considered separately.

COST OF KENNETT DEVELOPMENT

INVESTMENT COST.

The cost of the Kennett development (420 foot dam, 2,940,000 acre-foot reservoir) was estimated in Bulletin No. 13, "The Development of the Upper Sacramento River," at $80,000,000 That estimate was prepared on the basis of a power plant capacity of 400,000 kilovolt-amperes and with interest during construction at a rate of 6 per cent per annum. In this report the power plant capacity has been taken at 275,000 kilovolt-amperes as explained on page 15 of this report, and the interest rate reduced to a State financing basis of 4½ per cent. With these revisions the estimated cost is $70,000,000 This covers purchase of reservoir site and removal to new location of the Southern Pacific Company tracks and a part of the State highway that would be submerged, construction of the dam and a 275,000 kilovolt-ampere power plant The total cost is divided as follows:

Lands and improvements flooded	$22,882,000
Dam and appurtenances	30,118,000
Total reservoir and dam	$53,000,000
Power plant	17,000,000
Total development	$70,000,000

ANNUAL COST OF KENNETT DEVELOPMENT.

The annual cost of Kennett development (reservoir, dam and power plant) will vary in the first three of the five plans of financing suggested, owing to differences in costs between private and state ownership and financing. The annual cost of this development will be the same under Plans 3, 4 and 5, as each contemplates complete State ownership of the reservoir, dam and power plant. The annual costs are fully set forth in Table 8 and are based on the following units:

Basis of Estimated Annual Cost Kennett Reservoir and Power Plant

	Private ownership	*State ownership*		
Bond amortization basis		*Straight line*	*Sinking fund*	*Excluded*
Return or interest per cent of capital	7 5	4 5	4 5	4 5
Amortization of state bonds—40 year basis, per cent of capital	--	2.5	1 05	--
Depreciation:				
Land and improvements, per cent of capital	--	--	--	--
Dam and appurtenances, per cent of capital	.3	.3	.3	.3
Power plant, 40 year basis, per cent of capital	.65	1.05	1 05	1.05
Taxes:				
State, per cent of capital	1 35			
Federal, per cent of capital	.40			
Operating expense and maintenance, both private and state ownership	$200,000 per annum for dam and reservoir $300,000 per annum for power plant			

Return on private investment is that at present generally estimated as fair for large electric projects such as Kennett. The interest rate of 4.5 per cent for State investment is slightly above the present cost. Amortization is assumed on a basis of a forty-year period commencing ten years after date of issue of bonds. This period is within the legal limit for State bonds (seventy-five years). Ten years for construction and loading of power plant prior to commencement of amortization are allowed for Estimated costs under straight line amortization show the maximum annual charges with State development. A 4 per cent sinking fund amortization is included in the table in order to set forth the approximate average annual cost during the forty-year amortization period. The estimate, excluding amortization, sets forth the cost

TABLE 8

Estimated Annual Cost Kennett Reservoir and Power Plant

Division	Capital	Plan 1 Private development: Including state and federal taxes (based on average tax rate)	Plan 1 Private development: Excluding state tax	Plan 2 State development of reservoir and dam. Private development of power plant: *Straight line amortization of state bonds state taxes included	Plan 2 State development of reservoir and dam. Private development of power plant: Sinking fund amortization of state bonds state taxes excluded	Plan 3 State development of reservoir, dam and power plant: *Straight line amortization of bonds	Plan 3 State development of reservoir, dam and power plant: Sinking fund amortization of bonds	Plan 3 State development of reservoir, dam and power plant: Excluding amortization of bonds
Reservoir and dam	$53,000,000							
Interest or return		$3,975,000	$3,975,000	$2,385,000	$2,385,000	$2,385,000	$2,385,000	$2,385,000
Amortization				1,325,000	556,000	1,325,000	556,000	
Depreciation		90,000	90,000	90,000	90,000	90,000	90,000	90,000
State tax		407,000						
Federal tax		212,000	212,000					
Operation and maintenance		200,000	200,000	200,000	200,000	200,000	200,000	200,000
Totals, reservoir and dam		$4,884,000	$4,477,000	$4,000,000	$3,231,000	$4,000,000	$3,231,000	$2,675,000
Power plant	17,000,000							
Interest or return		$1,275,000	$1,275,000	$1,275,000	$1,275,000	$765,000	$765,000	$765,000
Amortization						425,000	178,000	
Depreciation		111,000	111,000	111,000	111,000	178,000	178,000	178,000
State tax		229,000		229,000				
Federal tax		68,000	68,000	68,000	68,000			
Operation and maintenance		300,000	300,000	300,000	300,000	300,000	300,000	300,000
Totals, power plant		$1,983,000	$1,754,000	$1,983,000	$1,754,000	$1,668,000	$1,421,000	$1,243,000
Reservoir, dam and power plant:								
Interest or return		$5,250,000	$5,250,000	$3,660,000	$3,660,000	$3,150,000	$3,150,000	$3,150,000
Amortization				1,325,000	556,000	1,750,000	734,000	
Depreciation		201,000	201,000	201,000	201,000	268,000	268,000	268,000
State tax		636,000		229,000				
Federal tax		280,000	280,000	68,000	68,000			
Operation and maintenance		500,000	500,000	500,000	500,000	500,000	500,000	500,000
Totals, reservoir, dam and power plant	$70,000,000	$6,867,000	$6,231,000	$5,983,000	$4,985,000	$5,668,000	$4,652,000	$3,918,000
Total cost in per cent of capital		9 81	8 90	8 55	7 12	8 10	6.65	5.60
Total cost per kilowatt hour produced	1,217,600,000 kwh.	$0.00564	$0.00512	$0 00491	$0 00409	$0.00466	$0.00382	$0 00322

* Estimated costs under straight line amortization represent maximum money requirements which occur in first year of amortization period

during the first years; also the estimated carrying cost of the development, excluding retirement of capital.

The length of bond amortization might be increased to a sixty or sixty-five year period under the legal limitation and thus reduce the annual outlay. The table, however, indicates the limits between which the results, based on other assumptions, will fall. No depreciation has been assumed on lands or improvements removed. A minimum of 0 3 per cent has been included on the dam and appurtenances to cover contingencies and minor replacements Depreciation on the power plant is estimated on forty years' life on a 6 per cent sinking fund for private and 4 per cent sinking fund for State ownership.

Operating and maintenance expenses are estimated to cover not only local but also general expenses and are somewhat higher than a study of expenses of the larger developments of the State would indicate in order to cover possible contingencies.

The table sets forth the estimated cost under private ownership of capital with and without State taxes. Under the present method of taxing electric utilities a private utility would pay the same State tax were it to purchase the power wholesale from the State as it would if the plant were constructed and owned by it, the tax being determined as a per cent of the total gross revenue of the utility. For comparison with costs of other power, therefore, the cost has been estimated excluding State taxes. The present State tax rate is 7.5 per cent of the gross revenue. Assuming revenue would equal total cost the resultant tax rate would be seventy-two hundredths of 1 per cent of the capital under Plan 1. This basis can hardly be expected to continue indefinitely. The rate of 1.35 per cent of capital is based on the average tax rate on general property now existing over the State equated to a per cent of capital cost. No State tax is estimated on the capital representing lands and improvements as the greater part of this cost represents cost of relocation of the railroad and highway and would not represent power company property.

COST OF TRANSMISSION.

Plan 4 contemplates construction and operation of trunk transmission lines to the important load centers of northern California, power to be wholesaled to political subdivisions and private utilities.

As indicated in Plate II and Tables 2, 3-A and 3-B, over 65 per cent of the market is located within a radius of 50 miles of San Francisco. From Table 1, it is to be noted that at present 94 per cent of the power is served directly by two companies. Further data show that within the Sacramento Valley and the San Francisco Bay region less than 2 per cent of the power is distributed by municipal systems, only one individual system distributing over 0.5 of 1 per cent of the existing load. These systems are scattered from Redding on the north to Santa Clara on the south This does not include the Modesto and Turlock districts which produce their own power and would require only standby service.

Transmission of such a large amount of power as Kennett output will require as a minimum, a double circuit 220,000 volt transmission line to the main load center in the Bay district.

It is apparent from an engineering consideration of the data that outside of the two main companies there are at present no municipal

or private resale systems of sufficient size or advantageous location to take power economically from the main trunk transmission line. Should another system develop which could avail itself of the purchase of power wholesale it must be assumed that the revenue to be received would justify the added capital expenditure. At present only two agencies of sufficient size to utilize the output of Kennett exist: one, the Pacific Gas and Electric Company; the other, the Great Western Power Company of California. If transmission of power by the State is contemplated the logical terminal of the transmission line would be in the general vicinity of Antioch, Contra Costa County, practically two hundred miles' transmission distance from Kennett. Both companies have important substations and transmission lines in this location which is near the center of load.

The cost of transmission per kilowatt hour will vary materially, depending on the plan of operation and whether adequate standby service against interruption is contemplated. By wholesaling the output to these two agencies the cost to the State will be reduced to a minimum. Under such delivery the transmission line can be limited to two circuits and one substation as the purchasing systems with their steam-electric and hydro-electric plants and extensive transmission networks will be adequate in size to take care of interruptions without detriment to the public service.

If the State contemplates delivery of power comparable in continuity to that now delivered by existing utilities an additional transmission line and steam-electric standby plant would be required in excess of that herein estimated.

Table 9 sets forth the estimated investment and annual cost to the State and to a private utility to transmit Kennett power to the load center wholesaling it to the existing agencies. This represents the minimum capital and annual cost requirements for transmission.

TABLE 9

Cost of Transmission of Kennett Power, Kennett to Antioch

Investment Cost

Transmission line—200 miles double circuit tower line	$6,000,000
Receiving substation, 200,000 kilowatt capacity	3,600,000
Total	$9,600,000

Power delivered 88% of 1,217,600,000 kilowatt hours = 1,070,000,000 kilowatt hours.

Basis of Annual Cost

Per cent of Capital

	State development		
	Straight line amortization	*Sinking fund amortization*	*Private development*
Interest or return	4 5	4.5	7.50
Amortization—40 years	2 5	1 05	-----
Depreciation	1.35	1.35	1.00
Maintenance and operating expense, including general expense:			
Transmission line	.75	.75	.75
Terminal substation	2 50	2 50	2 50
Taxes, state and federal	---	---	1 75

Annual Cost

1 Transmission line			
Interest on $6,000,000	$270,000	$270,000	$450,000
Amortization	150,000	63,000	-----
Depreciation	81,000	81,000	60,000
Maintenance and operating expense	45,000	45,000	45,000
Taxes	-------	-------	105,000
Total cost of transmission to substations	$546,000	$459,000	$660,000

2 Receiving substation.			
Interest on $3,600,000	$162,000	$162,000	$270,000
Amortization	90,000	37,800	-----
Depreciation	48,500	48,500	36,000
Operating expense	90,000	90,000	90,000
Taxes	-------	-------	63,000
Total cost of receiving substation	$390,500	$338,300	$459,000
3 (a) Total cost of transmission	$936,500	$784,300	$1,119,000
(b) Total cost of transmission, excluding state taxes	-------	-------	989,600
4. Cost per kilowatt hour delivered, a	$0.000875	$0.000733	$0.001044
b	-----	-------	0.000924

From Tables 8 and 9, the total cost to the State under Plan 4, assuming the wholesaling of power to the existing agencies, may be summarized as follows:

		Annual cost	
	Capital cost	*Straight line amortization of bonds—40 years*	*Sinking fund amortization of bonds—40 years*
1 Dam, reservoir and power plant	$70,000,000	$5,668,000	$4,652,000
2. Cost per kilowatt hour produced—(1,217,600,000 kilowatt hours)		($0.00466)	($0.00382)
3 Transmission line and substation	9,600,000	936,500	784,300
4 Totals	$79,600,000	$6,604,500	$5,436,300
5 Total cost per kilowatt hour delivered from terminal substation—(1,070,000,000 kilowatt hours)		($0.00617)	($0.00508)

In the above table and in Table 9, preceding, the figures under straight line amortization represent the maximum costs which occur during the first year of the amortization period.

VALUE OF POWER OUTPUT

The value of the power output of Kennett and the revenue from the power under Plans 1, 2, 3 and 4 will depend upon the characteristics of the output and upon the cost of power from other and competitive sources. Power that is available mainly in spring months or in wet years is less valuable, requiring more auxiliary steam-electric power installation than power which can be depended upon under adverse conditions of drought. Plate VII, heretofore referred to, sets forth graphically the estimated annual and monthly variation of power from Kennett compared with other hydro-electric plants of northern California. This comparison shows that Kennett power under the conditions of operation specified has better characteristics than the power from other plants.

There are three measures of the value of power, based upon cost of power from other sources:

1. Cost of power from other hydro-electric plants.
2. Cost of power from steam-electric plants.
3. Wholesale price for power as indicated by existing contracts.

Throughout this analysis comparison will be made on a unit basis of mills per kilowatt hour. Such a basis is only correct where power characteristics and point of delivery are equivalent. These units are better understood, however, and will be used with qualifying statements.

COST OF POWER FROM OTHER HYDRO-ELECTRIC PLANTS

The potential water power resources of California have been inventoried and summarized by Mr. F. E. Bonner of the Federal Power Commission, in a report just issued by that commission. Table 10, compiled from Table 9 of the Bonner Report, shows the present and principal ultimate development of the water power resources of the State. This shows by main streams the present and estimated ultimate installed capacity and output in average kilowatts, and ultimate output in millions of kilowatt hours. Although these figures are not directly comparable with estimates of kilowatt hours and plant capacities shown in other portions of this report, they are indicative of the extent of the present development, the potential development and the main source of future production of power in California from hydro-electric sources. It is to be noted from the table that 70 per cent of the potential hydro-electric power of California exists on streams north of Merced and tributary to northern California, and only 30 per cent in the territory tributary to southern California. Present development in the north is only 14 per cent of the total potential and indicates that for a long period undeveloped resources will exist.

The important streams of northern California are the Klamath; the Pit, McCloud and Sacramento group; the Feather and the American rivers. The important streams tributary to southern California are the San Joaquin and Kings. In view of the relative proximity of the Pit and Feather rivers to the Kennett development, the cost of power

TABLE 10. Summary of Water-power Resources of California

From Table 9, "Report to Federal Power Commission on the Water Powers of California," by Frank E Bonner

Drainage basin	Existing development: No plants	Existing development: Installed capacity, kw.	Existing development: Output average, kw.	Ultimate development [a]: No. plants	Ultimate development [a]: Installed capacity, kw.	Ultimate development [a]: Output average, kw.	Ultimate development [a]: Output, millions of kwh.	Per cent of group	Per cent of state
Northern group.									
1. Smith River	---	---	---	---	---	---	---	---	
2. Klamath River [b]	4	56,200	27,170	17	808,200	508,881	4,457 8	15 9	
3. Trinity River	3	2,775	800	12	303,000	180,925	1,584 9	5.7	
4. Eel River	1	6,800	5,700	2	11,000	8,800	77.1	.3	
5. Pit River	4	120,500	89,964	11	480,500	316,346	2,771 2	9 9	
6. McCloud River	---	---	---	4	221,500	133,705	1,171 3	4 2	
7. Sacramento River	6	37,000	19,097	9	469,000	257,647	2,257.0	8 1	
Totals (5–7, inclusive)	10	157,500	109,061	24	1,171,000	707,698	6,199.5	22 2	
8. Deer and Mill creeks	---	---	---	2	60,000	45,000	394 2	1.4	
9. West Fork Feather and Butte Creek	4	22,400	13,863	4	22,400	13,863	121 4	.4	
10. Feather River	4	175,800	105,023	24	1,065,800	698,251	6,116 7	21.8	
11. Yuba River (including Bear River)	9	114,375	74,200	18	389,675	251,707	2,205.0	7 9	
12. American River	3	29,000	14,270	22	546,000	317,408	2,780 5	9.9	
13. Mokelumne River	1	19,400	7,954	6	138,000	94,405	827.0	3.0	
14 Stanislaus River	7	73,200	31,393	16	293,700	207,680	1,819.3	6.5	
15. Tuolumne River	4	117,600	73,400	8	241,300	160,743	1,408.1	5 0	
Totals (1–15, inclusive)	50	775,050	462,834	155	5,050,075	3,195,361	27,991 5	100.0	70.5
Per cent of ultimate development	---	---	14	---	---	100	---	---	
Southern group.									
16. Merced River	6	34,150	15,810	12	93,650	47,541	416 4	3 5	
17. San Joaquin River	11	404,300	251,142	24	960,100	524,667	4,596 1	39 0	
18 Kings River	2	31,500	13,700	15	609,000	407,750	3,571 9	30 3	
19. Kaweah River	3	6,700	4,727	3	6,700	4,727	41 4	.3	
20. Tule River	2	7,500	4,205	2	7,500	5,791	50.7	.4	
21. Kern River	4	76,500	52,209	9	198,500	119,952	1,050 8	8 9	
22. Truckee River [c]	1	1,650	596	3	7,500	5,000	43.8	.4	
23. Carson River	---	---	---	1	6,000	4,000	35 0	.3	
24. Walker River	1	500	300	2	15,500	9,400	82 3	.7	
25 Mono Lake	4	25,000	8,380	3	24,100	7,582	66.4	.5	
26. Bishop Creek	5	24,475	13,927	6	27,575	17,124	150 0	1.3	
27. Owens River	12	103,320	34,246	20	244,860	162,564	1,424 1	12.1	
28. Santa Clara River	---	---	---	3	23,000	8,000	70 1	.6	
29. San Gabriel River	1	2,000	1,152	1	2,000	1,152	10 1	.1	
30. Santa Ana River	11	15,475	10,062	15	29,675	18,462	161 7	1.4	
31 Salton Sea	3	3,030	1,255	5	5,830	2,295	20 1	2	
32. San Diego County	2	800	400	2	800	400	3 5	.0	
33. Miscellaneous	1 [d]	950	350	1	950	350	3.1	.0	
Totals (16–33, inclusive)	68	737,850	412,461	127	2,263,210	1,346,757	11,797.5	100 0	29 5
Per cent of ultimate development	---	---	31	---	---	100	---	---	
Total State (1–33, inclusive)	**118**	**1,512,900**	**875,295**	**282**	**7,313,315**	**4,542,118**	**39,789.0**	----	**100.0**

[a] Including existing developments
[b] Excluding part in Oregon
[c] Excluding part in Nevada.
[d] Swanton Plant, Santa Cruz County.

TABLE 11

Estimated Cost of Hydro-Electric Power from Present and Future Pit and Feather River Developments

	Pit River developments		*Feather River developments*	
	Pacific Gas and Electric Company		*Great Western Power Company*	
	Present	*Future*	*Present*	*Future*
1. Plants included	Pit 1 and 3 Hat Creek 1 and 2	Pit 2, 4, 5 and 6	Caribou and Las Plumas	Plants 1–8b
2. Plant capacity	176,000 kva.	306,000 kva.	133,000 kw.	593,750 kw.
3. Average annual output	828 million kwh.	1,583 million kwh	870 million kwh.	3,430 million kwh.
4 Investment cost	$23,233,000	$40,100,000	$29,300,000	$105,704,000
5 Basis of computing annual cost:				*Per cent of capital*
Return				7 5
Depreciation				0 65
Operating, maintenance and general expense				0 75
Taxes				
Federal				40
State				1 35
Total				10 65
6. Total annual cost:				
(a) Including state tax	$2,474,315	$4,270,650	$3,120,450	$11,257,476
(b) Excluding state tax	2,160,669	3,729,300	2,724,900	9,830,472
7. Cost per kwh average output:				
(a) Including state tax	$0.00299	$0 00270	$0 00359	$0 00328
(b) Excluding state tax	$0.00261	$0.00236	$0 00314	$0.00287

from the present and future developments on these streams will indicate fairly closely the cost of power from other hydro-electric sources competitive with Kennett. These streams are being developed by the two major agencies serving northern California, namely the Pacific Gas and Electric Company and the Great Western Power Company, and are the probable sources of the main development during the next ten years or more.

Table 11 sets forth the estimated cost of power from the present developments and the estimated cost of power from future developments contemplated on the Pit and Feather rivers by the Pacific Gas and Electric Company and the Great Western Power Company, respectively. The cost of electric power from existing plants is based upon the actual costs or estimated costs of the projects under present price levels. The cost for future plants is based on tentative estimates heretofore prepared by these companies. The costs with and without State taxes are shown for the reasons heretofore set forth.

The characteristics of power from the present Pit River development compared with Kennett are shown in Plate VII. The locations of the present developments on Pit River are approximately forty miles further from the power market than Kennett. This results in a differential in favor of Kennett of approximately two-tenths mills per kilowatt hour.

The characteristics of the power now being produced by the existing plants on the Feather River and that which may be produced by future plants are in general closely comparable with the primary or dry year output of Kennett development; that is, the minimum output of 990,400,000 kilowatt hours, per year. This greater dependability has been made possible by the large cyclic storage of water in Lake Almanor at the upper end of the series of plants

It is to be noted from the table that the estimated cost including taxes for the present Pit development is approximately three mills per kilowatt hour and for the future development, two and seven-tenths mills, while the cost of power from the Feather River approximates three and six-tenths mills for present plants and three and three-tenths mills per kilowatt hour for future plants. These plants are 100 miles nearer the main power market than the Pit plants and the characteristics of power are better. If weight be given to these factors and the value of power measured at the load center near San Francisco Bay, the two sources of power are practically of equal value per kilowatt hour.

There are other potential developments of power, as indicated in Table 10 on the Klamath and south of the Feather River. Klamath, being approximately 90 miles further from the market, is subject to a differential in favor of Kennett of from four-tenths to five-tenths mills per kilowatt hour. The developments south of Feather River are in general at least 100 miles nearer the center of the power market than Kennett and therefore have a differential in their favor of from five-tenths to seventy-five hundredths mills per kilowatt hour, this differential including cost of transmission and shrinkage of kilowatt hours due to transmission losses

The San Joaquin Valley power market depends upon the San Joaquin and Kings rivers mainly for hydro-electric power. The cost of

power from these streams is estimated at three to five mills per kilowatt hour of average annual output. The distance from Kennett to the market in the San Joaquin Valley is from 300 to 450 miles. Generally transmission of power in excess of 300 miles has not been justified. The differential for transmission from Kennett would be at least two mills per kilowatt hour which, deducted from an average cost of four mills would leave two mills or less per kilowatt hour for power at Kennett.

The potential power available from the main streams of northern California which may be economically developed would indicate that until this is utilized the value of Kennett power measured by competition with other hydro-electric sources would be between two and seven-tenths and three and three-tenths mills per kilowatt hour. As the more economical sources are used the value compared with other hydro-electric sources may tend to increase

VALUE OF KENNETT POWER DETERMINED FROM COST OF POWER FROM STEAM-ELECTRIC PLANTS

COST OF STEAM-ELECTRIC POWER.

There has been during the last several years a marked increase in efficiency of steam-electric production A still further improvement in efficiency may be expected. On the basis of 60 per cent plant load factor with present efficiencies the fuel requirements are 15,000 British thermal units or less per kilowatt hour produced It appears from study of literature on the subject and from present trend of efficiency that reduction of the requirement to below 14,000 British thermal units may be expected in the near future and later as low as 12,000 British thermal units per kilowatt hour

The question of price of oil is impossible of determination for any period of time. The present price is $1 per barrel. The price has fluctuated widely in the past When the present condition of overproduction of oil is past, increase in price may be expected. Coal supply would indicate a limitation in fuel cost, however, to approximately the equivalent of $1.50 per barrel of oil

Table 12 sets forth the estimated cost of power from a steam-electric plant operating at 60 per cent load factor to supply a load necessary to absorb fully the potential output of Kennett. The conditions of efficiency are those that should be obtained by new plants in the next few years. Oil has been estimated at $1 per barrel. The cost of power from recently constructed plants would, on a basis of $1 per barrel for oil, be two-tenths mills per kilowatt higher. Table 13 sets forth the estimated cost based on probable further efficiency development and price of oil of $1 25 per barrel.

It is to be noted that the cost of steam-electric power is divisible into two parts; one fixed and amounting to approximately $17 or $15 50 per kilowatt of capacity, depending upon treatment of taxes, and on output cost varying with the power produced from two to two and twenty-three hundredths mills per kilowatt hour.

EQUIVALENT VALUE OF HYDRO-ELECTRIC POWER.

A determination of the relative value of hydro-electric power by comparison with the cost of steam-electric power requires special care to insure equivalent bases, owing to market difference in fundamental characteristics of output and variation in costs between the two sources The output of hydro-electric plants such as Kennett varies from year to year, depending upon conditions of precipitation. Costs are practically fixed and do not vary with output or with price of fuel. Steam-electric power output can be readily adjusted to demands, a considerable part of the cost varying directly with the output and the price of fuel. The determination of relative value has been made by load characteristics similar to those of northern California and sufficient to absorb the output of Kennett without wastage. This cost has then been compared with cost of power from Kennett with necessary auxiliary steam-electric power.

TABLE 12

Estimated Cost of Steam-Electric Power Basis of Probable Efficiency of Immediate Future

		Basis	
1	Steam-electric power installation to supply load equivalent to Kennett plus steam-electric auxiliary		
	(a) Annual production	1,275,000,000	kilowatt hours
	(b) Capacity for 60% load factor, 243,000 kilowatts, use	250,000	kilowatt capacity
	(c) Cost of power plant and connecting transmission line at $110 per kilowatt	$27,500,000	
2	Estimated efficiency 1 bbl. of oil per kilowatt per year plus 1/500 bbl of oil per kilowatt hour net output.		
3	Annual cost		
	(a) Return on investment	7.5%	
	(b) Depreciation	2.25%	
	(c) Operating expenses other than oil	$3.00 per kilowatt year	
	(d) General expense	3% of cost other than oil and taxes	
	(e) Oil	$1.00 per bbl	
	(f) Tax. State 1.35% Federal .40	1.75%	
4	Annual cost.		
	(a) Fixed costs:		
	Return at 7.5%	$2,062,500	
	Depreciation at 2.25%	618,750	
	Operating expense at $3	750,000	
	General expenses	102,940	
	Standby oil at $1	250,000	
	Taxes at 1.75%	481,250	
	Total fixed costs	$4,265,440	
	(b) Output costs. Oil at $.002 per kilowatt hour	2,550,000	
	(c) Total costs	$6,815,440	

		(a) *Including state tax*	(b) *Excluding state tax*
5	Unit costs		
	Demand or fixed cost per kilowatt of capacity	$17.06	$15.57
	Energy cost per kilowatt hour of output	.002	.002
6	Average cost per kilowatt hour	.00535	.00527

The steam-electric plant would be located on San Francisco Bay and as to relative distance to the market, would be equivalent to the terminal substation of Kennett transmission.

The cost of steam-electric power based on the estimates in Table 12 have been set up in Table 14 (Item "C"). From this has been deducted the annual cost of the auxiliary steam-electric plant required to supply the load without wastage of power from Kennett in years of maximum output. The balance (Item E-10) represents the relative value of Kennett Power delivered at Antioch. Deducting the cost of transmission the relative value of Kennett power at the plant is determined.

TABLE 13

Estimated Cost of Steam-Electric Power Basis of Probable Efficiency Future

Basis

1	Steam-electric power installation to supply load equivalent to Kennett plus steam-electric auxiliary		
	(a) Annual production	1,275,000,000	kilowatt hours
	(b) Capacity for 60% load factor, 243,000 kilowatts, use	250,000	kilowatt capacity
	(c) Cost of power plant and connecting transmission line at $110 per kilowatt	$27,500,000	
2.	Estimated efficiency. 75 bbl of oil per kilowatt per year plus 1/560 bbl of oil per kilowatt hour net output		
3	Annual cost		
	(a) Return on investment	7 5%	
	(b) Depreciation	2 25%	
	(c) Operating expenses other than oil	$3 00 per kilowatt year	
	(d) General expense	3% of cost other than oil and taxes	
	(e) Oil	$1 25 per bbl	
	(f) Tax State 1.35% Federal .40	1.75%	
4	Annual cost		
	(a) Fixed costs		
	Return at 7 5%	$2,062,500	
	Depreciation at 2.25%	618,750	
	Operating expense at $3	750,000	
	General expenses	102,940	
	Standby oil at $1 25	234,000	
	Taxes at 1 75%	481,250	
	Total fixed costs	$4,249,440	
	(b) Output costs Oil at $ 00223 per kilowatt hour	2,843,325	
	(c) Total costs	$7,092,765	

		(a) *Including state tax*	(b) *Excluding state tax*
5	Unit costs		
	Demand or fixed cost per kilowatt of capacity	$17 00	$15 58
	Energy cost per kilowatt hour of output	00223	00223
6	Average cost per kilowatt hour	00556	.00527

TABLE 14

Comparison of Value of Kennett Power With Steam-Electric Produced Power

A	Kennett development 220,000 kilowatts—275,000 kilovolt-amperes			
	1 Output of Kennett plant annual average		1,217,600,000	kwh
	2 Delivery from terminal substation		1,070,000,000	kwh.
	3 Steam-electric auxiliary plant output required to supply load that will absorb Kennett output without wastage		205,000,000	kwh.
	4 Total output basis of terminal delivery		1,275,000,000	kwh.
	5 Steam-electric auxiliary capacity required based on maximum monthly requirement 80% load factor		62,500	kw.
B	Steam-electric power equivalent			
	6 Steam-electric plant capacity to supply load on 60% load factor basis 243,000 kw., use		250,000	kw.
C.	Steam-electric plant costs		*Including tax*	*Excluding tax*
	7 Demand charge unit cost		$17 00	$15 50
	8 Demand cost	250,000 kw.	$4,250,000	$3,875,000
	Energy cost	1,275,000,000 kwh.	2,550,000	2,550,000
	Totals		$6,800,000	$6,425,000
	Per kilowatt hour delivered		00533	.00504
D	Auxiliary steam-electric cost			
	9 Demand cost	62,500 kw	$1,062,000	$968,750
	Energy cost	205,000,000 kwh.	410,000	410,000
	Totals		$1,472,000	$1,378,750
E	Value of hydro-electric power at substation terminals			
	10 Available for hydro-electric power from transmission (8)–(9)		$5,328,000	$5,046,250
	Per kilowatt hour delivered (1,070,000,000 kwh.)		00498	.00471
	11 Transmission cost		$1,119,000	$989,600
F	Value of hydro-electric power at Kennett		$4,209,000	$4,056,650
	12 Value per kilowatt hour (1,217,600,000 kwh.)		.00347	.00334
	13 Value per kilowatt hour based on future steam plant efficiency and oil at $1 25 per bbl		00368	.00355

Similar comparison has been made of the relative value of Pit power now developed This computation is shown in Table 15 The difference of two-tenths mill per kilowatt hour in the unit values between Kennett and Pit is accounted for mainly by the greater transmission distance to Pit plants

TABLE 15

Comparative Value of Pit Power With Steam-Electric Produced Power

A	Pit development 141,600 kilowatts			
	1	Output of Pit developments, annual average		828,000,000 kwh
	2	Delivery from terminal substation, 14% transmission loss		713,000,000 kwh.
	3	Steam-electric auxiliary plant output required to supply load that will absorb Pit output without wastage		387,000,000 kwh
	4	Total output based on terminal delivery		1,100,000,000 kwh.
	5	Steam auxiliary capacity required based on maximum monthly requirements 80% load factor		92,500 kw.
B	Steam-electric power equivalent			
	6	Steam plant capacity to supply load on 60% load factor basis 209,000 kilowatts use		215,000 kw.

			Including tax	*Excluding tax*
C	Steam-electric plant costs			
	7	Unit demand cost	$17 00	$15 50
	8	Demand cost 215,000 kw.	$3,655,000	$3,332,500
		Energy cost 1,100,000,000 kwh	2,200,000	2,200,000
		Totals	$5,855,000	$5,532,500
		Per kilowatt hour delivered	.00533	00505
D	Auxiliary steam-electric cost			
	9	Demand 92,500 kw.	$1,572,500	$1,433,400
		Energy 387,000,000 kwh.	774,000	774,000
		Totals	$2,346,500	$2,207,400
E	Value of hydro-electric power at substation terminals			
	10	Available for hydro-electric power from transmission (8)–(9)	$3,508,500	$3,325,100
		Per kilowatt hour delivered (712,000,000 kwh)	00493	00467
	11	Transmission cost	$845,000	$733,000
F	Value of hydro-electric power at Pit plants		$2,663,500	$2,592,100
	12	Value per kilowatt hour (828,000,000 kwh)	00322	.00313
	13	Value based on future steam-electric plant efficiency and oil at $1 25 per bbl.	.00342	.00333

The value of Kennett power measured at the power plant, determined from comparison with steam-electric power, is between three and thirty-four hundredths and three and sixty-eight hundredths mills per kilowatt hour based on the prices of oil considered.

MARKET PRICE OF POWER AS DETERMINED FROM EXISTING CONTRACTS

There exists at the present time in the northern and central parts of the State, six main contracts covering the purchase by utilities of the output of hydro-electric plants constructed by irrigation districts, municipalities or other public utilities. These contracts and purchases involve the following:

1. Merced Irrigation District and San Joaquin Light and Power Corporation
2. Turlock Irrigation District and San Joaquin Light and Power Corporation
3. South San Joaquin and Oakdale Irrigation Districts and Pacific Gas and Electric Company.
4. City of San Francisco and Pacific Gas and Electric Company
5. Feather River Power Company and Great Western Power Company of California
6. California Oregon Power Company and Pacific Gas and Electric Company

These contracts, in total, involve the delivery of approximately the amount of power to be produced at the Kennett development.

There are two other contracts not readily comparable which have not been included but, in so far as can be ascertained, indicate somewhat lower prices than the six contracts considered.

1. Merced Irrigation District and San Joaquin Light and Power Corporation

This contract involves delivery of power at the high tension terminal of the power plant on the Merced River. The power is seasonal in character and the output fluctuates between wide limits from wet to dry years. The contract was entered into when costs of construction and competitive costs of power were higher than at the present time The price is four and five-tenths mills per kilowatt hour and delivery is approximately fifty miles from a point which may be considered equivalent to Bay district delivery of Kennett power.

2 Turlock Irrigation District and San Joaquin Light and Power Corporation.

This contract provides for delivery at Livingston or Merced Falls of the surplus power of the Turlock Irrigation District. Obligation to purchase is maximum from June to December and reduced during the months of January to May The price is four and five-tenths mills per kilowatt hour. Delivery is practically equivalent in location to Merced District delivery.

3. South San Joaquin and Oakdale Irrigation Districts and Pacific Gas and Electric Company.

In this case the dam and reservoir were constructed by the Districts, the power company constructed the power plant and in addition to its own costs pays to the Districts for a period of forty years an amount equal to interest and amortization on the Districts' capital. The cost, including estimated State tax based upon power plant output, is approximately four and two-tenths mills per kilowatt hour. The contract provides, however, that after the forty-year period the power company

is obligated to pay to the districts only half of the operation and maintenance of the dam and reservoir and nothing in the way of return. The power is seasonal in character and involves fairly wide fluctuations between wet and dry years. Equivalent transmission distance is approximately 50 miles.

4. City of San Francisco and Pacific Gas and Electric Company.

This contract provides for delivery at Newark substation, which is comparable with delivery at Antioch, of the output of the Moccasin Creek plant at 75 per cent daily load factor The power supply is dependable from the standpoint of variation from wet to dry years, but the contract provides for cancellation. This contract represents the largest power delivery and the nearest comparable with the delivery of power from Kennett reservoir to a point such as Antioch. The price is four and eight hundred seventy-eight thousandths plus mills per kilowatt hour.

5. Feather River Power Company and Great Western Power Company of California.

This contract provides for a delivery of 40,000 kilowatts at approximately 60 per cent annual load factor at the high tension terminals of the power plant transformers, a distance of 150 miles from the Bay area. The price is four mills per kilowatt hour, but the contract provides that at the end of thirty-five years the total power development of the Feather River Power Company will become the property of the Great Western Power Company. The purchase of property feature in the contract represents about twenty-five hundredths mills per kilowatt hour.

6. The California Oregon Power Company and Pacific Gas and Electric Company.

The agreements between these companies call for 30,000 kilowatts delivery at 70 per cent load factor, measurement at Cottonwood substation of the Pacific Gas and Electric Company, but provide that the purchasing company will construct a part of the transmission line between the California Oregon Power Company plants and Cottonwood substation. The price for power at 70 per cent load factor or less is four and five-tenths mills per kilowatt hour The point of delivery is comparable generally with delivery at Kennett power plant.

Table 16 sets forth certain statistics with reference to the six agreements, showing the approximate annual power delivery, the voltage and point of delivery, the relative characteristics of the power compared with Kennett power, the approximate distance to the general market comparable with the 200 miles transmission from Kennett to Antioch, the equivalent delivery, the price covered by the contract, this price equated to delivery equivalent to Antioch for Kennett power, and to delivery at Kennett. In the determination of the differential between the various prices actually paid for power and the equivalent price at Antioch and Kennett, transmission costs and losses have been estimated as proportional to relative transmission distance from the power market.

TABLE 16

Comparison of Contract Prices for Power Purchased from Hydro-electric Power Plant Developments

	Company	Approximate amount of power purchased: Kw peak	Kwh annually	Equivalent delivery from transmission at market kwh annually	Delivery: Voltage (nominal)	Point	Power Characteristics (a)	Approximate distance to general market, miles	Contract period—years	Price per kwh mills (at delivery point)	Cost of equivalent delivery from transmission, mills per kwh. delivered	Resultant prices comparable to Kennett delivery at power plant, mills per kwh delivered
1	Merced Irrigation District and San Joaquin Light and Power Corporation..	30 000	120,000,000	116,500,000	60,000	Power Plant	Seasonal 80% load factor 40%–130% annual variation (*)	50	20	4 5	4 9	3 39
2	Turlock Irrigation District and San Joaquin Light and Power Corporation	2 500 to 6,500†	10 000,000	38,500 000	60,000	Merced Falls and Livingston	Annual (‡)	50	15	4 5	4.9	3 39
3.	South San Joaquin and Oakdale Irrigation districts and Pacific Gas and Electric Company (b)	25,000	100,000,000	97,000,000	60,000	Power Plant	Seasonal load factor not determined 62%–130% annual variation (*)	50	40	4 2	4 6	3 13
4	City of San Francisco and Pacific Gas and Electric Company	75,000	475,000,000	475,000,000	110,000	Newark Sub	75% load factor practically no annual variation (†)	0	Subject to cancellation	4 878	4 878	3.37
5	Feather River Power Company and Great Western Power Company of California (c)	40,000	208,000,000	187,500,000	220,000	Power Plant	Annual 63% load factor (‡)	150	35	4 00	5.19	3.64
6	California-Oregon Power Company and Pacific Gas and Electric Company (d)	30,000	180,000,000	158,500,000	110,000	Near Delta measured at Cottonwood	Annual 70% load factor (‡)	200	25	4.5	6.17	4 50
	Totals	201,500	1,123,000,000	1,073,000,000							4.96 (e)	3 45
7	Kennett Development	220,000	1,217,600,000	1,070,000,000	220,000	Power Plant	Annual 70% load factor 81 5%–108 2% annual variation	200				

(a) Seasonal indicates mainly spring and summer power.
"40%–130% annual variation" indicates variation in annual output wet and dry years
(†) *Indicates better than Kennett*
(‡) Indicates equal to Kennett
(*) Less valuable than Kennett

(b) Pacific Gas and Electric Company constructed and owns power plant. 4 2 mills = estimated cost, including taxes — amortization of district investment. Cost of amortization approximately 0 2 mills per kwh

(c) Price covers amortization of investment in plant in 35 years This equals approximately 0 24 mills per kwh.

(d) Major part of transmission capital already invested so that cost delivered not as great as 6.17 mills.

(e) Computed on basis of eliminating amortization referred to in (b) and (c) and ½ transmission cost of (d).

The purchase price for power from the California-Oregon Power Company is high, considered both from a standpoint of cost of hydro-electric power and in comparison with other contracts. At the time the contract was entered into, the Pacific Gas and Electric Company had excess transmission capacity from Cottonwood substation to Vaca-Dixon substation. It would still have this excess in lines from Vaca-Dixon to Antioch when completed for delivery of power to Antioch. For a part of the period of the contract, therefore, the added transmission cost of this power would be relatively small. This condition could not be applied to Kennett power, which in itself would require two transmission circuits The Pacific Gas and Electric Company, however, could, by coordinating its transmission lines with those from Kennett, obtain some advantage over conditions under separate operation.

The purchases from the City of San Francisco, Feather River Power Company, the California-Oregon Power Company and the Turlock Irrigation District are equal to or slightly better than Kennett in quality of power The total purchases under the contracts are practically equivalent in amount and in quality of power to Kennett power. With the adjustments for plant purchase in rates under certain contracts and for transmission capacity available in the case of the California-Oregon Power Company, the resultant value at Kennett is three and forty-five hundredths mills per kilowatt hour, and at Antioch four and ninety-six hundredths mills per kilowatt hour.

The above analysis indicates that from the standpoint of comparison with existing contracts for power, the value of electric power from Kennett under conditions of limited flood, salinity and irrigation operation would be three and forty-five hundredths mills per kilowatt hour at the power plant.

CONCLUSIONS RELATIVE TO VALUE OF KENNETT POWER OUTPUT

The value of Kennett electric power based upon the operation of the reservoir for limited flood and salinity control and irrigation, would appear from the foregoing to be approximately as follows:

Kennett delivery:	Mills per kilowatt hour
1 Based on other hydro-electric developments	2.7 to 3.3
2. Based on steam-electric costs as estimated	3.34 to 3.68
3 Based on existing contracts	3.45

From the present indications as to future economic conditions, the revenue that may be obtained from the sale of the electric power output of Kennett at the plant may not be expected to exceed $4,250,000 and at the terminal transmission near the Bay district not to exceed $5,300,000 per annum. Changes in economic conditions in the future may tend to increase or reduce these values.

RELATION OF REVENUE FROM POWER TO ANNUAL COST OF KENNETT DEVELOPMENT

Comparison of annual costs, as set forth in Table 8, with the estimated maximum revenue from power $4,250,000 per annum, indicates that this power revenue can be expected to meet State costs, excluding amortization, with a margin of safety of approximately 8 5 per cent, or $332,000. The annual cost under Plan 3, including 40-year sinking fund amortization, will exceed the power revenue, as estimated, by $402,000. Under Plan 2, with sinking fund amortization of State bonds and exclusion of State taxes, the annual cost will exceed the revenue, as estimated, by $735,000.

VALUE OF ELECTRIC POWER OUTPUT UNDER FULL CONTROL OF KENNETT RESERVOIR FOR IRRIGATION.

As heretofore referred to, analysis of the conditions under control for irrigation indicates that in the extreme the average annual output of the Kennett development will be reduced to about 770,000,000 kilowatt hours, varying from a minimum of 550,000,000 kilowatt hours, provided a minimum head on the power plant of 200 feet can be maintained, to somewhat over 1,000,000,000 kilowatt hours The proportion of dependable power would be so reduced and the secondary power subjected to such wide fluctuation that the economic value of the composite output under present economic conditions would not exceed $2,000,000 per annum.

OTHER SOURCES OF REVENUE REQUIRED.

Power can not be expected, even under State financing, to carry much more than interest, depreciation and operating expenses of the Kennett development Other sources of revenue such as State or Federal aid, sale of water for irrigation and payments by other beneficiaries will be required to cover amortization requirements under State financing Greater aid would be required to carry the total cost in case of private development.

PLAN 3a

TRANSMISSION OF POWER BY PRIVATE COMPANIES AS COMMON CARRIERS

Plan 3a suggests that the State sell power at Kennett to individual municipalities or private resale companies and that the private companies purchasing the larger portion of the output be required under their contracts to transmit power as common carriers from Kennett for these municipalities and private companies.

The service to municipalities and private companies distributing electric energy requires extensive secondary transmission and substation systems in addition to the main trunk transmission lines considered herein; also steam-electric standby plants to insure against shortage of power in years of low precipitation and interruptions. The power requirements of such companies are at much lower load factors (between 30 and 45 per cent) than the estimated load factor of the Kennett output (70 per cent). If power were to be purchased for such service at Kennett the price per kilowatt hour, owing to the lower use per kilowatt of demand, would have to be materially higher than the average costs or values referred to under Plans 1, 2 and 3 herein. For the same reason transmission costs per kilowatt hour would be higher than the average. The costs or values per kilowatt hour heretofore referred to are not, therefore, indicative of what the charges would be for such deliveries at Kennett or of the total cost of the energy delivered to the individual municipalities. The rates now in effect for wholesale power on the systems of the existing agencies are low compared with the cost of power production and transmission on these systems. The cost of hydro-electric power from the present utilities is equal to or less than the price that could be paid wholesale for Kennett power. The State, therefore, would not receive any greater net return from such a plan than could be obtained under Plan 3.

PLAN 5

STATE DISTRIBUTION OF ELECTRIC POWER FROM KENNETT

Plan 5 contemplates State ownership of the power development, transmission lines, steam-electric standby plants and the necessary distribution system required to distribute the electric energy to the general public. This plan is a material departure from Plans 1 to 4, inclusive, and will require the investment of at least twice the capital.

It is important in considering Plan 5 that a clear perspective be had of the present and future conditions of service.

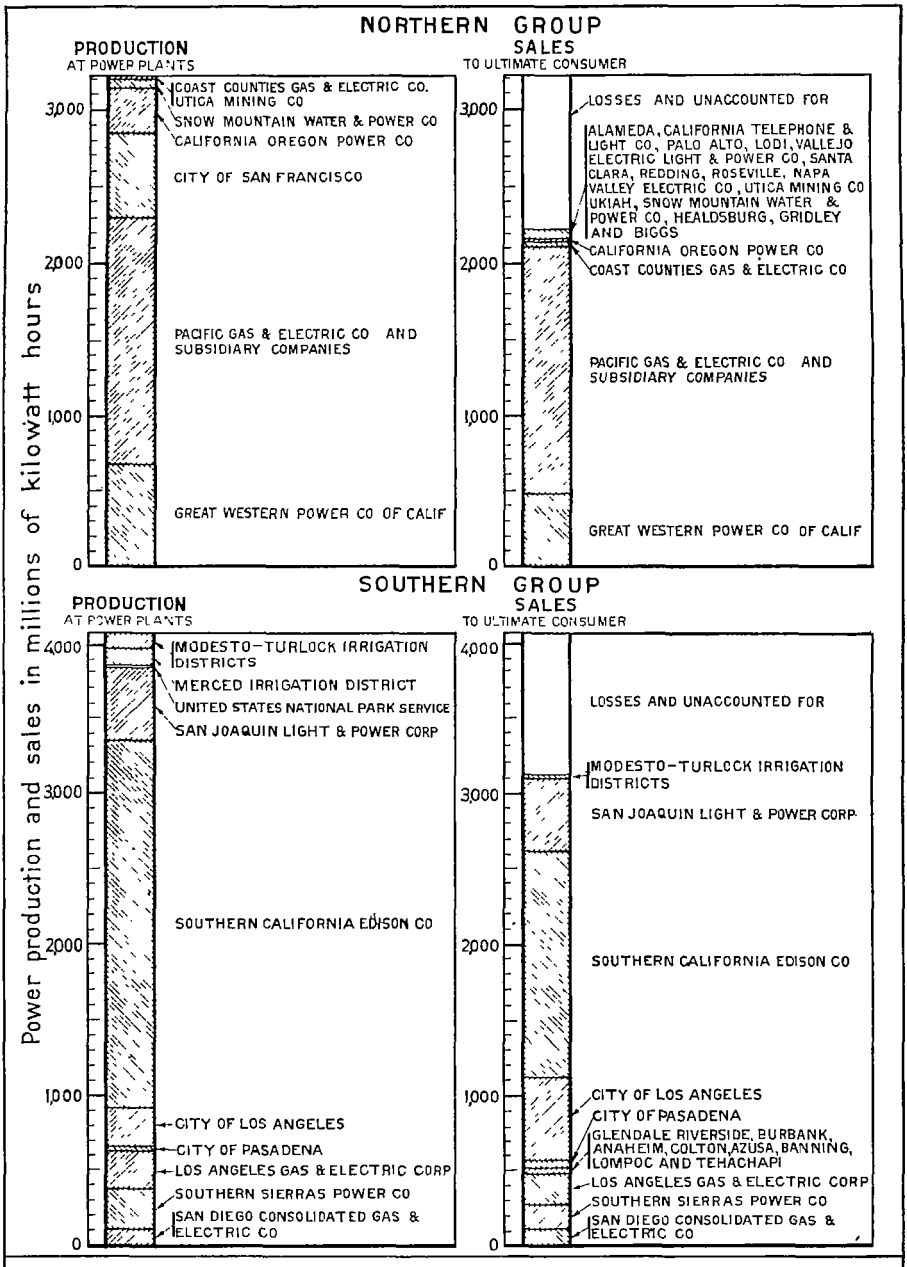
PRESENT DEVELOPMENT.

The past fifteen to twenty years of electric power development in the State have witnessed increasing consolidation of the electric utilities. Much of this has come about because of the possible economies from coordination and consolidation of the existing systems. This condition has developed to a greater extent in California than in many other states.

The market tributary to Kennett development is at present served by two main agencies supplying directly to the ultimate consumers 72 and 22 per cent, respectively, of the total load. At the time Kennett power would be available the entire market would be served by the existing agencies whose cost of power as far as production and transmission to the center of the market are concerned, is equal to or less than the cost that may be incurred by the State in the development of Kennett and no greater than the price the private utilities could pay for Kennett output in total. Plate VIII, "Electric Power Production and Sales by Companies in California, 1927," sets forth graphically the division of the market as indicated by production and sales by companies and political subdivisions for the northern and southern groups of the State for the year 1927. The relative extent of service by the various agencies in the northern part of the State is to be noted

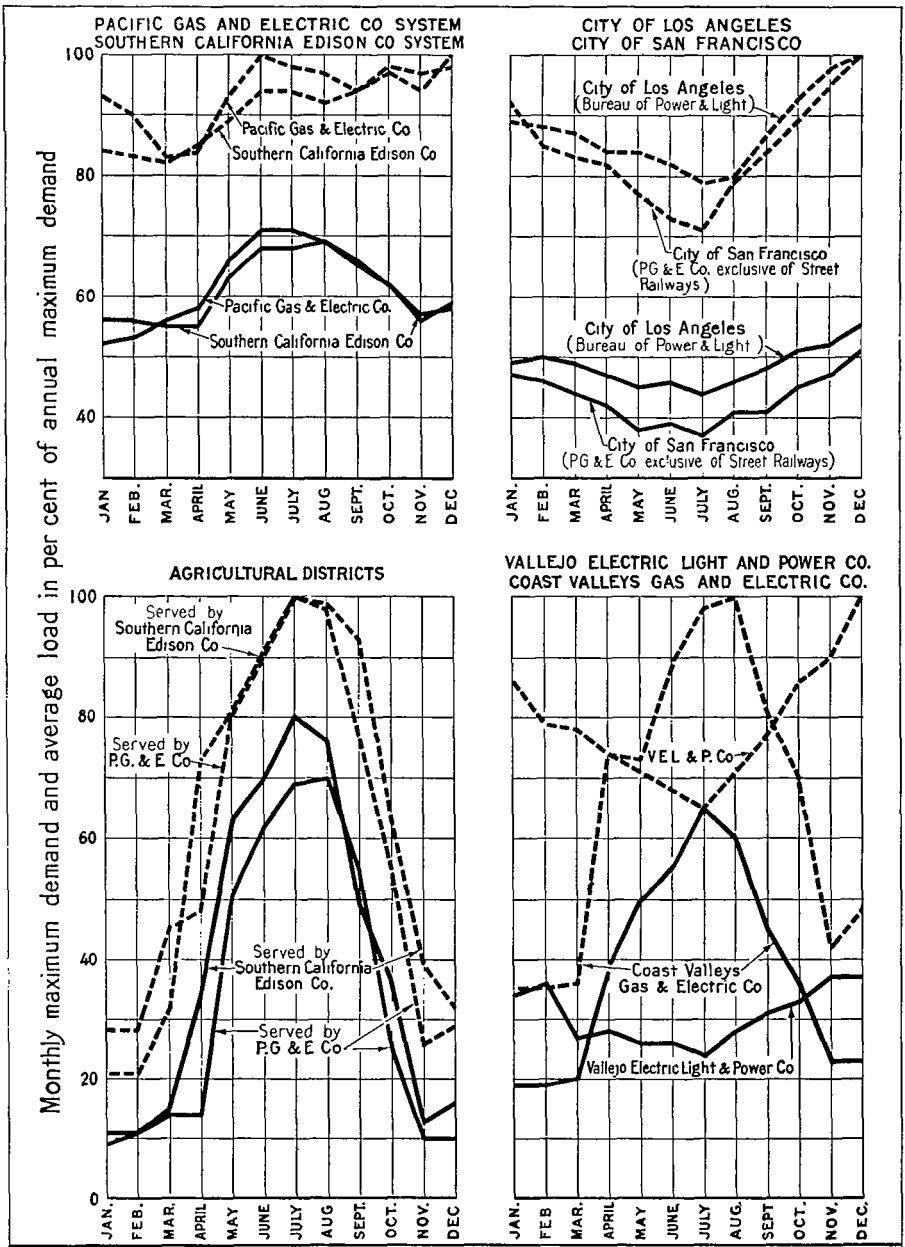
Plate IX, "Monthly Variation of Maximum Demand and Average Load for Typical Electric Power Systems in California, 1927," sets forth graphically some of the typical characteristics of the power demands of urban and rural territory. The upper right-hand chart indicates in percentage of the annual maximum requirement the variation in demand and energy requirements by months for two typical urban districts The average use is approximately 45 to 50 per cent of the maximum demand and use is least in summer and greatest in winter. The lower left-hand chart gives characteristics of power for typical agricultural districts with their wide variation in demand and energy requirements, the maximum occurring generally in July, little requirement coming in winter The lower right-hand chart indicates the wide variations between urban and rural power requirements. Compared with these characteristics for urban and rural power requirements is the upper left-hand chart giving similar characteristics of two of the most extensive electric systems of the State. This type of load is available to a development such as Kennett if its power were wholesaled to the existing agencies. Any one of the separate classes of service or districts could not supply a market which would readily

PLATE VIII.



ELECTRIC POWER PRODUCTION AND SALES
BY
COMPANIES AND POLITICAL SUBDIVISIONS
IN CALIFORNIA
1927

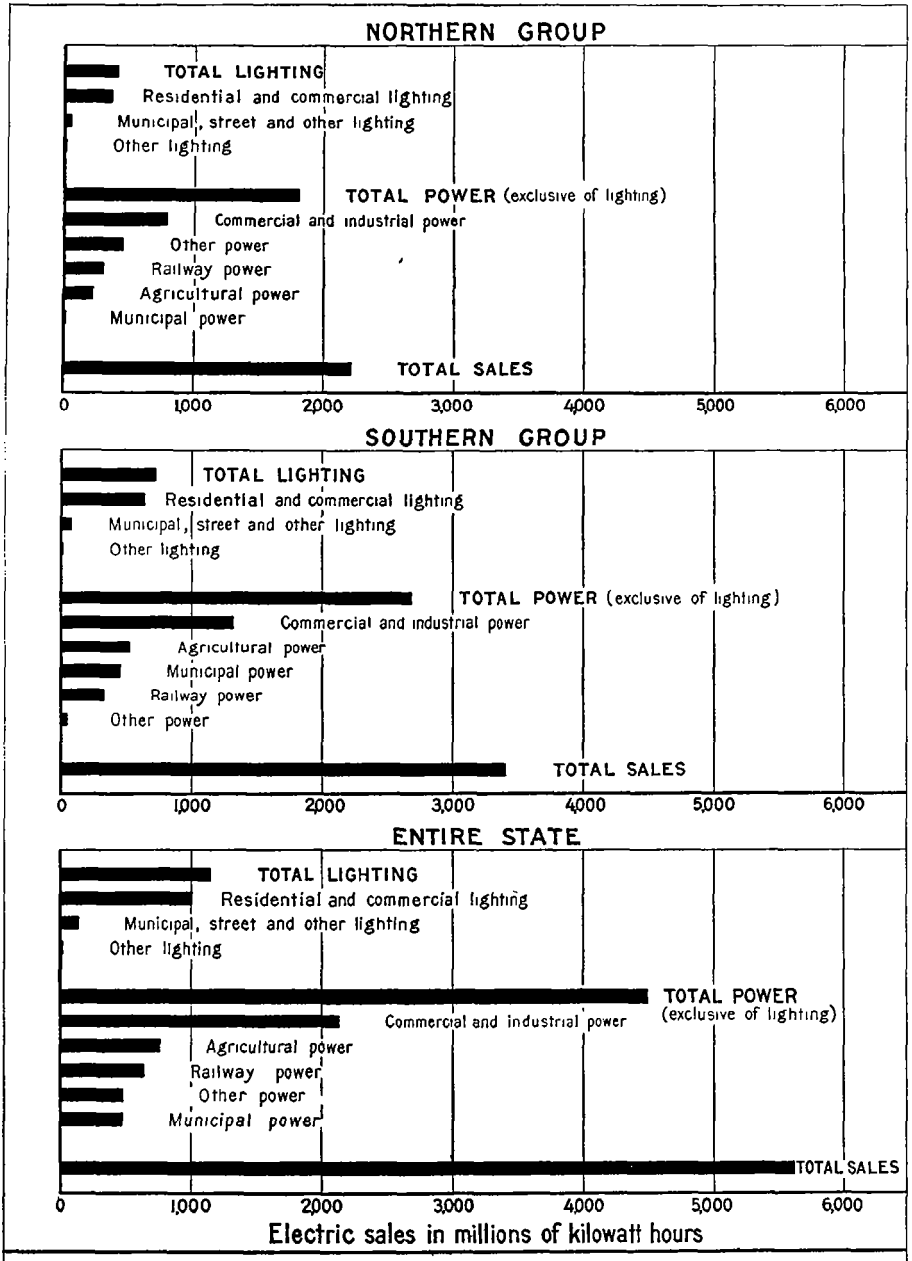
PLATE IX.



MONTHLY VARIATION OF MAXIMUM DEMAND AND AVERAGE LOAD FOR TYPICAL ELECTRIC POWER SYSTEMS IN CALIFORNIA 1927

---------- MAXIMUM DEMAND
———— AVERAGE LOAD

PLATE X.



CLASSIFICATION OF ELECTRIC SALES

IN CALIFORNIA

1927

absorb Kennett output. If power were retailed, the State must obtain a load having characteristics similar to those indicated in Plate IX for the Pacific Gas and Electric Company, otherwise its cost of service would tend to be higher than the cost on the existing two main agencies serving the territory.

Plate X, "Classification of Electric Sales in California, 1927," sets forth the relative amount of energy used for lighting and for power in the northern and southern districts of the State and in the entire State. The percentage of lighting requirements in the urban districts is much greater than in the rural districts. It is the combination of a balanced proportion of the lighting and power service that makes possible the relatively high load factor in effect on the large systems

BASIS OF PRESENT RATES.

The electric rates in California at present in effect are fixed to return to the utilities after all reasonable operating costs and allowances for depreciation are made an amount representing from 7 to 7.5 per cent upon the reasonable cost of used and useful property. The return resulting is available for the payment of fixed charges such as bond interest and dividends on stock. The return also covers compensation for any hazard in the business in the way of heavy losses, general depreciation of business, etc. Uniform rates for the several classes of service have been fixed over the larger systems and at present the rates are practically the same over the entire northern portion of the state, except residential and commercial lighting rates. Rates for these latter services are lower in the cities than in rural districts. The rates in general have been fixed, however, to give the developing and rural districts (especially agricultural service) the major portion of the advantage of the diversity of load characteristics between rural and city service. This basis of rates has materially assisted in the development of rural and agricultural districts, and of the State as a whole. It has been made possible only through ownership and operation by a few agencies of the production, transmission and, especially, distribution systems serving both districts. It has, however, resulted in somewhat higher earnings on local investment in congested and developed districts than on the average

VARIATION IN COST OF ELECTRICITY.

Plate XI, "Graphic Presentation of Source of Cost of Electricity," has been included to give a general visualization of the relative cost of electric energy at different points on the power system. This plate is based upon an analysis of the costs in 1923 on one of the largest systems in California. The average costs per kilowatt hour are shown at different points on the production and transmission systems and for deliveries to different classes of service. Although the costs indicated are not directly applicable to the conditions in northern California in 1928, they are sufficiently close to present costs to be used for qualitative analysis.

The average cost of 0.374 cent per kilowatt hour from hydro-electric plants is close to that existing on the main systems of northern California at the present time. Many of the hydro-electric plants are closer to the market than the Pit River or Kennett development, and this cost represents practically the equivalent value to Kennett power when weight is given to the difference in location relative to the market.

In this plate, the steam-electric standby service has been assumed to be delivered after secondary transmission and just prior to delivery to the distribution substation The figure of 0.752 cent per kilowatt hour, cost at intake of substation, is therefore not comparable to the value of approximately five mills per kilowatt hour heretofore set forth for delivery at the terminal of the main transmission line near Antioch. The larger figure is due to the cost of extensive secondary transmission systems. The average of 0.836 cent per kilowatt hour represents the average cost of the combined hydro-electric and steam-electric power delivered from the secondary transmission or distribution substations. Beyond this point, the average costs are shown for wholesale power delivery to large industries, and resale to private and municipal companies and retail delivery to general power consumers and to the residential and commercial lighting consumers.

Study of the rates fixed by the Railroad Commission for the various classes of service indicates that the resultant average revenues from the several classes of services agree fairly closely with the average costs as indicated in Plate XI.

PROBLEMS INVOLVED IN PLAN 5.

Table 14, heretofore referred to, indicates that complete utilization of the Kennett output would require the development, measured at main transmission terminals, of a load of 1,275,000,000 kilowatt hours annually, or 26 per cent of the total estimated load for the entire tributary market in 1936.

From consideration of the characteristics of the power requirements of urban and rural territory, it is apparent that to distribute the output of the plant readily and economically will require a market to be developed having a balanced percentage of both urban and rural service.

There are only two means of developing a market for the output of the plant under this plan:

1. Competition with and duplication of existing systems
2. Condemnation of sufficient of the existing agencies' systems, either directly by the State or by political subdivisions to make such a market available.

COMPETITION WITH AND DUPLICATION OF EXISTING SYSTEMS.

Competition would involve duplication of facilities, both in rural and urban districts, over a considerable portion of the entire northern part of the State in order to obtain a balanced market. Separately, neither rural nor urban districts would furnish a market that could readily absorb the output. On the basis of a division of the load in the competitive field equally between existing agencies and the State, the competition would have to be extended over nearly half of the market.

The procedure of obtaining a market by competition with a duplication of existing systems with its economic losses, is so far from being economically sound that it should not be given any further consideration.

CONDEMNATION OF EXISTING SYSTEMS.

Service of power load independently of existing agencies by condemnation or duplication of parts of their systems will require a greater expenditure for production and transmission capital than in the case

of the wholesaling of power as heretofore estimated. Kennett development, being located some 200 miles from the general market, would require additional transmission circuits and primary substations if operated independently of the existing systems and steam-electric standby capacity somewhat in excess of that indicated for comparative purposes in Table 14 In addition, secondary transmission lines and distribution systems would be required Analysis of costs under Plans 1, 2, 3 and 4 has been based upon operating the plant as a part of a large coordinated system under which conditions the minimum of transmission capital would be required. The approximate capital investment for production, trunk transmission and steam-electric standby to serve the entire output of the plant, as estimated in Table 14, would have to be increased to at least the following:

Kennett reservoir and plant	$70,000,000
Main transmission line to terminal substations, three circuits	10,000,000
Substations	5,000,000
Steam-electric plant capacity for standby, 100,000 kilowatts	11,000,000
Total	$96,000,000

This does not include any amount for secondary transmission and distribution. The cost of secondary transmission and distributing systems necessary to market the load will depend upon what portions of the territory the State would choose to serve; the price that would have to be paid for the existing systems for both tangible properties and intangible values and severance damages; and the length of time required to purchase the systems.

Delays in obtaining a market could be expected, for condemnation proceedings at the best are slow. There is, therefore, a probability that the necessary distribution systems serving a sufficient market would not be available upon the completion of Kennett development It is also doubtful whether certain districts would favor State ownership and operation as against local operation or a continuation of private service under regulation. A considerable development period, therefore, could be expected.

There are no criteria for estimating the prices that would have to be paid for secondary transmission and distribution systems and business of the existing utilities. Some indication of the cost may be obtained, however, from analysis of the cost of the physical property of existing systems. Study of the valuation of these properties indicates that the cost of secondary transmission and distribution systems in urban districts averages approximately $90 per thousand kilowatt hours of annual output of main substations. For rural systems it averages from $50 to $60, and for the combination as represented by the larger ultilities, approximately $65 per thousand kilowatt hours per annum of main substation output. On the basis of an average of $65 per thousand kilowatt hours annual delivery, capital expenditure for the physical plant required for distribution of Kennett power would be between $80,000,000 and $85,000,000. This, added to the cost of Kennett development, including trunk transmission lines and steam auxiliary plant, would make a total of approximately $180,000,000. To this would have to be added payments for going concern value and severance damages.

It is readily apparent that if the State were to go as far into the ownership and operation of distribution systems as would be necessary

to load a development such as Kennett, it would have to meet the growing demands of the territory being served. This would require continual outlay of capital for added power plants, transmission lines and distribution systems.

The minimum initial bond issue under Plan 5 would have to be not less than $200,000,000.

Disposition of power by wholesaling to municipalities for resale in urban districts and by State distribution in rural territory would not benefit the state as a producer of power beyond that under plans 3 or 4. Power sold to munipicalities would have to be at rates equal to or less than private utility rates to meet the competitive market. This, as has been indicated in discussing Plan 3a, would result in no benefits over plans 3 or 4. Distribution of power in rural districts would add no extra return to the State, for this service is rendered at the present time at rates justified only by the combination of distribution in both urban and rural districts.

POSSIBLE ECONOMIES UNDER PLAN 5.

The present utility rates are based on the utility as a whole making a reasonable return after operating expenses. No added economy in operating expenses could be expected under State ownership and operation over private ownership, and, at least during the transition period until adequate State machinery had been perfected for taking over and operating such a large utility, there would be a tendency for even higher operating costs Taxes which might be eliminated in the case of State ownership would represent no actual saving to the State except possibly as a temporary condition in the case of federal tax, as the income to the State from taxes would be reduced by an amount equivalent to the reduction in operating costs of the electric system resulting from elimination of taxes. The source of possible economy under State ownership is represented in the difference between the rate allowed the private companies for return and depreciation annuity and the comparable cost to the State. The cost to the State must include not only the actual payment for interest and depreciation annuity but also the cost of contingencies and hazards, which is covered in the return allowed the private companies. These hazards and contingencies may be classified as heavy losses due to earthquakes, floods, extensive failures of structures, the general obsolescence of the service as a whole and periods of economic depression.

The cost of these hazards is not subject to any exact determination. Rates of return allowed private companies are in some cases as much as 1 per cent above the theoretical cost of money. Many of the steam and electric railroads have experienced an obsolescence of service that has made impossible an earning much in excess of the operating expenses of the properties. This same condition might occur in the case of power systems. The return over theoretical cost and obsolescence of service of other utilities can be considered only as indicative of the possible extent of hazards.

The apparent differential, as indicated by the comparison of rate of return, on the one hand and rate of interest, on the other is considerably in excess of the net differential. Differences in depreciation rates

will reduce the differential approximately 0.6 per cent. It is doubtful whether the net differential in rate would equal 1.5 per cent per annum as applied to the problem herein considered.

The differential in the case of complete State distribution of power from Kennett development would be largely offset by the fixed charges on the extra cost over the rate base for private utilities which would probably be incurred in connection with development of a market and the payment for severance damages and intangibles.

If distribution in urban districts were not handled by the State but confined to rural districts, the differential would be applicable to secondary transmission and rural distribution capital In this case little or no saving would be actually available on account of the relatively low present rates in effect in rural districts.

It is doubtful if Plan 5 would assist sufficiently in carrying Kennett development to justify the added capital expenditures and service obligations that would be required of the State.

LIST OF POWER PLANTS IN CALIFORNIA, 1927. DELINEATED ON PLATE I

Group	*System*	*Company and plant*	*Classification*	*Index number*
Northern	I	CALIFORNIA OREGON POWER CO		
		Fall Creek	Hydro-electric	1
		Copco No 1	Hydro-electric	2
		Copco No 2	Hydro-electric	3
		Shasta River	Hydro-electric	4
		Headlight	Hydro-electric	5
Northern	I	PACIFIC GAS AND ELECTRIC CO. AND ITS SUBSIDIARY COMPANIES		
		Pit No 1	Hydro-electric	6
		Pit No. 3	Hydro-electric	7
		Hat Creek No 1	Hydro-electric	8
		Hat Creek No. 2	Hydro-electric	9
		Eureka	Steam-electric	10
		Junction City	Hydro-electric	11
		Kilarc	Hydro-electric	12
		Cow Creek	Hydro-electric	13
		Volta	Hydro-electric	14
		Coleman	Hydro-electric	15
		Inskip	Hydro-electric	16
		South	Hydro-electric	17
		De Sabla	Hydro-electric	18
		Centerville	Hydro-electric	19
		Lime Saddle	Hydro-electric	20
		Coal Canyon	Hydro-electric	21
		Bullards Bar	Hydro-electric	22
		Colgate	Hydro-electric	23
		Spaulding No 1 and No. 2	Hydro-electric	24
		Deer Creek	Hydro-electric	25
		Drum	Hydro-electric	26
		Alta	Hydro-electric	27
		Halsey	Hydro-electric	28
		Wise	Hydro-electric	29
		El Dorado	Hydro-electric	30
		American River	Hydro-electric	31
		Folsom	Hydro-electric	32
		Sacramento, Station "B"	Steam-electric	33
		Electra	Hydro-electric	34
		Spring Gap	Hydro-electric	35
		Stanislaus	Hydro-electric	36
		Phoenix	Hydro-electric	37
		Melones	Hydro-electric	38
		Stockton	Steam-electric	39
		North Beach	Steam-electric	40
		San Francisco, Station "A"	Steam-electric	41
		Oakland, Station "C"	Steam-electric	42
		Monterey	Steam-electric	43
Northern	I	CITY OF SAN FRANCISCO		
		Cherry Creek	Hydro-electric	44
		Moccasin Creek	Hydro-electric	45
Northern	I	SNOW MOUNTAIN WATER AND POWER CO.		
		Potter Valley	Hydro-electric	46
Northern	I	UTICA MINING CO		
		Murphy	Hydro-electric	47
		Angels	Hydro-electric	48
Northern	I	COAST COUNTIES GAS AND ELECTRIC CO		
		Big Creek (Swanton)	Hydro-electric	49
		Santa Cruz	Steam-electric	50
Northern	I	SOUTH SAN JOAQUIN AND OAKDALE IRRIGATION DISTRICTS		
		Melones Mine	Hydro-electric	51
Northern	I	WEST SIDE LUMBER CO.		
		Tuolumne	Steam-electric	52
Northern	I	TRUCKEE RIVER POWER CO		
		Farad	Hydro-electric	53
Northern	II–a	GREAT WESTERN POWER CO OF CALIFORNIA		
		Caribou	Hydro-electric	54
		Bucks Creek	Hydro-electric	55
		Las Plumas	Hydro-electric	56
		North Beach	Steam-electric	57
		Phelan	Steam-electric	58
		Bush	Steam-electric	59
		Oakland	Steam-electric	60

Group	System	Company and plant	Classification	Index number
Southern	II–b	SAN JOAQUIN LIGHT AND POWER CORPORATION		
		Kittridge	Hydro-electric	61
		Mountain King	Hydro-electric	62
		Merced Falls	Hydro-electric	63
		Crane Valley	Hydro-electric	64
		San Joaquin No 1	Hydro-electric	65
		San Joaquin No 1–A	Hydro-electric	66
		San Joaquin No. 2	Hydro-electric	67
		San Joaquin No. 3	Hydro-electric	68
		Kerckhoff	Hydro-electric	69
		Balch	Hydro-electric	70
		Tule River	Hydro-electric	71
		Kern Canyon	Hydro-electric	72
		Bakersfield	Steam-electric	73
		Midway	Steam-electric	74
		Betteravia	Steam-electric	75
Southern	II–b	MERCED IRRIGATION DISTRICT		
		Exchequer	Hydro-electric	76
Southern	II–b	TURLOCK AND MODESTO IRRIGATION DISTRICTS		
		Don Pedro	Hydro-electric	77
		La Grange	Hydro-electric	78
		Modesto	Steam-electric	79
Southern	II–b	UNITED STATES NATIONAL PARK SERVICE		
		Yosemite Park	Hydro-electric	80
Southern	III	SOUTHERN CALIFORNIA EDISON CO		
		Big Creek No 1	Hydro-electric	81
		Big Creek No. 2	Hydro-electric	82
		Big Creek No. 2–A	Hydro-electric	83
		Big Creek No. 3	Hydro-electric	84
		Big Creek No 8	Hydro-electric	85
		Kaweah No 1	Hydro-electric	86
		Kaweah No. 2	Hydro-electric	87
		Kaweah No. 3	Hydro-electric	88
		Visalia	Steam-electric	89
		Tule River	Hydro-electric	90
		Kern River No 3	Hydro-electric	91
		Borel	Hydro-electric	92
		Kern River No 1	Hydro-electric	93
		Azusa	Hydro-electric	94
		Sierra	Hydro-electric	95
		Lytle Creek	Hydro-electric	96
		Fontana	Hydro-electric	97
		Santa Ana No 1	Hydro-electric	98
		Santa Ana No. 2	Hydro-electric	99
		Santa Ana No 3	Hydro-electric	100
		Mill Creek No 1	Hydro-electric	101
		Mill Creek No. 2–3	Hydro-electric	102
		Redondo	Steam-electric	103
		Long Beach	Steam-electric	104
		San Antonio Creek No 1	Hydro-electric	105
		San Antonio Creek No 2	Hydro-electric	106
		San Antonio Creek No 3	Hydro-electric	107
Southern	III	CITY OF LOS ANGELES		
		Big Pine No 3	Hydro-electric	108
		Division Creek No 1	Hydro-electric	109
		Division Creek No 2	Hydro-electric	110
		Cottonwood No 1	Hydro-electric	111
		Haiwee	Hydro-electric	112
		San Francisquito No 1	Hydro-electric	113
		San Francisquito No. 2	Hydro-electric	114
		San Fernando	Hydro-electric	115
		River Power	Hydro-electric	116
		Franklin Canyon	Hydro-electric	117
Southern	III	CITY OF PASADENA		
		Pasadena	Steam-electric	118
Southern	IV	LOS ANGELES GAS AND ELECTRIC CORPORATION		
		Alameda Street	Steam-electric	119
		Seal Beach	Steam-electric	120
Southern	IV	SOUTHERN SIERRAS POWER CO		
		Mill Creek	Hydro-electric	121
		Poole (Leevining Creek No 1)	Hydro-electric	122
		Leevining Creek No 3	Hydro-electric	123
		Rush Creek	Hydro-electric	124
		Adams auxiliary	Hydro-electric	125
		Adams main	Hydro-electric	126
		Bishop Creek No. 2	Hydro-electric	127
		Bishop Creek No 3	Hydro-electric	128

Group	System	Company and plant	Classification	Index number
Southern	IV	SOUTHERN SIERRAS POWER CO —Continued.		
		Bishop Creek No 4	Hydro-electric	129
		Bishop Creep No. 5	Hydro-electric	130
		Bishop Creek No 6	Hydro-electric	131
		San Bernardino	Steam-electric	132
		San Gorgonio No 1	Hydro-electric	133
		San Gorgonio No 2	Hydro-electric	134
		Blythe	Gas-electric	135
		El Centro	Steam-electric	136
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		Vaca-Dixon	A
		Contra Costa	B
		Newark	C
Northern	II–a	GREAT WESTERN POWER CO OF CALIFORNIA	
		Antioch	D
		Golden Gate	E
		Brighton	F
Southern	II–b	SAN JOAQUIN LIGHT AND POWER CORPORATION	
		Wilson	G
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		Vestal	H
		Eagle Rock	I
		Laguna Bell	J
		Lighthipe	K

EXHIBIT "C"

REPORT OF THOS. H. MEANS,

Consulting Engineer

ON SALT WATER PROBLEMS OF SAN FRANCISCO BAY AND DELTA.

THOS. H. MEANS
CONSULTING ENGINEER
216 Pine Street
SAN FRANCISCO

Telephone Sutter 78

June 15, 1928.

Association of Industrial Water Users of Contra Costa and Solano Counties.

Dear Sirs:

Statements in this report on pages 39, 51, 56, 63 and 69 concerning the proposed Southern Pacific Railroad's Suisun Bay Bridge, located near Army Point, were published before the plans of that company were made public. The information now available shows that the site selected for the railroad bridge lies from 800 to 1800 feet above the location for the Salt Water barrier selected by Mr. Young. The plans for the bridge provide for piers founded on rock over both the waterway and marsh areas. The experiences of the railroad do not favor the location of the tracks upon rock fill dikes, as proposed by Mr. Young, but would require piers to rock throughout the length of the structure. According to estimates by the railroad company's engineer, the saving in cost by combining the railroad bridge with the barrier under these conditions would be small and the disadvantage of having the lift span located close to locks, where the movement of vessels is slow, serves to offset any saving in cost.

The railroad bridge as planned provides for a bridge giving a clearance of 70 feet (as compared with 50 feet in Young's plans), a height great enough to permit the free passage of river boats. The lift span will be used for ocean-going vessels Piers are spaced 413 feet on centers and foundations in all cases will be carried to bedrock. The construction of the barrier as proposed by Young will not be interfered with if this site is selected.

The estimated cost of the bridge now proposed is about $6,400,000, exclusive of approaches, track, etc.

There is no advantage to be gained by a combined structure unless the result is in decreased cost to both barrier and railroad. Since there is apparently no such advantage to be gained and the bridge will not interfere with the barrier if the Army Point site is located, I suggest that this letter be attached to my report in correction of the statements made therein.

Very truly yours,

THOS H. MEANS.

PREFACE

The following report by Engineer Thos. H Means was financed by the Association of Industrial Water Users of Contra Costa and Solano counties.

The only instructions given Mr. Means in preparing this report were to get the facts, and it is hoped that this document will be of benefit in establishing some of the facts relating to the proposed Salt Water barrier as designed by Engineer Walker R. Young.

The following firms are members of the Association.

American Smelting & Refining Co.
Associated Oil Company
Atchison, Topeka & Santa Fe Railway Co.
F. E. Booth Company
California-Hawaiian Sugar Refinery
Columbia Steel Corp.
Coos Bay Lumber Co.
Fibreboard Products, Inc.
General Chemical Co.
Great Western Electro Chemical Co.
C. A. Hooper & Co.
Johns-Manville, Inc.
Kullman-Salz & Co.
Mountain Copper Co.
Pioneer Rubber Mills
Redwood Manufacturers Co.
San Francisco & Sacramento R. R.
Shell Company of California
Southern Pacific Company
Union Oil Company

ASSOCIATION OF INDUSTRIAL WATER USERS
OF CONTRA COSTA AND SOLANO COUNTIES.
C. W. SCHEDLER, *Chairman.*

PENETRATION OF SALT WATER IN UPPER BAY AND LOWER RIVER REGION

Under natural conditions, Carquinez Straits marked, approximately, the boundary between salt and fresh water in the upper San Francisco Bay and delta region of the two tributary rivers—the Sacramento and San Joaquin. Ordinarily salt water was present below the straits and fresh water was present above. Native vegetation in the tide marshes was predominantly of salt water types around San Pablo Bay and of fresh water types around Suisun Bay.

In tidal waters, into which run fresh water streams of variable flow, there is an ebb and flow of salt water and the zone of mixing will move up and down stream as the fresh water flow increases and decreases. For short intervals in late summer of years of minimum flow, salt water penetrated the lower river and delta region, and in wet seasons the upper bay was fresh, part of the time, to the Golden Gate This variation in quality of water was not, however, of sufficient duration to affect the characteristic vegetation growth of the regions on each side of the straits, nor to change the designation of Suisun Bay as ordinarily a fresh water body and San Francisco Bay as salt water.

The works of man have changed conditions in many ways. The most important changes have been brought about gradually—so slowly as to be hardly noticeable. The dry season of 1918—when large summer diversions for irrigation in the Sacramento Valley resulted in the sudden penetration of salt water farther upstream than ever known before, at such an early period in summer—first brought the salt water problem to public notice The slow effects of increasing diversions in previous years had escaped notice, but were brought prominently to the attention of the inhabitants of the upper bay and delta regions in this year. Since 1918, the dry years of 1920, 1924 and 1926 have more convincingly demonstrated the importance of the salt water problem.

An accurate picture of natural conditions is not possible, because no records have been collected on which such a picture can be based, but very close approximations can be made. The log of the distance traveled by the water barge of the California-Hawaiian Sugar Company in going upstream to obtain fresh water has been kept since 1908. These figures give the means of determining approximately the conditions during that period. In 1908 irrigation had been extensively developed in both valleys and conditions then were not natural. For an estimate of earlier conditions we must go to the stream flow records of the tributary streams before important diversions are taken out.

It is the practice of the sugar company to send the barge upstream until water of approximately 50 to 70 parts per million chlorine is reached. The crew of the barge are equipped with apparatus by which water is analyzed until this degree of purity is reached. Since trips are made nearly every day during the summer months, the record is a very good indication of the point reached by salt water. A summary of the complete records shows the fluctuation of the line between fresh and salt water. Records of the sugar company are attached. (Table 1)

The Sugar Company requires water of great purity. For irrigation, domestic or ordinary industrial uses, water of a lesser degree of purity may be used A comparison of the point where the sugar company's

barge is filled with the point where the remaining uses could be satisfied, indicates that from five to ten miles downstream from the place where the barge turns, water could be obtained satisfactory for domestic supply. Making an allowance of 7½ miles in the average records, we find that an average flow of 5000 second-feet in both streams will maintain fresh water at Collinsville; 7000 second-feet will maintain fresh water at the San Francisco-Sacramento ferry.

If we sum up the flow of the important tributaries of the Sacramento and San Joaquin rivers at the points where these streams leave the mountains and assume that this flow under natural conditions would have reached the head of the Suisun Bay, we will find that at no time in the past ten years would the average monthly flow have been less than 5100 second-feet. It is probable, should all streams be running in a natural way, that salt water would have penetrated no farther in this extremely dry period than Antioch, and then only for a few days at a time.

It is not possible to make a more detailed study of this condition without making a number of assumptions as to speed of flow from the gaging stations to the head of the bay, and there is little accurate information on which the assumptions may be made. The definite statement that salt water under natural conditions did not penetrate higher upstream than the mouth of the river, except in the driest years and then only for a few days at a time, is warranted. (See Table 2 for monthly flow of tributary streams.)

At present salt water reaches Antioch every year, in two-thirds of the years running further upstream. It is to be expected that it will continue to do so in future, even in years of greatest run-off. In other words, the penetration of salt water has become a permanent phenomenon in the lower river region.

Cause of Change in Salt Water Conditions.

The cause of this change in the salt water condition is due almost entirely to the works of man. If natural changes have had any effect, it is too small to be measured. The most important natural condition is the sequence of dry and wet periods. Since 1917 the state has experienced dry years with low run-off in nearly all streams. During this period two years have exceeded normal stream flow in some streams (1921 and 1927). In each of these years excessive salinity (over 100 parts chlorine per 100,000) was present at Antioch about two months.

Irrigation

Storage and diversion of water have been the principal causes of salinity increase in the upper bay country. The area irrigated varies from year to year; in 1926 the acreage of lands on the floor of the valley was approximately as follows:

Estimate of Diversions and Area Irrigated 1926—Sacramento and San Joaquin Valleys, Not Including Mountain Areas

	Acre-feet diverted	*Acres irrigated*
Sacramento and tributaries above Sacramento, including rice, 128,439 acres	1,644,973	235,995
Delta uplands	146,906	53,649
Delta area	———	264,479
San Joaquin Valley estimated	2,100,000	700,000
	3,891,879	1,254,123

In addition to this area on the valley floor, there is a large acreage in the mountains which uses water from the streams tributary to the rivers that drain through Suisun Bay. The acreage irrigated in the mountains is not so accurately known as the area on the valley floor, but it is large and, particularly in low flow seasons, very effectively uses up the water in the streams. The use of the water in the mountains is usually more economical than in the valley and the return seepage is less. The net effect is to consume all the water diverted. The effect upon the flow is pronounced.

The latest accurate determination of area irrigated is that made by the United State Census.

Irrigation in California

Census of 1920

	1902	*1919*	*1920* *Area in enterprises*	*1920* *Area capable of irrigation*
Sacramento River and tributaries	206,312	640,950	1,204,769	864,605
Sacramento River direct	10,942	104,397	439,169	296,748
Pit River	72,072	89,984	129,984	107,478
Cow Creek	2,321	6,068	12,488	7,446
Cottonwood Creek	1,858	2,972	21,016	4,112
Battle Creek	2,642	2,966	6,590	5,108
Stony Creek	4,110	23,559	45,143	36,191
Feather River	67,111	142,841	186,756	167,463
Yuba River	Not Rep.	19,473	69,074	23,492
Cache Creek	3,756	24,541	56,498	31,212
American River	10,112	47,156	82,695	52,842
Other tributaries	31,388	86,993	155,356	132,513
San Joaquin River and tributaries	220,651	1,069,161	2,072,739	1,497,661
San Joaquin River direct	129,647	642,261	1,083,862	873,300
Fresno River	10,729	12,412	30,004	14,016
Merced River	19,636	65,151	222,715	71,709
Tuolumne River	Not Rep.	165,533	298,418	250,425
Stanislaus River	13,840	75,359	155,453	111,192
Calaveras River	Not Rep.	13,323	21,598	16,489
Mokelumne River	5,558	36,848	155,480	72,144
Cosumnes River	Not Rep.	3,259	9,011	6,405
Other tributaries	41,241	55,015	96,198	81,981

The above includes springs and wells.

Where area in watershed is not reported (not rep) it is included in other watersheds.

Records for other census periods have not been tabulated so as to be comparable.

This table shows that in the 18 years between 1902 and 1920 the area irrigated in the Sacramento Valley trebled, while in the San Joaquin Valley the increase was nearly five times as great. The area included in irrigation enterprises was only half watered in 1920, while the area capable of being irrigated was only about two-thirds watered. The total area irrigated in both watersheds was 1,710,000 acres in 1920.

No accurate records have been collected since 1920. It is known, however, that the growth of irrigation has continued, though at a slower rate than prior to 1920. Since 1920 the growth in area has been proportionately larger in the San Joaquin than in the Sacramento Valley. In the latter valley grain production (seldom irrigated) is still profitable and much land within irrigation projects goes into grain. Other crops, such as rice, vary in area with the price of rice.

United States Department of Agriculture tabulation of area in rice in California is shown below:

Acres in Rice in California

1920	162,000
1921	135,000
1922	140,000
1923	106,000
1924	90,000
1925	103,000
1926	149,000

Storage reservoirs, both for irrigation and power, have been built on many streams in the past fifteen years. Many others are planned and their construction will be undertaken within a short time. The following list of reservoirs is as complete as it is possible to make it. Small reservoirs—less than 1000 acre-feet capacity—have been omitted.

Storage Reservoirs

Golden Gate Drainage Watershed

Sacramento Basin		*Height of dam*	*Reservoir capacity, acre-feet*
Cottonwood Creek	Misselbeck Reservoir	105	5,460
Pit River	Darris Reservoir	---	12,500
Pit River	Big Sage Reservoir	---	------
Pit River	Mt. Shasta Power Co. No. 3	112	36,000
Stony Creek	East Park	139	51,000
	Stony Gorge	120	50,000
Paradise Creek	Paradise Reservoir	---	------
Battle Creek	2 Reservoirs	---	3,000
Feather River	Lake Almanor	125	1,317,000
	Bucks Creek	128	103,000
	Butte Valley	115	106,000
Yuba River	Bullards Bar	183	11,000
	Lake Francis	70	2,400
	Spalding	---	74,000
	25 Reservoirs, small	---	54,000
	Bowman being enlarged	---	------
American	4 Reservoirs	---	12,800
Mokelumne	Pardee under construction	350	200,000
	Electra System, 7 Res.	---	24,800
Stanislaus	Salt Springs, under construction	300	130,000
	Relief	140	15,000
	Strawberry	135	18,000
	Utica, 3 Reservoirs	---	8,900
	Woodward	---	36,000
	Melones	191	112,500
Tuolumne	Hetch Hetchy	---	------
	O'Shaughnessy Dam	344	206,000
	Dom Pedro	284	290,000
	Lake Eleanor	---	25,300
	Dallas Warner	---	28,000
	Davis	---	48,000
Merced	Exchequer	330	278,000
San Joaquin	Florence Lake	---	64,500
	Huntington	165	88,700
	Shaver Lake	183	138,500
	Crane Valley	150	38,000
Cache Creek	Clear Lake	---	400,000
Suisun Creek	Gordon Valley	104	10,000
Total Constructed Reservoirs			3,998,360

Projected Reservoirs (Partial List)

Sacramento	Kennett	420	2,838,000
	Iron Canyon	---	709,000
American	Folsom	220	300,000
Mokelumne	Dry Creek	140	1,200,000
Tuolumne	O'Shaughnessy, increased to	430	350,000
Total Projected Reservoirs			5,397,000

In round numbers, reservoirs of a capacity of 4,000,000 acre-feet are in use on streams tributary to San Francisco Bay above Carquinez Strait. Reservoirs of much larger capacity are being considered for future construction.

Mining Debris Mining debris and sediment in the rivers and by-pass channels have probably changed the tidal flow to a small extent, and may have affected salt water movements. The effect has been too small to measure, but it has been generally in the direction of reducing tidal prism and tidal flow where the deposits are laid down in bay waters, and of increasing tidal flow through the Golden Gate where deposited in the rivers The net change has probably been very small. Gilbert, in his report upon Hydraulic Mining Debris (U. S. G. S. Prof. Paper 105, page 87) estimates the reduction in tidal currents in Golden Gate caused by deposition of debris as 2.49 per cent.

Land Reclamation Reclamation of land by building levees has affected tidal flow and movement of salt water in two ways: first, by decreasing the tidal prism in the delta and, second, by changing the time of arrival of floods and of low water.

First, Reduction of Tidal Prism: The reduction in tidal prism by the construction of levees in the delta region and around the upper end of San Pablo Bay and around Suisun Bay has probably had the effect of slightly reducing the tidal flow through Golden Gate. As has been shown by Gilbert in the publication above referred to, the effect of leveeing in the lower river has had the tendency of increasing Golden Gate flow, while the same work in Suisun and San Pablo Bays has had the opposite effect. The net effect, however, is small and results in decreased flow. Gilbert (U. S. Geologic Survey Professional Paper 105, page 79) estimates the average percentage of the flow through Golden Gate as follows, when all marshes are leveed:

Marsh Land Areas—Average Volume Flowing Through Golden Gate Expressed in Percentage

	Per Cent
San Pablo marshes and Napa River	*1.95
Suisun Bay	†1 18
Sacramento Delta	†1 04
San Joaquin Delta	†3 35
Net effect on Golden Gate flow	†1 26

* Means decrease in tidal flow through Golden Gate
† Means increase in tidal flow through Golden Gate

Second, Change in Time of Arrival of Floods: The effect of leveeing upstream from tide lands has been to decrease the storage in basins and to increase the rate of travel in floods toward tide water. Under natural conditions the basin areas filled with water in flood time and slowly released this water in late summer, maintaining the flow well into the period of low water.

Most of these up-river basins have been leveed and floods run through the river channel and by-passes to the ocean with very little retardation by storage. There is no stored water from these basins to maintain low flow, consequently the low flow reaches the tidal channels earlier in the year than under natural conditions.

The effect of this reclamation work upon salt water conditions has been very pronounced. In the period just prior to 1918, some of the largest reclamation districts were leveed, Sutter Basin being a notable example. Prior to this closing off from flood flows these basins retained large volumes of water, sometimes until the middle of summer, the water slowly draining back into the channel. Nowadays instead of delivering water to the channel, water is taken from the channels for irrigation during the summer months. Drainage returns a small part of the irrigation water directly to the river.

Return seepage from irrigation has had the effect of increasing the low water flow in the Sacramento. Stafford, in publications of the Division of Water Rights (Biennial Report November, 1924, page 133; Sacramento-San Joaquin Water Supervisor's Report 1926, page 85) estimates the water returned to the Sacramento River as follows:

Water Returned to Sacramento River (Including All Accretions)

Flow in Second-Feet

	1924	1925	1926
July	879	----	2,280
July	734	1,624	1,573
August	785	1,320	1,240
September	634	1,310	1,077
October	---	460	----
Mean	763	1,179	1,543

Dredging, particularly in the Sacramento River, near its mouth, has had the effect of increasing the water prism, but the probable effect upon tides through Golden Gate is to decrease them. The dredging work is so far up-stream as to be on the tidal movement opposite to that in the Golden Gate.

The deepening of the channel has, further, the effect of permitting the deep flowing salt water to pass upstream with more ease through the deep channel. A like effect will probably result from deepening of Suisun Bay and San Joaquin River to Stockton, a navigation project authorized by congress.

It is not possible to measure these effects, but it is well established that salt water being heavier moves along the bottom of deep channels with greater ease than over shallow ones. Any deepening of channels or straightening of approach through dredger cuts has the tendency to facilitate the movement of the deeper waters.

Irrigation and Storage of Water in the San Joaquin Valley. Irrigation in the San Joaquin Valley has had an effect upon tidal conditions and the movement of salt water in two ways: first, by diverting and storing water during flood period, and second, by increasing the flow in late summer and fall months through return seepage.

A much larger utilization of water resources has taken place in the San Joaquin than in the Sacramento Valley. Rainfall is lighter on the floor of the valley, so dry farming has been less profitable and there is greater necessity of irrigation. All streams tributary to the bay are

now completely diverted during the low flow period and no water enters the tidal channel except return flow. This condition has been true for over ten years.

The following brief description of the streams and the irrigated area will show the extent to which the water supply has been put to use.

Upper San Joaquin. The upper San Joaquin enters the valley floor at Friant. The mean annual flow of the stream at the valley's edge averages 2,050,000 acre-feet. Storage above this point, built by the San Joaquin Light and Power Corporation and the Southern California Edison Power Company under contract with riparian owners and appropriative users of water, amounts to 330,000 acre-feet. Other storage reservoirs have been planned. Lands irrigated from the stream lie on both sides of the river and aggregate 400,000 acres. The diversion capacity of the ditches, sloughs and canals in use is very large.

Above the Merced River, canals, ditches and sloughs with control gates have a capacity in excess of 7000 second-feet. Sloughs and channels used for wild flooding increase this diversion capacity to in excess of 10,000 second-feet. Below the Merced, a number of pumps take water from the river to West Side slope. Down to Paradise Dam, about the head of tide water, these diversions total in excess of 500 second-feet.

All water entering the valley is diverted in late summer. The San Joaquin is dried above Merced for three or four months a year. Return seepage commences to "make" about the mouth of the Merced. Below that point there is always water in the channel, except for short periods of time, just below some of the larger pumping plants.

Fresno River. This stream has a small watershed area of low mountains with a mean annual flow of 68,000 acre-feet. The entire low flow is utilized around Madera and toward the San Joaquin. No return seepage makes from this area, as pumping plants have lowered the ground water plane and probably intercept nearly the entire ground water flow.

Chowchilla River. This stream has about the same area and topographic conditions in its watershed as has the Fresno. Its mean flow approximates 68,000 acre-feet. All low flow is utilized. Pumping has been heavy on its lower course. No return seepage makes from this area.

Merced River. The Merced Irrigation District and riparian lands lying above the junction with the San Joaquin utilize all low flow. The Exchequer Reservoir of the Merced District, with a storage capacity of 278,000 acre-feet, controls the stream except in wet years. The power plant at the dam delivers water into the river, when water is plentiful, in excess of the district's diverting capacity. Water always passes the district's headgate for use of lands lower down on the Merced. The mean flow of the stream is 1,330,000 acre-feet. Return seepage maintains a continuous flow at the mouth of the Merced, the water coming from both the Turlock and Merced sides of the river. This return flow now amounts to 80 to 100 second-feet in summer months and there are indications that it is increasing. Pumps along the Merced utilize a part of this return flow.

Tuolumne River. The Tuolumne drains a high mountain area and has a mean annual flow of 2,055,000 acre-feet. Three irrigation districts—the Waterford, Modesto and Turlock, with a total of 276,783

acres—divert water at the LaGrange Dam. Three storage reservoirs with capacity of 366,000 acre-feet are operated by these districts. The City of San Francisco has rights on the upper watershed for water for domestic uses and has built reservoirs of capacity of 231,000 acre-feet. A conduit of capacity of 620 second-feet is under construction. San Francisco has control of other reservoir sites and proposes, ultimately, to divert 400 million gallons daily (620 second-feet) from the watershed. To do this, storage of about 850,000 acre-feet will be required.

Return seepage in the Tuolumne, at its mouth, resulting from irrigation now amounts to from 250 to 350 second-feet constant flow. Additional seepage from these irrigated areas appears in the Merced, the Stanislaus and San Joaquin rivers.

Stanislaus River. The Stanislaus River (mean annual flow, 1,376,000 acre-feet) is under storage control for both power and irrigation. Power reservoirs with capacity built or being built of 172,000 acre-feet, high on the stream, increase the low flow, but this water is re-stored in reservoirs or diverted by the South San Joaquin and Oakdale irrigation districts. These districts, with an area of 145,548 acres, have in Melones and Woodward reservoirs a storage capacity of 148,000 acre-feet. All low flow is diverted. Return seepage in the Stanislaus River at its mouth (coming in part from the Modesto District) now varies from 100 to 160 second-feet constant flow. An additional amount enters the San Joaquin River.

Return Flow in the San Joaquin River. Return seepage in the San Joaquin River from the mouth of the Merced to Durham Ferry (just above tide water) now amounts to a continuous flow of from 600 to 1000 second-feet. About 300 second-feet of this water is diverted above tide water by pumps irrigating West Side lands. Additional pumps recently installed or in process of installation and pumps diverting from the tidal portion of the stream have a combined capacity of between 750 and 800 second-feet. In the peak of the irrigating season these West Side pumps divert practically all of the visible flow in the San Joaquin River. The delta lands and islands are dependent upon ground water flow and such water as flows down the Calaveras, Mokelumne and connecting sloughs from the Sacramento River.

NET RESULT OF IRRIGATION AND STORAGE ON SALT WATER PROBLEM

Summarizing former statements upon the effect of irrigation and storage upon the flow of salt water in the lower river and upper bay region, the following may be said:

1. Under natural conditions the boundary between salt and fresh water was Carquinez Straits. In late summer, Suisun Bay became brackish but salt water penetrated as far as Antioch only rarely and then for but a few days' time.

2. The combined effects of irrigation and diversion in the Sacramento Valley have been to reduce the flow entering tidal waters to a small fraction of the flow under natural conditions. In 1924 the flow at Sacramento was about 720 second-feet and was below 1000 second-feet for in excess of a month. In 1925 the flow at Sacramento reached a minimum of 2750 second-feet and was below 3000 for nearly a month. In 1926 the flow of the Sacramento reached a minimum of 1200 second-feet and was below 2000 for over a month.

3. The late summer flow of the San Joaquin (all return seepage) has been below 1000 second-feet in all years except 1927. The capacity of pumping plants irrigating West Side lands exceeds the inflow nearly every summer, so that, so far as visible flow in the San Joaquin is concerned, all of the late summer inflow into tidal channels is used on West Side area. The delta lands now must obtain their supply from the water stored in channels or which flows underground, or from the Calaveras, Mokelumne, and sloughs connecting with the Sacramento River.

4. The use of water by the delta lands on both San Joaquin and Sacramento rivers has not been accurately determined The area irrigated amounts to 360,000 acres. If this area consumes $1\frac{3}{4}$ acre-feet of water per annum, of which 20 per cent is used in a month, the consumptive draft will be at the rate of 2100 second-feet. This quantity exceeds the low flow in years of light rain.

PRESENT CONDITIONS OF SALT WATER IN UPPER BAY AND LOWER RIVER REGIONS

Salt water conditions have been under observation by the Division of Water Rights of the Department of Public Works since 1917. Results have been published in the annual reports of this division. Earlier records of much value in the study of the problem are those of the California-Hawaiian Sugar Company, referred to earlier in this report, covering the period from 1908 to 1920. In 1920 the Sugar Company obtained a supply from the Marin Municipal Water District at San Quentin Point, approximately 15 miles from Crockett. Since then, when the distance traveled upstream to fresh water is less than 15 miles, the water is taken from the river; when the distance exceeds 15 miles, the Marin County water is used.

A number of other investigations of salt water conditions have been collected at various places and are of help in the determination of the changes which have taken place in recent years. Among these records are those collected by Mr. William Pierce north of Suisun Slough, on the north side of Suisun Bay; records for a short period by the Pacific Portland Cement Company at Suisun, showing salinity of Suisun Slough; records of the Great Western Electro Chemical Company at Pittsburg, extending from 1916 to date, giving total solids and chlorine in the river water; and information collected at various times in the investigation of water supplies by the City of San Francisco, the City of Richmond, and the East Bay Water Company. A large amount of information from these various sources has been obtained and is helpful in interpreting the changes which have taken place and in formulating a fairly accurate conception of conditions in the past and what may be expected in the future.

Attached to this report is a chart of the region, the base being photographed from the annual report of the Division of Water Rights. On this chart red lines have been placed showing the penetration of salt water during the months of June and September, 1924. Similar charts for other years show that in every year, salt water has penetrated to a point beyond Antioch on the San Joaquin River and Collinsville on the Sacramento, and that in years of low flow, such as 1918, 1920, 1924 and 1926, the extreme limit of salt water penetration has been well into the delta region.

The year 1927 is one of approximately 100 per cent run-off in the streams tributary to San Francisco Bay. In this year salt water reached the middle of Suisun Bay in June, was approximately at Collinsville and Antioch in July, and during August and September had reached approximately to Emmaton on the Sacramento and the lower end of Jersey Island on the San Joaquin River.

Stream flow records show that approximately one-third of the years are in excess of 100 per cent run-off and two-thirds of the years below that figure. This gives, roughly, an approximation of the period of time in which salt water conditions will be worse than in 1927 and the period in which better results can be expected.

For practical purposes, a period of thirty days or more would be detrimental to either irrigation, domestic use or supply for industrial purposes. An examination of records in more detail indicates that, under the conditions now existing, in practically all dry years salt water will reach the lower end of the delta for at least a month's time, and that in two-thirds of the years water will be in the lower delta region in excess of a month's time or as much as three to four months.

The areas of delta land within the salt water flow are shown in the following table.

	Approximate stream flow in per cent, normal	*Area of delta penetrated by salt water*
1924	24	169,000
1925	74	8,500
1926	53	58,000
1927	100	5,000

PROSPECTIVE CHANGES IN THE FUTURE

Storage of water for power purposes and diversion for irrigation and domestic uses in the watersheds tributary to the bay are steadily increasing. The rate of increase of the irrigated area is not so rapid as during the decade 1910 to 1920, but there is a steady, continuous growth and plans are on foot for large increases in the use of water through new projects and through the extension of irrigation on old projects.

As illustrating the extent to which conditions are changing, reference may be made to the growth of the San Joaquin River basin since the year 1920, a period ordinarily regarded as one of stagnation in irrigation development in California. Since 1920, the Southern California Edison Power Company has constructed and placed in operation the Florence Lake and Shaver Lake Reservoirs on the San Joaquin River with a storage capacity of 203,000 acre-feet. This stored water will be diverted and used as fast as it is released for power purposes by the agricultural lands above the mouth of the Merced.

On the next stream, the Merced Irrigation District has built a storage reservoir of 278,000 acre-foot capacity and has approximately trebled the area in irrigation in 1920. The district is rapidly growing and the entire irrigable acreage in the total of 189,000 acres will be all in cultivation within a few years.

On the Tuolumne River, since 1920, the Modesto and Turlock Irrigation districts have built the Dom Pedro Reservoir of 290,000 acre-foot capacity, and both districts have extensively increased their irrigated area. The growth is steady.

The Waterford District has acquired rights to use the water of the Yosemite Power Company, which formerly delivered approximately 60 cubic feet per second into the Tuolumne River below LaGrange Dam, further reducing the stream flow.

Since 1920 the City of San Francisco has built Lake Eleanor and the O'Shaughnessy Dam, storing 231,000 acre-feet. The water released from these reservoirs has not yet been diverted from the watershed, but it has been picked up, at least during the summer period, by the irrigation districts, and no water except return seepage has flowed into the Tuolumne River during the summer and early fall months.

On the Stanislaus River, the Melones Dam has been built by two irrigation districts in cooperation with the Pacific Gas and Electric Company, and the late summer use of water has been very much increased.

In addition the power companies have now under construction Salt Springs Reservoir on the headwaters of the Stanislaus, with the intention of ultimately raising this to storage capacity of 130,000 acre-feet. This water when released will be caught by the Melones and Woodward reservoirs lower on the stream and utilized during the late summer.

The East Bay Utility District has now under construction the Lancha Plana Reservoir site on the Mokelumne River, a reservoir of 200,000 acre-foot capacity, and has completed a pipe line from the Mokelumne to the East Bay district of a capacity of 60 million gallons daily (90 second-feet). The water to be diverted by this utility district will be taken out of the watershed and there will be no return flow from it.

In addition to the reservoirs and increased irrigated area on the east side of the San Joaquin, several pumping plants have been built, lifting water up the West Side slope for the irrigation of high lands. Important among these are the Banta-Carbona Irrigation District, approximately at the head of tide water, which commenced irrigating in 1925, and now has a pumping capacity of 220 cubic feet per second.

The Burkhart Ranch further south has installed a pumping capacity of about 50 cubic feet per second since 1920, and a number of other districts and appropriators of water have increased either the size of their pumping equipment or the extent of their use, so that at the present time the capacity of the pumping plants irrigating West Side lands exceeds the flow in the San Joaquin River at the place where tide water is reached.

Further extension of this irrigated area is in progress and one new district is now engaged in preparation of plans which will result in the pumping of approximately 300 second feet from the river.

Extension of area supplied by pumping from wells has been going on at the same time In Fresno, Madera, Merced, Stanislaus and San Joaquin counties, hundreds of pumping plants have been installed since 1920, all drawing from water which, under natural conditions, would have its outlet to the sea through the San Joaquin River. It is impossible to accurately estimate the effect of this withdrawal of water upon the stream flow or the underflow to delta areas, but, if it has not already done so, it will at some time affect the flow by reducing the quantity of water which reaches the stream from underground sources and affecting to that extent the late summer discharge into tidal waters.

Irrigation development has not been so pronounced in the Sacramento watershed since 1920. There are a large number of irrigation and reclamation enterprises in the Sacramento Valley which have irrigation systems of a capacity larger than the irrigated area. There is, in addition, a large area of land still devoted to grain, rice, sugar beets and other general farm crops, which goes in and out of cultivation as economic conditions vary. The years when grain prices are high, large areas of grain go into cultivation, a portion of which is irrigated. With prospects of low prices for grain other crops are planted, some of which use more water than does grain. The most noticeable effect on the water supply, however, is the increase and decrease in the rice crop. The area irrigated in rice since the industry became stabilized varies from 130,000 to in excess of 200,000 acres a year and in years of large crop the effect upon the water supply is very noticeable.

Although no large new enterprises have been built in the Sacramento Valley in recent years, the increase in irrigation in the older districts has been steady. The area devoted to orchards, to alfalfa, and to general farm crops requiring irrigation, steadily increases. The result has been continued drafts upon the supply from the river and to gradual reduction in the total flow downstream from the main cultivated section. The reduction in flow, to some extent, has been controlled by the operations of the Division of Water Rights through the commissioner appointed to superintendent the diversions from the Sacramento and San Joaquin rivers. The principal effect of the work of the Commissioner has been to reduce the waste of water, to encourage economy and to endeavor to keep the flow at Sacramento as high as possible, both for purposes of navigation and the use of delta lands.

Return seepage and waste from the lower ends of the rice irrigation canals have to some extent ameliorated the extreme low flow conditions experienced in 1920 and 1924, but the steady increase in irrigated area goes on each year. The total quantity of water which passes out of the valley in late summer is slowly but surely decreasing.

There is nothing to indicate any change of conditions in the immediate future. Irrigation has reached nearly stable conditions on the upland areas of the San Joaquin Valley, largely because the streams are nearly developed to their full capacities. On the Sacramento River, however, large areas of fertile land under irrigation systems built to supply them with water are certain to be placed in crop and increase the use of water. The result will be a steady depletion of the stream and an increase of the salt water menace.

Salt water conditions such as have occurred in the lower delta since 1918 have become permanent and will not be improved until some additional water supply is turned into the river during the low flow period, or unless a barrier is built to prevent the approach of salt water from the ocean. It is difficult to conceive a set of natural conditions that would change this situation. We have reason to expect years of heavy runoff to follow the long period of dry years since 1917, but a review of the past does not lead to the belief that summer water supply can be increased to such a point that any appreciable effect will be experienced by the delta region and industrial area.

EFFECT OF SALT WATER ON DEVELOPMENT

The industrial and agricultural areas along the upper bay and lower river region came into being before there was any serious thought of the salt water problem, in other words prior to 1918, for that was the year in which the encroachment of salt water was serious and over a long period of the year. Since 1918 there has been no large increase of cultivated land in the delta region and few new industries of importance have been established in the industrial area. There has been, however, a steady growth in the industries already established.

The effect of salt water upon the various users of water will be discussed in the following paragraphs.

Agriculture. Water to be supplied for agricultural purposes must be free from large quantities of soluble matter. The upper limit of concentration safe for use depends upon the soil, crop, rate at which it has been used, drainage facilities, and to some extent upon whether fresh water is available at other times in the year for leaching purposes. The determination of the safe limit is, therefore, a matter of considerable difficulty, as it will vary as these factors differ.

For the purposes of this report, however, it is fair to assume that water containing 100 parts of chlorine per 100,000, equivalent to 160 parts of sodium chloride or common salt per 100,000, is the upper limit of safety; since the water contains other salts the total salinity of water containing 100 parts of chlorine will vary from 175 to 200 parts per 100,000. Water of this degree of salinity is not safe for use, except where precautions are taken to provide good drainage and to continue leaching the water through the soil so that there is no accumulation of salty matter. Such water may be used with safety on light soils where drainage is good and the use excessive, and is not harmful where used occasionally during late summer. One-half of this quantity, or 50 parts per 100,000, is much safer for use and waters of this degree of salinity could be used with comparative safety.

The records quoted above show that in years of extreme low flow, waters of 100 parts of chlorine per 100,000 will penetrate into the delta region to points beyond Rio Vista on the Sacramento, and to Stockton and beyond the mouth of Middle River on the San Joaquin. During some part of the summer approximately one-half of the delta area will be surrounded by salt water.

This condition has several results: First, it renders questionable the irrigation of permanent crops, particularly such crops as are sensitive to salt; second, it has a tendency through the percolation beneath the levees of sub-irrigating the adjoining land with saline water; third, it reduces the value of lands through the fear of salinity; and fourth, it adds expense and uncertainty to the question of domestic supply, for on most of the delta the river is a source of domestic water.

The net effect of this condition is to render agriculture uncertain in the delta, to reduce the value of land, and to create a menace which will result in the destruction of the land by the accumulation of salts.

AREA OF AGRICULTURAL LAND AFFECTED BY SALT WATER BARRIER

The area of agricultural land affected by the salt water barrier is taken as:

First—The area of marsh land lying practically at sea level.

Second—The area of land up to elevation 150 above sea level; an elevation to which pumping has been carried with success.

These areas may be subdivided into geographic regions as follows:

First—The area around San Pablo Bay, between Carquinez Strait and the site of the San Pablo barrier.

Second—The area around Suisun Bay, that is, from the mouth of the river at Collinsville to Benicia.

Third—The delta area or region upstream from the mouth of the river.

Fourth—Irrigated or irrigable lands above the delta.

San Pablo Bay Area. A large area of marsh land lies along the west and north shores of San Pablo Bay. At present a large part of this area is in process of reclamation. Much of it is growing grain crops or pasture, but little of it is irrigated. The surrounding waters are salty at nearly all times of the year. Fresh water fills the sloughs and bay during flood time, a period becoming shorter each year. Ground water of good quality has not been found and there is little likelihood of its ever being obtained, as deep wells have been drilled in many places.

Much of the land is yet salt and all of it is influenced to some extent by the salt in the bay, and the reclamation by using rainfall alone to wash out the salt is slow. The presence of fresh water surrounding the area would permit much more rapid reclamation and would make it possible to bring into profitable agriculture nearly this entire area.

Surrounding the marsh area is an area of high ground nearly as large, all of which is now unirrigated. This marginal area could be all watered and made available for many different crops by fresh water from San Pablo Bay and tributaries if this bay were kept full of fresh water. Novato, Petaluma and Sonoma Creeks and Napa River all penetrate the marsh lands and extend to high land; they would make fresh water available for the adjoining high ground and enable pumps to supply small units or large, depending upon the physical conditions.

It is to be expected that at some future time all agricultural lands in California will make use to some extent of irrigation water where such is available. Irrigation in the coastal belt has not advanced as rapidly as in the interior valleys, because owners of such land can grow profitable crops without artificial watering. Maximum results can be obtained only by irrigation and it is but natural to expect water to be in demand at some future time.

The San Pablo Bay areas which may at some time become interested in irrigation are all areas where climate and soil are acceptable to agricultural pursuits. The region is close to centers of population; transportion facilities are usually good or easily improved; it is one where increased population is certain. The availability of fresh water in the bay and tidal sloughs will serve to stimulate this growth.

Lands so situated, close to tidal waters and centers of population, are likewise attractive to industries. As the San Francisco Bay region grows, more and more of the territory adjoining the bay will change from agriculture to industrial or residential property. With a water supply attached to it, the change in use becomes easier, for the amount of water required for agriculture supplies the needs of residential or industrial occupation.

Carquinez Strait. Carquinez Strait—7½ miles long—extends from Suisun Bay to San Pablo Bay. High hills with only small areas of flat land bound the strait. The opportunities for extensive developments for use of water in this territory are limited by the topographic conditions. Industries already occupy much of the available territory and the small valleys, particularly in Contra Costa County, are now filled by towns, the population resulting from industrial, transportation and commercial enterprises along the waterfront.

If the strait is filled with fresh water and tidal fluctuations and currents are decreased, the more complete occupation of all available ground will be possible. At the present time growth is restricted by water supply. Martinez, Port Costa and adjoining territory obtain a part of their water from wells at Concord 12 miles away. The supply from ground water is limited. Large additions to this supply are impractical. The Sugar Refinery at Crockett has barged water from the river or the Marin County shore at great cost for many years.

On the north side of the strait, the town of Benicia has a small water supply but cannot increase this supply very much without great expense.

Suisun Bay Area. Marsh lands adjoining Suisun Bay total 70,000 acres Immediately adjacent to these marshes is an area of 93,000 acres of higher land suitable for agriculture but not now irrigated. Fresh water in Suisun Bay would make it possible to convert this area of dry land to irrigated areas of high value.

The marsh area of Suisun Bay is all practically at sea level. Much of it is salt marsh or at least contains enough salt to interfere with some kinds of agriculture. A large part has been leveed and utilized for pasture. but with unsatisfactory drainage, and salt has accumulated.

Fresh water in the surrounding tidal channels and freedom from daily tidal fluctuations will permit the leaching of this land and make the reclamation of it practical. The land is inherently fertile and will become very productice when leached of salt. The works to accomplish this are simple in character and the operation is simple and certain of success.

If fresh water is made available, there is little question but that these marsh lands can eventually be made as productive as the delta lands of the Sacramento and San Joaquin rivers further upstream.

The high ground above these marsh areas and which may be watered by practical lifts out of todal channels includes the lower parts of Green Valley around Cordelia, the lower part of Suisun Valley, now highly developed to deciduous fruits, and the region from Suisun to Denverton.

South of the bay the lower parts of Walnut Creek and Ignacio and Seal Creek valleys may be reached with low pumping lifts. These

valley lands are now in part planted to fruits and the agricultural possibilities of the region have been demonstrated. Irrigation water cannot be obtained for these areas from any other source known at this time. Wells are of small yield and uncertain life. Storage reservoirs on these streams may be possible but none is known except small ones, and these will serve only small local areas.

The most important difficulty is the extremely erratic nature of the runoff from this area. In wet years floods are heavy, but in years below normal precipitation the runoff may be very limited, often negligible. Storage to be dependable must hold water over two or three dry years, an impracticable condition for agriculture except in very limited areas. The greater part of the area will remain unirrigated unless some cheaper, more dependable supply of water is made available. A salt water barrier will place fresh water at points where it can be readily obtained by practical developments.

The Delta Region The delta region, affected by tide levels, extends as far up the San Joaquin River as Duncans Ferry (6 miles below the mouth of the Stanislaus River) and up the Sacramento a short distance above the city of Sacramento The distance from the mouth of the San Joaquin to the head of tide water by river is 77 miles; to the head of tide water on the Sacramento is 56 miles. Between these extremes are many miles of tidal channels and sloughs affording access by boat to nearly all parts of the region, and by relatively short dredger cuts, making it possible to deliver tidal water at the edge of high ground.

This region includes 376,000 acres of land, either marsh or swamp and overflowed, and 91,000 acres of high ground immediately adjacent to the marsh on the west side of the valleys. These total 458,000 acres.

The entire area is irrigated or irrigable from waters at tide level. The most recent information indicates that of this area 360,000 acres are now irrigated in both deltas. In both deltas an area of 98,000 acres remains to be irrigated, part of which are irrigated and farmed irregularly. The economic status of the farmer has much to do with the area under cultivation.

The Up River Country. The entire irrigated area tributary to Suisun Bay is to some extent interested in the salt water problem. At the present time a suit is before the Superior Court of San Joaquin Valley, between riparian users and appropriators in the delta region and 443 defendants on the streams above the delta. This suit involves nearly all of the large users of water, both for irrigation and power, on the stream Much other litigation is in prospect. The outcome of this controversy cannot be foreseen but it is impossible to predict anything but serious complications and nearly endless difficulties no matter which turn the courts may take.

Should the outcome of the present suit be that tide water lands have no riparian rights upon waters of the streams, in excess of one-half of the present delta area will be periodically surrounded by salt water. The argricultural industry will be affected and the salt water menace to these lands will become permanent. The final result will be disastrous to a very large area of land which has been the most uniformly productive land in the state. The continued storage and use

of water above tide level and the increase in pumping to high lands around the tidal area will cause salt water to enter the rivers in all years, and at times the greater part of the tidal waters will be contaminated with salt from the ocean.

Should the courts take the view that owners on tidal waters have riparian rights to the flow of the stream, a great deal of very valuable land now using water must release the water which has heretofore been used and a tremendous damage to higher areas will result. The release of waters may affect salt water conditions to some extent but it is impossible to conceive a condition in which enough water will be released to push back salt in years of light runoff.

As is shown later in this report in the chapter on "Storage and Release for Control of Salinity," the plan under which this proposal has been made does not look practical as a means of taking care of the irrigation problem of the delta. Furthermore, it leaves out of consideration the entire industrial area that lies just below the delta.

Power Companies. Two power companies supply the industrial region—the Great Western Power Company and the Pacific Gas and Electric Company. Both companies have an interest in the salt problem in two ways. The market for power is the first and most apparent interest the power companies have in this problem in that the maintenance of the present industries and their growth in the future affect the income of the distributing companies

In a later chapter a statement of the approximate use of power for industrial and domestic purposes is included. The rate of growth of power sales indicates a steady increase in industrial activities. The more rapidly these factories grow and the more new factories there are installed, the better will be the power companies' incomes. A potential industrial territory offers opportunity for a very large increase in the use of power and the encouragement of these industries is a legitimate function of power companies.

The second way in which these companies are interested is the question of litigation mentioned above. The Great Western Power Company and the Pacific Gas and Electric Company and subsidiary companies, such as the Sierra and San Francisco Power Company and Mount Shasta Power Corporation, are parties to the suit previously mentioned In addition to them the San Joaquin Light and Power Company and Southern California Edison Company, both developers of power on the San Joaquin River, are included, and the Modesto and Turlock, South San Joaquin and Merced irrigation districts are included on account of their storage and use of water on tributary streams. The interests of these concerns, therefore, are created by the direct attack upon their storage and use of water in the higher watersheds.

Should the outcome of this suit establish the riparian right of the delta land owners, the power companies will suffer very seriously in consequence, by the necessity of either releasing water now stored or condemning the right to continue the practice of controlling the flows.

Fishing Industry. Under present conditions, with the Sacramento and San Joaquin rivers open to the flow of tides, fish have free access from the ocean to the fresh water streams draining the Sierra Nevada

Mountains. Several types of commercial fish are caught in these waters and other fish are important as food for the commercial varieties. There has developed a considerable fishing and fish-canning industry along the bay and lower river shore. The catch in river and upper bay approximates 5,000,000 to 6,000 000 pounds a year—largely salmon, shad and striped bass (See table.)

The Fish and Game Commission has in charge the maintenance of fishing and the preservation and control of natural fish life, together with the propagation of existing species and the introduction of new forms suitable to these conditions.

Plans for the salt water barrier provide for fishways so that fish may travel upstream. Fish will have free travel at such times as gates are opened and will no doubt pass through the ship locks at all times.

THE FUTURE OF THIS REGION

The future of the industrial region on Carquinez Straits and Suisun Bay depends upon the growth of population. California and other Pacific coast states are growing more rapidly than any other section of the United States. There has been for many years a constant inflow of people from the East and an increase in population along the whole Pacific shore The cities of Los Angeles. Oakland, San Francisco, Seattle and Portland have grown much more rapidly than is the average growth of American cities.

There is no such rapid development anywhere in the country except the industrial growth in the cities around the Great Lakes, where large manufacturing interests have centered. Aside from the city of Los Angeles, the rapid-growing cities of the country have been the industrial centers. In the case of Los Angeles, the industrial growth has been large but the great increase in population arises, to a large extent, from the attractive climate of this southern city.

Estimates of future population of the San Francisco Bay region have been made by several organizations in studies concerning public utility matters. The results of three such studies are shown in the table following. The first, column I, is the estimate of the population of San Francisco and east bay cities made in connection with studies of trans-bay bridge; column II is an estimate of the metropolitan district, taken as San Francisco, Alameda, Contra Costa and San Mateo counties, by the telephone company; and column III the estimate of population of the East Bay Municipal Utility District by that organization. Each of these estimates indicates that the population will double in about 25 years.

Estimates of Growth of Population

Year	*I San Francisco and Trans-bay Cities*	*II. San Francisco Metropolitan District*	*III. East Bay Municipal Utility District*
1910		686,873	229,404
1915	760,000		
1920	850,850	891,477	330,348
1925	976,000		
1930	1,100,000	1,329,200	501,000
1935	1,250,000		
1940	1,400,000	1,856,700	702,000
1945	1,577,000	2,172,000	
1950	1,750,000		948,000
1960			1,230,000

I. Estimate of population San Francisco and East Bay cities by Board of Engineers Trans-Bay Bridge, San Francisco, May, 1927.
II. Pacific Telephone & Telegraph Company—estimate by Robert W. Bachelor, includes San Francisco, Alameda, Contra Costa and San Mateo counties, April, 1925 Published in "San Francisco Business" April 17, 1925.
III. East Bay Municipal Utility District, Annual Report 1925, page 7.

Contra Costa County has grown at a more rapid rate than the bay region as a whole. Census figures for the counties around the bay are shown in Table 4. Contra Costa's growth as compared with other bay counties is shown below:

Subdivision of State	*Population 1920*	*Increase 1910 to 1920 Per Cent*	*Increase 1900 to 1920 Per Cent*
State	3,426,861	44	130
Alameda County	344,171	40	164
Contra Costa	53,889	70	198
Marin	27,342	9	74
Napa	20,678	4	26
Sacramento	91,029	34	98
San Francisco	506,676	22	48
San Joaquin	79,905	58	125
San Mateo	36,781	38	204
Solano	40,602	47	69

Recent figures to show increase in population are shown in Table 5, in which are given the school enrollments for years 1915, 1921 and 1927. These are summarized below:

School Enrollment Bay Shore Districts—Contra Costa County

	1915	1921	1927	*Per cent increase* 1915–21	1915–27
Elementary schools	5020	7262	9118	45	82
High schools	510	1037	1586	103	210
Totals	5530	8299	10,704	50	94
Increase		50%	30%		

Population Growth and its Cycles. California, in common with other states, is going through a readjustment of population distribution and kind of occupation. A comparatively few years ago the greater part of our population was engaged in agriculture; today manufacturing and mechanical industries occupy more people than agriculture. In 1920 agricultural pursuits (including forestry) occupied 18 per cent of the wage earners of the state as compared with 28½ per cent engaged in manufacturing and mechanical industries Today the percentage engaged in manufacturing is higher and increasing all the time.

Students of population growth recognize cycles of growth which, for certain reasons, start slowly, grow rapidly and decline slowly. California has gone through two cycles of growth—mining and agricultural—and is now entering upon a third cycle—industrial.

The gold rush commencing in 1848 caused the first rapid increase of population after California became a part of the United States. As mining gradually declined in importance, agriculture attracted many people and a great increase in population occurred. Agriculture ceased to make rapid growth in 1912 and since that period manufacturing and mechanical trades have been the principal source of increase in population.

There are several reasons for present conditions:

1. Agriculture has been depressed since the deflation period of 1921. Costs are still high and the sale price of products has not entirely recovered. Profits have been low

2. Land values in California are high There is no more chance for cheap land. The incentive which caused many to enter agricultural pursuits in the great period of agricultural growth does not now exist.

3. Farming is more and more becoming purely mechanical; the same area of land can be farmed now with fewer men. This releases men for other occupations and reduces the number of men trained in farming operations—the potential buyers of farms.

4. Freight rates increased during the war and added greatly to cost of placing agricultural products in eastern market centers. At the same time the increase in freight has made it practically necessary for many manufacturers to establish branches on the Pacific coast.

5. Since 1900, hydro-electric power and long distance transmission of energy to manufacturing centers have been made practical and cheap, and dependable power for manufacturing has resulted

6. California, since 1900, has become a large producer of oil. The cheap oil has encouraged manufacturing in many ways.

7 The Panama Canal and better shipping facilities have made raw materials for manufacturing more easily available, and have made it easier to ship products of manufacture to other markets.

8 The climate of the coast region of California has become recognized as being well adapted to manufacturing The cool weather, uniformity of seasons, freedom from freezing or destructive storms, have attracted workmen and capitalists.

The result of all this is that at present the growth of California lies around industrial centers We are now living in an industrial age. The future of the state depends largely upon the rate and quality of this manufacturing and industrial growth.

This does not mean that there is to be expected a decline in agricultural activity. On the contrary, the growth of cities and centers of industrial enterprises will stimulate the growth in agriculture. Markets for more farm produce will result from increases in industrial population, there will be a better market for the raw products of manufacture which originate on the farm and the improvements in transportation that will result from manufacturing will benefit agriculture. We may expect the growth in agriculture to continue, but at a rate lower than during the years prior to 1912.

Agricultural Extension Possible and to Be Expected. In the chapter in which the region lying tributary to the upper end of the bay and lower river is described, the statement is made as to the area of land which could be irrigated from fresh water basin above the proposed salt water barrier: These areas are as follows·

Areas Irrigable From Fresh Water Basin Above Barrier

	Marsh	*Upland*	*Total*
San Pablo Barrier—San Pablo Bay	51,000	48.000	99,000
Army Point Barrier—Suisun Bay	70.000	93.000	163,000
Totals above San Pablo	121.000	141.000	262,000
Delta region above mouth of river—			
San Joaquin	257,000	58.000	315.000
Sacramento	110,000	33.000	143.000
Grand totals	488,000	232.000	720,000
Of this area, that above Army Point is	437,000	184,000	621,000

Of this area, approximately 360,000 acres are irrigated in the delta region. The areas around Suisun Bay and on San Pablo Bay are surrounded by salt water for so much of the summer that pasture crops alone are grown to a considerable extent.

Following the history of growth of the country, it is reasonable to expect that all of the areas which can be irrigated from this fresh water basin will be irrigated and cultivated as rapidly as the population and increase in markets warrant. The region is close to markets, well supplied with transportation facilities, which will be both by rail and water, has a climate suitable to a great variety of crops, and it would be only natural that such areas would be put to use.

Industrial Growth to Be Expected. There is no possible way of predicting what increase there will be in the industrial development except that it will be large and substantial in character. There are many basic industrial activities not represented in this part of the Pacific coast—industries that will unquestionably settle in this region when a fresh water supply is assured—and there will be a continued and more rapid growth of the ones already on the ground.

Every large industrial region of the world has developed at points where fresh water is abundant and cheap, and where facilities for handling of raw products to factories and carrying the finished products to markets are well established, and the rates to markets are reasonable. San Francisco Bay, being in the geographical center of the Pacific coast, is the natural point where large factories will locate. The fact that large cities are close at hand, that transportation facilities are established, that power is abundant and cheap where oil pipe lines bring oil from the fields further south, and that the climate is an unusually good one for a manufacturing business, are all important. If there is added to these essential conditions a large fresh water reservoir, there will be no more favorable location for manufacturing. It can be expected that the growth here will be as rapid as in any other part of the country and more rapid than has been true at any time in the past history of the state or Pacific coast.

WATER REQUIREMENTS OF THE REGION

The present water requirements of the region are supplied from many sources. Richmond, on the upper end of San Pablo Bay, is within the East Bay Municipal Utility District, a public organization engaged in the construction of a water supply system from the Mokelumne River. It is to be expected that this district will purchase the distribution system of the East Bay Water Company now serving the territory, and that it will construct such additional facilities as may be required to supply industrial and domestic requirements of the territory. Water from this system will be costly. The charges of the East Bay Water Company average nearly 30 cents per 1000 gallons. Little if any reduction in cost can be expected from the utility district unless a part of the expense is raised as taxes.

The smaller towns, such as Martinez, Port Costa, Benicia, Bay Point, Antioch and Pittsburg, obtain water either from wells or by pumping from the river at fresh water times, or by small storage reservoirs filled during flood or fresh water season. In all of these towns water is high-priced (the average price of water from the Port Costa Water Company is about 27 cents per 1000 gallons), usually of inferior quality

at least some time of the year, and there is no great supply in sight to take care of rapid increase in growth of population. In fact the growth of the territory outside of the Utility District mentioned is to a large extent restricted by its water supply. The Utility District can not serve the industrial plants on account of the high cost of water.

The construction of a salt water barrier will effectively remove this deterrent to growth, for it will place fresh water of good chemical quality alongside of all of these towns, and with the modern methods of filtration and purification the water will be suitable for domestic or any industrial use. The cost of pumping will be a small part of the cost of water from any other known source.

The industries now established between Oleum and Antioch, on both sides of the straits, use 10 million gallons daily and the use is increasing at the rate of a million gallons daily per year. Enlargements and extensions to these plants will probably increase this rate of growth.

Prediction as to the future is hazardous, as much depends upon whether or not a salt water barrier is built. This structure will greatly stimulate growth of present industries and will encourage the establishment of new ones. It is within the bounds of reason to expect 100 million gallons daily to be used by industries within the next 25 years.

Domestic Supply for Cities and Towns. Water for domestic purposes is higher priced in San Francisco and the East Bay cities than in any other large cities of America. This high price results from the difficulty of securing water in quantities sufficient to take care of the rapid growth of these communities. The same thing may be said of smaller cities along Carquinez Straits. Water for domestic use has been difficult to secure, the price is high, the quality is not good at all times. There is no known way by which small communities can satisfactorily grow unless the water supply is ample for the needs of their growing population.

As an example of this condition, the history of the Benicia Water Company may be cited. This company has made a careful investigation of the possibilities of securing water, has drilled wells for underground investigation, has considered storage possibilities in the hills back of the town, and has finally been required to use river water at such times as this water is available, and to supplement this supply with pumps. During much of the year the community is unable to supply water of a good quality without great difficulty.

On the south side of the straits the water supply for towns of Crockett, Martinez and surrounding territory is provided by the Port Costa Water Company, largely from wells in the neighborhood of Concord. Litigation has restricted the extent to which these wells can be utilized and this community will be faced with the very large expense of going to distant points for a water supply if the growth of the towns continues.

The town of Pittsburg is supplied from wells and, at seasons of the year when the water is fresh, from the San Joaquin River. The limit to the availability of underground waters is in sight and Pittsburg will be placed to great expense to secure a water supply if the growth continues to be as rapid as it has been in the past. Similar conditions

prevail at Antioch, where protracted litigation called the attention of the state to the difficulties of this community carrying out its plan of pumping water from the river. Since 1920 Antioch has built a storage reservoir on the slopes to the south of the city, into which fresh water is pumped during the early summer, and stored and used in late summer. The result is that water is more costly and of poor quality for domestic purposes, largely on account of the taste of stored water in open reservoirs in bright sunlight.

The entire industrial areas along Suisun Bay and Carquinez Straits may be said to be restricted in growth on account of the fact that there is no easily obtainable supply of fresh water. The result has been a restricted rate of growth of population and an increase in cost of water to those who are already in the community.

The salt water barrier, to a large extent, will remove these difficulties If the barrier is located at the San Pablo site, the entire area will be cared for. If it is placed at the Army Point site, the entire region upstream will be on a fresh water lake. The industrial area below the upper end of the straits can then be supplied from a relatively short pipe line heading above the barrier.

The reversal of flow, caused by tides at Sacramento, has endangered the cities' water supply by causing sewage to back upstream The barrier will prevent this from occurring, as it will raise low water at Sacramento and prevent upstream flow.

SURVEY OF REGION AFFECTED BY SALT WATER

The region affected by salt water includes the area from the lower end of Carquinez Straits upstream to Isleton on the Sacramento River, Wakefield Landing on the San Joaquin, and Mansion House on Old River. It includes Carquinez Straits, Suisun Bay, and approximately one-half of the delta on the San Joaquin and Sacramento rivers. San Pablo Bay is of course affected but salt water is more nearly a natural condition in that body of water. Indirect effects are experienced in all parts of the watershed draining through Carquinez Straits and the Bay region and cities which have commerce with these industrial and agricultural areas. The problem, in fact, is one which interests all of California, for the prosperity of this industrial region and the prospective growth of this country in some measure affect the entire area engaged in agriculture or trade in this part of the Pacific Coast

The region directly affected by the recent invasion of salt water includes the cities and towns of Oleum, Crockett, Port Costa, Martinez, Bay Point, Pittsburg and Antioch on the south side of the straits and Suisun Bay, and Vallejo and Benicia on the north side. Salt water extends as far upstream as Rio Vista

The estimtaed population of these towns and outlying territory is in excess of 30,000.

Industries. The important industries located along the Straits of Carquinez and Suisun Bay are as follows:

INDUSTRIES

Carquinez Straits.

Left Bank: *Town*

1—Union Oil Company ---------- Oleum
Refining, casing and shipping petroleum products.

2—Selby Smelting & Lead Company ---------- Selby
Branch of American Smelting & Refining Co.
Smelting and refining non-ferrous metals.

3—California-Hawaiian Sugar Company ---------- Crockett
Sugar refineries, largest in world, 5,000,000 lbs. a day.

4—Port Costa Brick Company ---------- Port Costa
Makers of brick, etc.

5—Grain Warehouses ---------- Port Costa
Storing, cleaning, shipping—principally barley.

6—Petroleum Products Company ---------- Martinez
Petroleum products.

7—Mountain Copper Company ---------- Martinez
Copper smelting and refining, fertilizers.

8—Shell Oil Company ---------- Martinez
Refining and shipping petroleum products.

9—Southern Pacific Company ---------- ————
Operating railroad and ferries.

Right Bank:

10—Mare Island Navy Yard ---------- Vallejo
Repairs and construction of naval ships.

11—Sperry Flour Company ---------- Vallejo
Milling of wheat and other grains.

12—Benicia Barracks and Arsenal ---------- Benicia
U. S. Army stores.

13—Kullman-Salz Tannery ---------- Benicia
Leather.

Suisun Bay

Left Bank: *Town*

1—Associated Oil Company ---------- Avon
Refining and packing for shipment petroleum products.

2—Coos Bay Lumber Company ---------- Bay Point
Manufacturing and wholesale lumber; large storage 75,000,000 F. B. M.

3—Pacific Coast Shipbuilding Company ---------- Bay Point
Ship building—steel and iron products.

4—General Chemical Company ---------- Nichols
Large manufacturers of heavy chemicals.

5—San Francisco & Sacramento Railroad Company ---------- ————

Most Important from Pittsburg to Antioch:

6—Booth Cannery Company ---------- Pittsburg
Canners of fish, fruit and vegetables.

7—Hickmott Cannery Company ---------- Pittsburg
Fish, fruit and vegetables.

8—Paraffine Company ---------- Pittsburg
Paper board.

9—Great Western Electro Chemical Company ---------- Pittsburg
Diversified heavy chemicals.

10—Redwood Manufacturing Company ---------- Pittsburg
Redwood pipes and tanks and other products of redwood.

11—Columbia Steel Company ---------- Pittsburg
Steel products.

12—Pioneer Rubber Company ---------- Pittsburg
General rubber products.

13—H. W. Johns-Manville Company ---------- Pittsburg
Magnesium and asbestos building specialties.

14—Santa Fe Railroad Company ---------- ————

Industries in Richmond and along the shores of San Pablo Bay are as follows:

Left Bank—Below Carquinez Straits:	*Town*
1—California Cap Company Caps for detonating high explosives.	Stege
2—Stauffer Chemical Company Bulk chemicals from crude ores.	Stege
3—Metropolitan Match Company Matches.	Stege
4—Pullman Manufacturing Company General shops, repairs and construction of cars.	Richmond
5—Santa Fe Railroad Company General shops, repairs and construction of cars	Richmond
6—Standard Sanitary Mfg. Company Porcelain and enamel plumbing fixtures. Distribution of other porcelain and enamel ware.	Richmond
7—Certainteed Products Company Roofing and paints.	Richmond
8—Republic Steel Package Company Metal containers, principally drums for oil and gasoline.	Richmond
9—Standard Oil Company Refining and shipping of petroleum products.	Richmond Point
10—Philippine Refining Corporation Refining copra and other vegetable oils.	Richmond Point
11—California Wine Association Formerly largest winery in world; industrial alcohol.	Winehaven, Richmond Point
12—Giant Powder Company Dynamite and other explosives.	Giant
13—Hercules Powder Company Dynamite, T.N.T. and other explosives.	Hercules

The majority of these establishments along the Straits and Suisun Bay produce large outputs of material and are in the class ordinarily called "heavy" industries. They produce products essential to modern life both in peace and war times. Steel, iron, petroleum products of all kinds, chemicals, fertilizers, powder and fuse, leather, brick and tile, flour and feed, lumber and lumber products, ships and boats, sugar, fish and canned goods are produced in very large quantities.

A survey of the plants between Oleum and Antioch shows an annual production in 1927 of products valued at $250,000,000 The increase in annual output is large and the growth has been regular The first large factory to establish in this territory was the Sugar Company in 1907. The period up to 1920 was an active one in growth, but since sale water troubles became so prominent only one new plant of large size has located here.

Freight in and out of this district by rail and water, directly attributable to these plants, approximated 14,000,000 tons in 1927. Three railroad systems serve the territory Vessels, both river and ocean-going, handle much freight. Oil pipe lines from the fields in the San Joaquin Valley deliver oil to the refineries, to large tank farms for storage, and to vessels

Expenditure for electric power by these industries was $800,000 in 1927. Electric power is furnished by the Pacific Gas and Electric Company and the Great Western Power Company. The use of power increases every year. Power rates are the same as in the Bay cities.

In 1927 these plants employed on an average of 8500 persons, the annual payroll amounting to $15,000,000. Comparatively little sea-

sonal employment is found—most of the factories run fairly constantly through the year. The population dependent upon the factories, using a ratio of 4 to 1, is 34,000

The industrial territory on San Pablo Bay below Oleum, in Contra Costa County, is nearly as large as the district described above. If the entire waterfront area in Contra Costa County is considered, we find the annual products to be $515,000,000; the number of employees to be 17,000; the annual payroll $29,000,000.

The industries between Oleum and Antioch now use 10,000,000 gallons of water a day. The annual increase is 10 per cent, or a million gallons a day. All of this water is pumped from tide water level when there is fresh water in the stream, but some of the factories use wells during the salt water period. Draft upon the ground water is causing a change in the quality of many wells by drawing in salt water. There is a definite limit to the amount of water which may be drawn from underground sources, and it is apparent that this limit has been reached.

Factories engaged in the production of large quantities of "heavy" products ordinarily locate where fresh water is abundant and can be had at the cost of pumping. New plants seldom locate under any other conditions and when there is a choice between localities, the one where water is abundant and cheap is selected, providing the other factors which control locations are the same. There is only one place on the coast of California where such conditions existed in the past—the upper bay and lower river country. Industries now located there expected to obtain water by pumping direct from tide levels, and the change brought about by the invasion of salt water has added to expense of operation and has discouraged increase in plants which involve increased use of water.

There is great need of restoration of the favorable conditions of fresh water which formerly existed in this region. New industrial establishments will be attracted by abundant fresh water. If California does not provide such facilities, northern cities will offer greater inducements and many industries will locate Pacific Coast branches in these northern cities. There are in these other states large areas of land where pure, fresh water is abundant and may be had for the cost of pumping from permanent lakes or streams.

Rates for water in California cities are higher than in the north, as is shown in the following table:

Cost of 500,000 Gallons of Water Per Month

San Francisco	$157 56
Oakland	161 71
Los Angeles	72 16
Stockton	54 50
Portland	44 11
Seattle	32 94

The recent disaster to Los Angeles' St. Francis Dam will probably result in an increase in water rates in that city. Proposals have been made to increase the base rate from 5 cents per 100 cubic feet to 18 cents. If this proposal is carried into effect the rate for 500,000 gallons in the above table will be nearly $120.

Hardness of water is another factor in which northern cities have an advantage over the public supplies in California cities. Hardness is undesirable in water for either domestic or industrial uses—in some classes of industries hard water must be treated before use.

The comparison below will show the relative hardness of public water supplies of Pacific Coast cities:

Hardness in City Water Supplies

Hardness as Calcium Carbonate, Parts Per Million
(From Water Supply Paper 496)

	Maximum	Minimum	Average	
San Francisco	166	83		
Oakland			181	Reservoir and wells.
Stockton			560	Wells.
Sacramento			60	River.
Los Angeles			163	Owens River.
			251	Los Angeles River.
Portland, Oregon	22	6	9	
Seattle, Washington	33	14	23	

The supply of Sacramento approximates the hardness of water that will be retained above a salt water barrier. The quality of water reservoired above the barrier will be better than any other city supply in California shown.

Hardness may be partly removed from water in modern purification plants. At Columbus, Ohio, water with average hardness of 272 parts per million was reduced to 97 parts at a cost of treatment of 2.45 cents per 1,000 gallons. (Proceedings of American Society of Civil Engineers, February, 1928.)

One of the needs of California today is a fresh water reservoir around which factories can be located with assurance of a permanent supply of pure water. Probably no single accomplishment in the construction program now under discussion will do more toward the general progress of the state More factories mean greater population and more local markets for agricultural produce and amelioration of the general level of prosperity of the state.

A salt water barrier at San Pablo or Army Point will remove the obstacle now deterring the location of new industries in this region. It will remove the cause of added expense to the present plants and will encourage their more rapid growth.

Besides great quantities of water, large industries require cheap power, efficient transportation facilities, both by rail and water, and a good climate attractive to labor. The lower river and upper bay region lack only water. The salt water barrier will supply this single deficiency. If the barrier is not built, California, without doubt, will lose many important factories.

Shipping Interests San Francisco Bay and the rivers drained through Carquinez Strait are used by boats engaged in river and bay traffic as well as ocean-going vessels At the present time there is a large amount of river and bay traffic between Stockton, Sacramento and numerous delta landings and the cities around the bay. During parts of the year the river traffic extends beyond Sacramento and upstream from Stockton Ocean-going vessels land at Carquinez Strait points, Bay Point, Pittsburg and intermediate ports. Traffic by water is on the increase.

Tables 6, 7 and 8, in this report, give the tonnage and value of freight carried by water.

Projects for the improvement of navigation above Carquinez Strait have been approved by congress and the work of acquiring rights of way in preparation for dredging is nearly completed. Two projects have been approved: First, the dredging of the channel through Suisun Bay to provide 26 feet of water for navigation purposes through this bay, and second, the Stockton deep channel which will provide 26 feet of water to Stockton.

Projects for deepening and regulating water depths for Sacramento River navigation are under consideration. A system of dams for controlling levels at low flow has been proposed, though not yet adopted by act of congress. The present project provides 7 feet of water to Sacramento, 4 feet to Colusa, and with provision for 3 feet as far upstream as Chico Landing. Practical navigation upon the upper San Joaquin is now limited to the head of tide water, though if the project of the state for canalization of the San Joaquin under the "Coordinated plan for development of water resources" is carried out, navigation will be practical to points far above any places recently reached by boats

Water transportation is available to all of the islands and reclaimed lands in the delta region, and nearly all of the agricultural produce grown in this country is shipped to market by boat

Tides, currents and salt water phenomena in the upper bay and lower river region are important to shipping interests for several reasons: First and foremost is the fact that the presence of salt water has retarded growth and, if continued, will decrease the agricultural productivity of this region Second, and no less important to shipping interests, is the fact that the industrial region along Suisun Bay and Carquinez Strait is held back in its natural growth by the menace of salt water. The water-carried tonnage in and out of this industrial area is large and is on the increase The completion of the deep water channel will give a stimulus to commerce by water.

The natural result of a salt water barrier would be to increase very rapidly the industrial territory and there would be, in consequence, much more freight to be moved, a larger population to be served, and a tremendous increase in shipping. The effect will be noticeable on both bay and river boats and upon ocean-going traffic.

The plans for a salt water barrier provide for locks so that vessels may have uninterrupted access to the fresh water basin above the barrier. As discussed later, the Young report considers thoroughly the shipping business and the plans provide for locks of at least two sizes—one for small vessels and the second for large vessels. Locks are designed to provide for future increase in traffic, both in size and amount of traffic and depth of drafts.

Tides and currents now cause a loss of time to the shipping interests and necessitate special provisions and greater care in the handling of vessels, particularly in the rapid currents in the Carquinez Strait region. A barrier will provide for a constant water level above the structure except during periods of flood, which will reduce the currents to one direction only, and that downstream, and will facilitate the movement of vessels by reducing the time now consumed by bucking adverse currents. The ability to dock without currents is an additional value to ships.

It is generally agreed by navigation interests that there is some benefit in sea-going vessels docking in fresh water, in the destruction of growths of salt water which cling to the bottoms of the vessels and reduce their speed Ocean-going shipping entering the fresh water basin above the barrier will have the benefit of this condition.

Sediment carried by the river waters into Suisun and San Pablo bays adds to the difficulties of navigation and causes annual expenses in its removal. Debris from hydraulic mining is one of the principal sources of such hindrances to navigation. The rivers which enter Suisun Bay bring to salt water each year a portion of the debris deposited in stream channels in years of unrestricted mining. From the best information available, it is probable that the peak of movement of debris has passed out of the rivers and is moving through Suisun and San Pablo bays en route to the ocean.

What effect the salt water barrier will have on the movement is important from the standpoint of navigation interests. Studies which furnish information on the problem have been made several times in the past twenty-five years. The brief statement below discusses these investigations.

In 1906 the writer, then in the employ of the United States Reclamation Service, made a study of the sediment carried by many important streams in the west The results are in part published in Water Supply Papers Nos. 274 and 237. The investigation had in part the determination of the amount of sediment carried in streams that might be lodged in storage reservoirs. At the time this study was undertaken, experimental work was carried on to determine methods of field and laboratory work. Sampling apparatus was designed and tested to permit the collection of samples at any depth. The use of this apparatus indicated that the problem resolved itself in two phases—suspended silt and sand rolled along the bottom. The suspended silt was found to be very fine and to remain in suspension a long time. It is moved as the water moves and in the tidal portions of the stream remains in suspension during the tidal movements.

Samples collected daily during 1906, a 125 per cent run-off year with heavy floods, gave an average silt content (weighed for flow) of 64.5 parts per million by weight or, for silt weighing 80 pounds per cubic foot, 0.081 cubic yards per acre-foot. In 1908, a 67 per cent run-off year, the average silt content was 85 parts per million by weight or 0.106 cubic yards per acre foot. The total suspended silt in 1906 was 2,300.00 cubic yards; in 1908 it was 1,550,000 cubic yards.

The greater part of this material continues in suspension until the bay is reached, where slow currents permit a part of it to drop to the bottom. Flocculation from salt water to some extent encourages the deposition.

A salt water barrier will have the effect of improving conditions as affected by the deposition of the suspended silt. Fresh water above the barrier will remove the effect of salt water flocculation above the structure and there will be a greater tendency for the silt to be carried lower than under present conditions. As it is now, the flocculation commences in Suisun Bay or at the first point where fresh water and salt water mix. Eighty per cent of the sediment is carried in the flood months, at times when the barrier gates will be opened and the current

above the barrier is highest. In these periods the tendency will be for sediment to be carried through the barrier with less deposition in Suisun Bay than under natural conditions.

Below the barrier, where fresh and salt water mix, there will be the same tendency for deposition and flocculation that now exists, the only important difference being the decreased tidal movements due to the barrier. There is no reason to expect any great change in conditions from those now found Sediment moves to a large extent in flood periods, so that any accumulations which are deposited in low flow periods or in years of light run-off are swept away in flood years. Fine sediment which enters the streams probably will not greatly change in amount in future years, as the fine materials originating in former hydraulic mining operations are on the decrease. Storage reservoirs on the headwaters will tend to trap sediment and further reduce the load that will arrive at tide waters. On the whole, the barrier will probably benefit rather than harm the navigation interests so far as it affects suspended silt.

Sand and coarse debris rolled along the stream bottom make up an important but unknown part of the total stream load of sediment. Estimates by the writer, made in 1905, indicated that the equivalent of from 10 to 20 per cent of the suspended load was carried along the bottom. In a recent study of silt in the Colorado River (U. S. Dept. of Agriculture Technical Bulletin No. 67), the estimate is made that in that stream 80 per cent of the silt is in suspension and 20 per cent carried as bed load. Though the actual quantity may be in doubt, there is no question but that the stream bed at Sacramento and below has been lowering in recent years—an indication that the burden of debris from the old hydraulic mines is decreasing.

Sand and gravel along the stream bed do not move at ordinary flows but only when the stream is in flood. The barrier, therefor, will have little or no retarding effect upon the movement of sediment carried along the bed, for in times of flood the flow in all practical consideration will be unobstructed and the downstream velocity wil be practically the same as without the barrier. The bed load will move as it now does, or at least will move as it would if the barrier were not present.

Structures in Water. The teredo and other varieties of marine life which destroy wood have been noticeably active in San Francisco Bay and adjoining waters since about 1914. Prior to that time all wharves, docks and other structures in water in the upper bay country were built of untreated piles and the lives of the structures were very long. About 1914 the teredo became active and in the dry years which followed 1917 practically all wood structures in water below Antioch were destroyed. The Marine Piling Committee estimates that $25,000,000 damage was done in this period. Of this sum several million dollars represent damage in the territory upstream from Richmond. Here the invasion of the teredo is encouraged on account of the encroachment of salt water. In earlier periods fresh water was present each year long enough to prevent wood-destroying animals establishing themselves.

Many of these structures have not yet been replaced. Those which have been replaced have been largely of creosote or other treated piling at an additional cost over untreated timber. No form of treatment

gives permanent protection but reduces the activities of boring animals and lengthens the life of timber.

The cost of structures built of timber is, therefore, greatly increased over what it was prior to the invasion of salt water in the upper bay. Where concrete is used an additional increase in cost also occurs, for concrete to be placed in sea water has to be of much better quality that concrete suitable for fresh water conditions. The ordinary mix of concrete for sea water contains approximately two-thirds of a barrel of cement per cubic yard in excess of that considered good quality for fresh water conditions. On this account alone concrete work costs at least $2 00 a yard more due to the salt water invasion.

Under the present conditions, all future structures to be erected in this region must be built to resist teredo and other boring animals and salt water. The increased cost of wharves, docks, bulkheads, and all similar structures in water, will approximate 20 to 25 per cent more that if fresh water were present. The construction of a barrier to prevent the encroachment of salt water will greatly simplify such construction work and will reduce the cost under present conditions.

Corrosion of Pumps, Piping and Equipment from Salt Water. Steel and iron are corroded more rapidly in brackish or salt water than in fresh water. Experiments indicate that unpainted steel or iron lasts from two to ten times as long as fresh water as in brackish or salt water. This means that all gates, pipes, pumps and other parts of structures in water, or in industrial establishments where water is used, must be pointed frequently or they will corrode more rapidly, require more frequent replacement, and cost more to operate than where fresh water is present. In the large industries, such as oil refineries, steel mills and plants where large amounts of cooling water are used, this becomes a very important factor.

Accurate estimates of the cost of salt water due to corrosion alone are difficult to make. Mr. C. W. Schedler, of the Great Western Electro Chemical Company of Pittsburg, California, estimates that there is a minimum of three million dollars' worth of equipment located in the plants between Crockett and Antioch being seriously depreciated by the presence of salt water. The normal life of this equipment is twenty years, or a depreciation of $150,000 a year. Mr. Schedler estimates that the salt water conditions of 1924 caused a depreciation twice as fast as ordinarily. The loss between Crockett and Antioch in that year is a cash loss of $150,000.

Conditions nearly as bad as 1924, so far as these industries are concerned, occurred in 1920 and again in 1926, and in each of the years between there is some increase in corrosion from salt water. Conditions in the future offer little promise of improvement, and the probability is that unless a barrier is constructed the present industrial plants alone, without consideration of future extensions or new plants, will suffer an annual loss from salt water in excess of that experienced in the past.

Estimates by the writer in the territory from Oleum to Antioch, on both sides of the channel, indicate a loss from salt water corrision in excess of that made by Mr. Schedler. The writer is of the opinion that the average annual loss approximates $300,000 a year in the plants now operating.

Railroads. The natural and most feasible direction of travel north to south is across Carquinez Strait for both vehicular and rail traffic. At the present time all railroad transportation is handled by boats. Four lines of boats carry freight and passengers across this waterway. A year ago the first bridge was built—that across Carquinez Strait—for vehicular traffic only.

The Southern Pacific Company, the greatest railroad system in California, has studied a plan of bridging Carquinez Strait for many years. It is understood that a more active study of this problem is now going on than in any time in the past, and that prospects are good for the railroad to carry out such a development.

The San Francisco-Sacramento Railroad, which crosses the channel near the upper end of Suisun Bay, at one time acquired a permit to build a bridge at this point. The traffic carried by the company did not warrant such a heavy expenditure at that time, but recently the control of this road has been acquired by the Western Pacific Railroad Company, and it is likely that a large development of this transportation company will take place in the near future.

Any barrier built to hold back tide water can be easily arranged to act as a bridge for rail and vehicular traffic. In the Young report, a part of which is quoted later, estimates of the cost of providing such a barrier with a bridge are given

Two applications have been recently filed with the county board of supervisors of Contra Costa County for a bridge permit across the bay region in the neighborhood of Richmond, the estimated costs being from $9,000,000 to nearly $20,000,000.

Should the barrier be built at San Pablo Point, it can serve there all present and probably future transportation needs A barrier in Carquinez Straits, either at Army Point or Dillon Point, will be available for rail transportation, and when the present bridge facilities are outgrown it may be used for vehicular traffic

Mr. Herbert Benjamin, of the Southern Pacific Company, stated before the Joint Legislative Committee on April 16, 1928, that his company had made plans for a bridge between Bulls Head and Army Point, and that the cost, including approaches, was estimated to be less than $10,000,000. The bridge was designed to give clearance of 70 feet. Application for permit had not been formally made to the War Department.

The site selected for this bridge is one of the sites investigated by Young, and any bridge built for the railroad would prevent its use as a site for a salt water barrier It is highly advisable that full consideration be given of the barrier problem before any bridge permit is let for this location The barrier can be made to serve as a bridge and the advantages of the double use are apparent If the barrier is built to accommodate both rail and vehicular traffic and a proper allowance made for this service, the net cost to other interests can be lowered. This phase of the question is discussed later in this report.

Ferries. The ferry from Benicia to Port Costa, now operated to care for vehicles, could be replaced by a barrier at Army Point or Dillon Point. The ferry now operating from Richmond to Point San Quentin could readily be replaced by a barrier at San Pablo Point. This slow method of crossing the water barrier can be replaced by a modern bridge, with little delay in traffic and with cost not greater than the

present ferry charges. The automobile registration in California is on the increase and travel across the straits will be greatly stimulated by a bridge. There is no certain method of determining this quantity.

Local Shipping. The tonnage and value of local shipping on the Sacramento and San Joaquin rivers are given in attached tables. It will be seen that there has been a nearly constant increase in freight, except during the period of, and following, the World War. At present 2,100,000 tons, of a value of $140,000,000, are carried yearly.

The increase in shipping which will follow the construction of a barrier against salt water will benefit local shipping. As shown elsewhere, the advantages of the barrier will offset the disadvantages, and on the whole greatly benefit shipping.

Ocean-borne Traffic. Ocean borne traffic is varied, though lumber and petroleum products make up the greater part of the business. The tables attached show the volume of business in Suisun Bay to be about 2,500,000 tons, valued at over $40,000,000; for Carquinez Straits 4,000,000 to 5,000,000 tons, valued at $100,000,000 to $150,000,000; San Pablo Bay, 4,000,000 tons, valued at over $60,000,000.

Increases in ocean-borne traffic will follow the building of a barrier and completion of a deep-water channel to Stockton. The stimulation to industrial production will greatly increase traffic for all classes of vessels. Ocean shipping will benefit by the ability to dock in fresh water without the menace now caused by tidal currents. Fresh water tends to cleanse ocean vessels of growths which retard movement.

The menace to shipping in passing through locks is so small that no additional insurance is charged to vessels which use locks. The safeguards to navigation, now provided around locks, greatly reduce the danger in using them. Periods of fog are the times of greatest difficulty. The removal of ferry traffic across the straits at Benicia will probably offset the dangers due to navigating through locks in foggy weather.

SOLUTIONS OF THE SALT WATER PROBLEM

Several solutions of the salt water problems may be suggested:

1. Salt water barrier.
2. Storage and release.
3. Fresh water brought in by conduits or pipes

The first is the only complete and the most satisfactory method of solving the problem The Young report best describes the barrier and its effects upon the territory.

The Young Report. Mr Walker R Young, Construction Engineer, U. S Bureau of Reclamation, has written a "Report on Salt Water Barrier—California, Below the Confluence of Sacramento and San Joaquin Rivers." This report is dated August 27, 1927, and was made by the U. S. Bureau of Reclamation in cooperation with the California State Department of Public Works, Division of Engineering and Irrigation, and Sacramento Development Association.

The report consists of a volume of 405 pages of discussion and descriptive matter, a volume of 592 pages of exhibits and tabulations, a portfolio volume of drawings and diagrams, and three volumes giving records of borings at various sites. The work described in these volumes extended over a period in excess of three years, or from January, 1924, to the date of completion.

A large amount of field work was done as a basis for office studies. The investigations include all problems that affect the construction or operation of the structure.

In his report Mr. Young describes in detail the various investigations he has made concerning the salt water problem. He presents sixteen preliminary designs and estimates with three alternatives "in order that they may be readily available in the economic study which is considered necessary in the final determination of the feasibility of the barrier." He made "no attempt to study the economic aspect of the problem other than to enumerate the advantages and disadvantages, as such a study was not considered within the scope of this (his) report." The report, therefore, is an engineering study of the barrier so far as concerns its physical feasibility.

The report determines what kind of a barrier should be built to accomplish its purpose, and presents a large amount of data to show its bearing upon various activities which will be affected by it. Four sites were investigated and the merits and objections to each are set forth in detail, but no final recommendation as to a site is made.

The following quotation from this report gives in condensed form the essentials included therein:

"SUMMARY OF RESULTS

"*General.* The studies made lead to the conclusion that it is physically feasible to construct a salt water barrier at any one of the sites investigated, but at great expense; and that it will be effective in controlling the salinity of the reservoir impounded above it. Not only will it protect the delta and industrial plants along the shores of the bays, but its construction will result in the conservation of a large part of the fresh water required to act as a natural barrier against invasion of water under present conditions.

"Without the barrier, salinity conditions will become more acute unless mountain storage is provided to be released during periods of low river discharge to act as a natural barrier against invasion of salt water. The amount estimated as necessary to act as a natural barrier was in excess of the flow in the Sacramento River above Red Bluff in 1924, and Red Bluff is located above the points of diversion of water used in irrigating the Sacramento Valley.

"The sites selected for development by drilling are considered geologically satisfactory for the type of structure proposed. Although preliminary designs and estimates are presented for four sites, there are only two general plans involved. A barrier, if constructed at the Army Point, Benicia, or Dillon Point site, would create a body of fresh water in Suisun Bay and in the delta channels, while a barrier at the Point San Pablo site would include San Pablo Bay as well.

"*Type of Dam Proposed.* The type of structure to which principal consideration is given is one in which the ship locks and flood gates are located at one side upon rock foundations, the closure of the present waterway being effected by means of an earth and rock fill dam to be brought up to its designed height after completion of the ship locks and flood gate structure. In another type studied the flood gates form the closure between concrete piers sunk to bed rock foundations in the present waterway by the open caisson method. Both types have been

designed with and without provision for carrying a railroad and highway.

"The passage of floods is probably the most important problem since it involves the safety of the delta levee system. It would be desirable, if practicable, to provide gate area equivalent to, or slightly in excess of, the present waterway area in order that conditions of flow might remain unchanged, but the accomplishment of this plan would be very costly, if not altogether infeasible.

"In the design of the structure, advantage is taken of the difference in the elevation of water surface which it is possible to create above and below the barrier to discharge flood water. On account of the fluctuating head, resulting from tides on the downstream side, the discharge through the flood gates will vary from a maximum at low tide to a minimum at high tide. The reservoir above the barrier, therefore, will function as a basin in which the river discharge in excess of the flow through the flood gates at high tide is stored to be discharged at a rate in excess of the river discharge during low tide.

"The flood gates are of the Stoney roller type with sills depressed to 50 or 70 feet below sea level in order better to control the salinity of the water behind the barrier as explained in Chapter IX. In operation, the gates would be raised clear of the water surface as required to allow free passage of the floods. As the flood receded the gates would be lowered, one at a time, as necessary to maintain the water surface above the barrier at any predetermined elevation.

"The requirements for passing vessels through the barrier is an important consideration irrespective of where it might be located, but particularly, if located below Mare Island Navy Yard. In the designs proposed, ship locks have been provided in number to care for considerable growth in water-borne commerce, and in size to pass the largest ships likely to navigate the waters above the barrier.

"In some of the designs for the Army Point site, the ship locks would be constructed away from the flood gates, which, of course, would be advantageous for shipping during the passage of great floods from the rivers, but these are rare and considerable study would be required before it could be determined whether the advantage thus gained would offset the advantage of having the large salt water sump adjacent to the ship locks where the salt water entering the fresh water reservoir through the locks could be caught and returned to the salt water side. It is possible that the design with the ship locks and flood gates separated would be even more efficient in controlling salinity, but this is doubtful. The plan at the Army Point site in which the structures are separated interferes least with the plant of the Mountain Copper Company and results in economy otherwise.

"In the designs including a railroad and highway bridge across the locks these have been placed at an elevation to permit a large proportion of vessels using the locks to pass underneath without opening or lifting the bridges. In one design at the Dillon Point site, the clearance is made sufficient to pass large ships without the necessity of moving bridges. Adequate clearance will be more important 25 years hence than at present on account of the increase to be expected in commerce.

"A fish ladder is provided in one of the ship lock walls and provision is made for relieving salinity above the barrier by pumping salt water from that side in an emergency. The design of the structure is discussed in Chapter IV.

"*Estimated Cost.* Following is a table showing the estimated cost of the barrier at each of the sites investigated. It should be noted, particularly, that the estimates for the Benicia site are based upon assumed foundation conditions since the site was not developed by drilling as were the other three sites. No attempt will be made to analyze the costs, as such an analysis would be quite involved and of no particular value. Conclusions as to the desirable plan can be arrived at best by balancing the estimated costs against the features of the design as shown on the general plans referred to in the table, and to other drawings contained in Volume IV. Estimate No. 13 is unique in that Carquinez Straits, for its full width, is taken advantage of in providing an extra large flood gate area, and the railroad and highway bridges are placed at the elevation required to avoid the necessity of lifting bridges to allow the passage of vessels.

"The preliminary estimates are believed to be conservative. Refinements in the final designs will undoubtedly result in reduction of quantities. All construction materials are readily available in large quantities and can be brought to any of the sites investigated by rail or water. Large manufacturing plants, foundries and machine shops are located nearby, all tending toward low unit costs. The estimates of cost are based upon present prices of material and labor. Should these change materially it will, of course, be necessary to make adjustments in the estimates.

"The benefits to be derived from the construction of the barrier are believed to be commensurate with the cost but an economic study of the situation must precede the adjustment of the cost of the barrier for the reason that so many interests will be directly affected—beneficially or otherwise. The true value of the project can be determined and a decision reached as to who should contribute to the cost thereof only after such a study has been completed.

"*Tides and Floods.* The most critical condition to be met is a combination of a large flood from the rivers, a storm on the ocean tending to pile up the water driven through the Golden Gate in the bays, and an unusually high tide. An analysis of past floods leads to the conclusion that provision should be made for the passage through the barrier of not less than 150,000 second-feet.

"According to computations made the effect of a barrier of the type proposed at the Army Point site would be to raise the water surface immediately above the structure 0.7 of a foot with a discharge of 750,000 second-feet. The effect would be felt less at the mouth of the rivers as a result of the smoothing out of irregularities by the reservoir created. The studies indicate that if a 750,000 second-foot flood from the rivers should coincide with a tide reaching the maximum height records at Army Point in 1909, but otherwise similar to the high tides of January 24 and 25, 1914, the elevation of extreme high water (8.5 feet above mean sea level) at Collinsville, computed by the flood control bodies of the state, would not be exceeded.

"It is probable that the rise in water surface at Collinsville, due to a barrier at the Point San Pablo site with equivalent gate area, would be less than if located at the Army Point site, but it would not be safe to reduce the gate area at Point San Pablo for the reason that extreme tides through the Golden Gate are more effective near the gate as evidenced by the fact that the tide of November 18, 1918, at Presidio, was 0.7 feet higher than that of January 25, 1914, at which time the maximum elevation of water surface at Suisun City was reached.

"At the Army Point and Dillon Point sites the ship locks are considered effective in passing extremely large floods, but they are not considered available at the Point San Pablo site because of the greater necessity for keeping the locks open to navigation at that site, even during great floods.

"The effect of a barrier at the Army Point site would be to reduce the tidal volume passing the Golden Gate by less than 8 per cent in comparison with about 35 per cent if it were built at the Point San Pablo site. The occurrence of frequent high tides in the bays due to piling up of water in them as a result of storms on the ocean would be to elimininate through construction of a barrier at any one of the sites investigated. The effect on the elevations of tides below the structure would be to raise them slightly according to the U. S. Coast and Geodetic Survey

"*Navigation and Bridge Traffic.* Any plan for the control of salinity involving the construction of a dam across the bay or river channels must be coordinated with the requirements of navigation.

"Ship locks are provided in number and size to meet the requirements of the present and immediate future. Provision for ultimate traffic at the time the barrier is constructed does not seem necessary since flood control on the upper rivers will improve to permit the replacement of flood gates by ship locks as the need for them develops. A summary of the operation as it would have occurred on July 6 and 7, 1925, is shown in Table 6-33.

"Although railroad and highway bridges are contemplated in most of the designs they are not regarded as indispensable and are omitted in some anticipation of indifference on the part of railroad and highway interests toward the opportunities afforded by the barrier. In the studies made it is considered that traffic over them is subject at all times to the convenience of navigation. The bridges are designed to give a vertical channel of 50 feet above high water when in the lowered position and 135 feet when raised. The interruptions to bridge traffic, as they would have been on July 6 and 7, 1925, are summarized in Table 6-40.

"An examination of Plates 2-3 and 2-4, showing depths in San Pablo and Suisun bays, will indicate the limitations placed upon commerce under present tidal conditions. If the elevation of the water surface above the barrier were maintained at about 2½ feet above mean sea level, a constant depth equivalent to that at mean high tide under present conditions, would be obtained Uncertain and varying tidal currents would be eliminated above the barrier and they would be reduced in velocity below. The maintenance of a permanent water level would not only be convenient for navigators, but would be a material benefit to owners of wharf property above the barrier.

"The farther downstream the barrier is located the more it will interfere with shipping. Locking requirements can be satisfied with least expense at the Army Point site and conditions are most unfavorable at the Point San Pablo site.

"The construction of a barrier at the Point San Pablo site probably would be looked upon with disfavor by the Navy Department for the reason that it would restrict free navigation through San Pablo Bay to the Mare Island Navy Yard by the necessity of passing war vessels through ship locks. This objection does not apply to the Dillon Point, Benicia or Army Point sites.

"*Storage in the Delta Channels and Bays.* For convenience the calculated storage in the tidal prism above each barrier site, between elevations—3.6 and+6.4 U. S. G. S. Datum (0 and 10, U. S. Engineer Datum) has been summarized in Table 7-2, Volume II.

"*Silt.* The problem has been attacked with the idea that any structure that would be detrimental to San Francisco Harbor would be looked upon with disfavor by those in jurisdiction. The investigation has not definitely determined the effect of a barrier upon silting. Conclusions must, therefore, take the form of conjecture until studies more comprehensive than it was possible to make in this investigation have been completed.

"The construction of a barrier at any one of the sites investigated may possibly have a beneficial effect upon the Golden Gate bar rather than detrimental. The movement of silt toward San Francisco Bay will be checked by the construction of a barrier at Army Point, Benicia, or Dillon Point. A beneficial effect upon the Pinole Shoal will result through the construction of a barrier at Army Point or Point San Pablo. The effect upon Pinole Shoal of a barrier at Dillon Point is at present indeterminate, as is also the effect on silting in San Francisco Bay of a barrier at Point San Pablo.

"Whether the scouring action of the tidal current tends to maintain or destroy fixed channels in the bay system remains to be determined. Should shoaling occur it will be comparatively small in amount and the channels can readily be maintained by dredging, perhaps with less effort and expense than without the barrier. Dredged material pumped into the marshes would build them up and improve their fertility.

"*Salinity.* In years of normal river discharge there is no salinity problem in the delta. It is menacing for a few days in the fall only but, considering the marshes surrounding the upper bays and the towns and industrial plants along their shores, the encroachment of salt water presents a serious problem almost every year.

"Conflict between irrigation interests in the upper valleys and in the delta region never will occur in years of large run-off for the reason that in the development of storage the construction of expensive reservoirs to hold the excessive run-off from the drainage area, occurring only once in a number of years, will not be practicable even though sufficient reservoir sites in which to store all of the run-off were available.

"The introduction of salt water into the fresh water lake through the ship locks can not be prevented but means are provided for drawing

off this salt water and thereby controlling the salinity of the water up-stream from the barrier.

"Leakage of salt water past the flood gates, although comparatively small in amount, can be prevented by maintaining the water surface above the barrier at a higher elevation than below.

"Deep gates, opening from the bottom, are essential to the successful operation of the barrier for dependence is placed upon them as a means of drawing off the heavier salt water which seeks the deep holes and channels, and for flushing out the reservoir above the barrier.

"Unless fresh water is available for occasional flushing, the reservoir above the barrier will gradually become salty. Flushing can be accomplished quite readily if water is available for that purpose. The studies of water supply, although based on meager data, indicate that in normal years there will be from eleven to twelve million acre-feet available for that purpose. In years of deficient water supply there will be little, if any, fresh water available for flushing and the reservoir above the barrier may have to hold over one or more years without flushing.

"*Return Flow.* Return flow will increase with irrigation development in the upper valleys with the result that the salt menace in the delta will be alleviated; but, even though the return flow should increase to the 3500 second-feet estimated to be sufficient to act as a natural barrier against encroachment of salt water, the demand for water will be such that it could not be used for that purpose unless it is replaced by water from mountain storage.

"*Control of Salinity by Storage in Mountain Reservoirs.* Salinity in the delta can be controlled through construction of storage reservoirs in the mountains from which water could be released during the season of low river discharge in the amount necessary to act as a natural barrier against invasions of salt water. Mountain storage would be a temporary expedient for the reason that, ultimately, there will be use for all of the available flow from the rivers, and the discharge into Suisun Bay and thence to the ocean, of water sufficient to act as a natural barrier against salt, would be an economic waste. However, storage created in mountain reservoirs constructed mainly for other purposes might be used for some time to control the salinity in the upper bays and delta channels during development of the requirement for full use of the reservoirs for the purpose for which they were primarily constructed, thus deferring the large investment in the salt water barrier.

"*Teredo.* The factor of salinity is one of fundamental importance in the distribution of teredo. The average lethal salinity for teredo navalis, the species to be feared most in the upper bays, has been determined experimentally as 5 parts per 1000; therefore, if the water above the barrier is maintained at a concentration below the limit for irrigation use teredo can not exist there.

"*Fish.* Fishing industries above the barrier, if constructed, should not suffer for the reason that, even though the fish ladder, which is an integral part of the structure, should fail to function, the fish would not be prevented from entering the fresh water reservoir because they would have free access to it through the ship locks which, under normal conditions, would be operated many times throughout each day and night.

"*Sewage.* No investigation was made of the effect of the barrier upon sewage, but from investigations made elsewhere it appears that fresh water will be better adapted for receiving sewage than either salt or brackish water since, gallon for gallon, fresh water disposed in a normal manner of more sewage than salt water. It will be best, in this respect, to keep the water above the barrier fresh because the intermittent admission of salt water interferes with bacterial, animal and vegetable growths that effectively aid in taking care of and digesting sewage.

"*Use of Water in Operation of the Barrier.* The seven main sources of loss of fresh water accompanying the operation of the barrier are evaporation from the water surface of the reservoir created; water required for the operation of the ship locks; leakage around the flood gates; water used in operating the fish ladder; and water to supply the requirements of industries, municipalities and possibly irrigation. With the exception of losses past the flood gates and through the fish ladder, which are constant for the same type of structure, the losses increase as the barrier is moved downstream and this factor has an important bearing upon the selection of a site.

"Owing to the increasing difficulty of maintaining the reservoir created by the barrier free from salt water as the water surface is permitted to fall, and because of navigation requirements, it probably will not be advisable to allow the water surface to fall below mean sea level. Likewise, because of the nature of the delta levees and the cost of drainage in that region by pumping, the ultimate maximum allowable water surface for periods of several months' duration may be fixed at 4.0 feet above mean sea level, although later developments may show that this maximum storage level can be increased to 5.0 feet.

"It is not necessary to decide at this time at what elevation the water surface above the barrier should be maintained. To begin with, it should be held at, or a little below, ordinary high tide level. As time goes on the elevation may be raised as experience dictates.

"Water drawn from the fresh water lake for irrigation, domestic and industrial uses, as well as that required in the operation of the ship locks, should be replenished from river flow or mountain storage with the idea of maintaining a constant depth of water for the navigable waterways effected by construction of the barrier. In years of extreme low run-off the water surface could be drawn down to the elevation of mean sea level, or possibly, in an emergency, to the elevation of mean lower water.

"As the water surface behind the barrier is lowered, the cost of maintaining the Delta levee—not considering floods—should become less; the cost of pumping water out of the lake for any use becomes greater; the cost of pumping seepage water would become less; the difficulties of keeping the lake fresh would increase; and the depth of navigable channels affected would become less

"Ship locks are provided in various sizes in order to economize on the use of fresh water and to prevent entrance into the fresh water lake of larger volumes of salt water than necessary by requiring vessels to use the smallest lock which will accommodate them. Intermediate lock gates are added for the same reason.

"Economy in the use of fresh water in the operation of the ship locks can be effected through the adoption of lock gates divided horizontally at a depth to allow a large portion of the vessels having a shallow craft to pass through the locks without opening the lower half of the gates and it is assumed that this type of construction will be adopted. It is estimated that the resulting annual saving of fresh water, based on an average daily traffic as it was on July 6-7, 1925, would be:

Army Point site	173,000 acre-feet
Dillon Point site	146,000 acre-feet
Point San Pablo site	295,000 acre-feet

it being assumed that the water surface above the barrier would be maintained at an elevation 2½ feet above mean sea level.

"It will be necessary to flush the reservoir, preferably once each year, to rid it of accumulations of brackish water resulting, principally, through the inability to trap all of the salt water finding its way into the fresh water reservoir from one source or another. The amount of fresh water required can not be predicted with any degree of accuracy but a study was made of the amount of fresh water available for the operation of the barrier, based upon the assumption that storage in the mountains was well developed. The study is based upon meager data but the results are believed to be indicative.

"From Table 10-13, it is evident that if the maximum height of water surface in the reservoir is restricted to 2½ feet above mean sea level, the water stored in the reservoir thus formed will not be sufficient to operate the barrier at any of the three sites studied during the irrigation season, even in years of heavy run-off, and it will be desirable, therefore, to seek the highest practicable elevation at which to maintain the storage level.

"The shortage due to lack of reservoir capacity increases as the barrier is moved downstream, although the capacity of the reservoir is greater. This is principally due to the greater evaporation, and to the larger requirements of navigation, industries and municipalities.

"As the storage elevation above the barrier is raised the amount of water available for flushing in years of low run-off is decreased. According to Table 10-13, no water would be available in the season 1923-24 for flushing out the reservoir created through construction of a barrier at the Point San Pablo site whether water were impounded to elevation +2.5, +4.0 or +5 0. It appears that, in any case, there would be no flushing water available in 1923-24 if water were stored to elevation +5.0, although in a normal year there would be a large amount available for flushing, regardless of where the barrier is constructed or of the elevation at which the water surface above the barrier is maintained.

"If the above analysis is correct, it may be concluded that since one of the principal objects of the salt water barrier is to conserve fresh water, it will be desirable to maintain the largest practicable storage capacity above the structure. Likewise, it is evident that the farther downstream the location for the barrier is chosen the greater will be the quantity of water required for operation, and the greater will be the shortage during seasons of low run-off. Since the shortage must be

supplied from mountain storage in order to maintain sufficient depth for navigation, and to hold the water level at an elevation where the reservoir will not be deluged with salt water whenever the ship locks are opened, it is apparent that consideration of the necessity for conservation of water would require the selection of one of the upstream sites—Army Point, Dillon Point or Benicia, if the latter, upon investigation, is found to be suitable structurally."

Discussion of Young's Report. The summary just given of Young's report gives his main engineering conclusions. As will be seen, the engineering conclusions are as follows:

1. The construction of a salt water barrier is feasible at either San Pablo Point or at one of three sites near the upper end of Carquinez Strait.

2. The barrier can be utilized for both rail and automobile traffic.

3. The cost will depend upon the method of construction. A barrier can be built at Army Point with bridge of 50-foot clearance for $49,800,000; at Benicia for $46,200,000; at Dillon Point for $44,700,000; at Point San Pablo for $75,200,000.

4. The barrier will pass a flood of 750,000 second-feet (larger than any flood measured into Suisun Bay) with an estimated raising of water surface of 0.7 of a foot at the barrier, at Army Point, and about 0.55 of a foot at Collinsville. Water levels in the delta under extreme conditions are estimated to be below elevations of high water computed by Flood Control Engineer of the state. With a barrier at Point San Pablo, the raise in water level would be slightly less than at Army Point.

5. The barrier would effectively handle both water transportation through locks and bridge transportation.

6. The barrier would store fresh water and prevent the encroachment of salinity now taking place every summer.

7. The barrier will prevent teredo from working above its location.

8. The barrier can be operated so as not to be a detriment to the fishing industry.

9. The elevation at which water is maintained above the barrier in summer has not been determined. To begin with it should be held a little below ordinary high tide. This point is discussed in more detail in the following pages.

10. Young makes no determination of the economic features of the barrier, nor does he recommend a site.

Two things in connection with Young's conclusions may be given further consideration: first, that return seepage will increase in quantity and ameliorate conditions in the delta, and, second, that water from the Sacramento river may be temporarily carried across the delta for use in the San Joaquin valley by releasing stored water and without the construction of the salt water barrier.

With reference to the first matter, it has been shown that return seepage in the San Joaquin valley is being recaptured by the pumping plants on the west side of the valley and there is now no benefit from the return seepage to delta lands in late summer. There is no prospect for increase in return flow, in fact the increase in pumping from wells all over the valley and new pumps along the river will decrease that flow.

In the Sacramento valley similar conditions prevail. It is not certain that return seepage on this stream has reached a maximum, because a large area of land close to the river is not yet regularly irrigated. When this land becomes more intensively farmed, it is to be expected that it will utilize to a great extent this very return water and decrease the net amount which reaches the tidal waters. Return flow, therefore, cannot be depended upon, in either river, to improve salt water conditions in the delta.

As to the second matter, it may be said that so long as the tide ebbs and flows there will be the opportunity for salt water to penetrate the delta, just as far or farther than was the case in dry years since 1917. In 1920, 1924 and 1926, salt water went beyond Three Mile Slough, the principal connection between the Sacramento and the San Joaquin deltas. If water were drawn up the San Joaquin, there would be a greater tendency for salt water to penetrate the delta and be drawn southward. It should be remembered, too, that in dry years released water from storage reservoirs is going to be very difficult to deliver past the large areas of riparian lands. The flow of the rivers will undoubtedly be so low that tides will carry salt water beyond Three Mile Slough. Certainly no dependence can be placed upon this method of carrying water across the delta. The barrier is essential to prevent tidal movements and the encroachments of salt water.

ELEVATION OF WATER ABOVE BARRIER

Objection, from owners of delta land, has been raised to the proposal by Young that levels above the barrier might eventually be raised above mean high tide in order that more water might be stored for use by the towns, irrigated area and industries around the lake above the barrier.

Mr. G. A. Atherton, who is probably as thoroughly acquainted with the delta region as any other person, is authority for the statement that a level of 6.0 feet U. S. E. D. (or 2.4 U. S. G. S.) continuously maintained in summer months is as high as can be safely held against the delta levees under present conditions. According to him, to carry water higher would endanger the levees would increase seepage and pumping, and therefore add greater maintenance cost to the delta land owner. It should be understood that Mr. Atherton has reference to the delta lands where peat predominates.

The answer to this argument is that the delta lands will be surrounded by salt water unless the barrier is built, but the barrier can, and should, be operated so as to do no damage to these peat areas.

There is some uncertainty as to the exact difference between the datum of the two surveys (U. S. G. S. and U. S. E. D.) and the level of tide as indicated by tide tables. U. S. G. S. elevations refer to mean sea level and are based upon a number of years of observation. U. S. E. D. levels are based theoretically upon mean lower low water but practically are taken as 3.6 feet lower than the U. S. G. S. levels. Tide gage levels are theoretically based upon mean lower low water but practically are referred to the elevation of a point on the Presidio tide gage staff in San Francisco. As near as can be determined, the U. S. E. D. and tide table datum planes are not the same, but the U. S. E. D. datum is about 0.63 feet lower. This figure is not exact, however, and for practical purposes it may be assumed that the two are the same. In the delta region the tidal range varies more in different

parts of the delta than this variation between the two systems of measurement.

If water is held at 6.0 U. S. E. D., it will be at less than high tide in the central delta. Here the tide rises to over 7.0 feet two or three times a year, and in times of southwest storms it has risen to over 8.0. In 1907, during the flood, the elevation exceeded 10.3. With water held at 6.0 there will be no menace to levees and comparatively little increase in pumping out of seepage water. Furthermore, this elevation will permit the efficient operation of the barrier, for salt water is higher than 6.0 at the Golden Gate less than one per cent of the time, excluding storm and flood periods.

Any increase in height should be made only if it can be done without menace to the island levees. In storm periods water will be held lower than would naturally occur except in the most extreme floods. Reservoirs which have been constructed on nearly all tributaries of the Sacramento and San Joaquin rivers will undoubtedly have the effect of reducing the peaks of floods, and there is little likelihood of a repetition of the extremes experienced in 1907, at least such extremes will occur less frequently.

On the whole, the delta lands will be better off with the barrier than without it. The one factor of slightly increased pumping with the summer level held at 6.0 will be more than overbalanced by the freedom from the present menace of salt water.

SELECTION OF SITE FOR BARRIER

Mr. Young in his report sets forth the conditions surrounding the locations investigated as sites for the barrier. The following statement compares the two locations—the three sites investigated near the upper end of Carquinez Strait being treated as one:

Water Supply. Tables attached give the estimated quantities of water required for all uses above the barrier. The quantities here given are estimated uses when all area above the barrier is developed and are liberal figures, with an allowance for flushing to remove salt water let in by ship locks and leakage. The figures show that under these conditions the requirements for the full year are:

Point San Pablo	2,024,000 acre-feet
Army Point	1,160,000 acre feet
Difference	864,000 acre feet

For the irrigation period May to September, inclusive, the requirements are:

Point San Pablo	1,236,000 acre-feet
Army Point	638,000 acre-feet
Difference	598,000 acre-feet

The large difference comes principally from the quantity of water required to operate locks and the increased evaporation in the lower site. In other words, from six to eight hundred thousand acre-feet are required to supply the additional unavoidable losses from evaporation and ship lockages in San Pablo Bay.

In the matter of cost, Young's estimates show for a barrier with 50 feet of clearance the following:

Point San Pablo	$75,200,000
Army Point	49,800,000
Difference	$25,400,000

The convenience to other interests is of great importance. The Mare Island Navy Yard is located above Point San Pablo but below Carquinez Strait, naval officers will object to the barrier. On account of the greater number of vessels which pass San Pablo than through the upper end of Carquinez Strait, there will be less objection to the upper site.

Barriers at both sites will serve as bridges. The San Pablo location will replace a ferry now in operation—the upper site in Carquinez Strait will serve both for rail and vehicular traffic and will replace two ferries

The opportunity to combine the barrier with the Southern Pacific railroad at Port Costa should not be overlooked. The railroad company is contemplating the construction of a bridge to replace the present ferry. If the Army Point-Suisun Point site is selected by the railroad, the barrier can not be built on this site. In some respects this is the most attractive site and until final determination is made of the location, no permit should be given for a bridge across this place.

STORAGE AND RELEASE TO CONTROL SALT WATER

This method of solving the salt water problem has been suggested in several recent publications of the Department of Public Works. Examination in detail of the proposals shows that "salt water control" means the supplying of water of less than 100 parts chlorine per 100,000 to the delta lands Emmaton on the Sacramento and Jersey Island on the San Joaquin are the limits of control and no suggestion has been made that it is practical to release water to supply Antioch or any of the lower industrial area. This, in fact, leaves out of consideration the area now most seriously damaged.

Studies by the Division of Water Rights based on records including the year 1925 show that to control salinity below 100 parts chlorine per 100,000, the combined flow of the Sacramento at Sacramento and San Joaquin at Vernalis (both points about the head of tide water in late summer) must exceed the following figures:

For control at	*Cubic feet per second*
Emmaton and Jersey Island	3500
Antioch	5000
Collinsville	5500
Oakland and Antioch ferry	6000

These quantities will depend to some extent upon the months preceding the period when control is desired and will, of course, vary with the diversions below the points of measurement. Furthermore, storage of water above tide level will affect the matter by limiting the distance salt water is forced downstream by spring floods.

To effectively supply these quantities of water will require very large storage capacity in dry years.

In 1924, storage in excess of a million acre-feet would have been required to control salinity at the Oakland and Antioch ferry and 370,000 at Emmaton and Jersey. In 1926 over 500,000 acre-feet would have been required at the Oakland and Antioch ferry and 200,000 acre-feet at Emmaton and Jersey. Storage in large amount would be needed about half the years at Emmaton and Jersey and every year for control at the Oakland and Antioch ferry.

The above is under the assumption that storage and diversions in these two valleys do not increase. As shown earlier, this condition has already been violated, for there has never been such increased activity in building storage reservoirs as in the period since 1924. Many reservoirs are planned for construction in the near future. Furthermore, diversions increase every year. Estimates of the quantities required for storage control must therefore be continuously revised upwards.

Release of stored water, to control salinity, will occur in dry parts of the year and to the greatest extent in dry years. To effectively control the right of storage and release, all riparian owners below the reservoir must agree to the arrangement. As the law now stands, the use of such a reservoir may be enjoined and it will be impossible to prevent, except through litigation, the riparian owners from diverting the released water. This difficulty can be removed by condemnation of rights along the stream. The problem looks too large for human accomplishment in any reasonable time and at any reasonable cost.

To one acquainted with water problems in California, it does not seem reasonable to expect that in the dry part of a dry year a flow of 5000 or more feet per second would be allowed to pass pumps and ditches, under which crops were suffering, in order that salt water could be pushed back into the ocean.

As to the cost of storage reservoirs to accomplish the release for salt control, there is little definite information which permits a comparison of costs. The following statements are of some interest:

Kennett Reservoir is proposed by the State Department of Public Works as a unit in the "Coordinated Plan." (See Bulletin 13, Department of Public Works, 1928.) The recommended reservoir capacity is 2,940,000 acre-feet; the estimated cost of dam and rights of way is $55,000,000; of power plant $25,000,000; a total of $80,000,000. With allowances for prior rights, mean annual irrigation yield of reservoir will be 2,838,000 acre-feet. In minimum years the deficiency would be large; 19 per cent in 1920, 42 per cent in 1924. If this reservoir were depended upon for salinity control, the entire available supply would be needed to control salt water at the mouth of the river, leaving no water for the area depending on this reservoir for irrigation. In other words, the very year when the reservoir is most needed it would be of little practical use. Furthermore, Kennett is not practicable unless operated to generate electric power. If the water is held and released for salt water control, the power value is greatly decreased.

Iron Canyon Reservoir is proposed as a secondary unit in the "Coordinated Plan." (See Bulletin 13 of Department of Public Works.) The recommended capacity is 1,121,900 acre-feet; the estimated cost of dam and power plant is placed at $26,000,000; the canal system to utilize this water is estimated at $30,000,000. The reservoir may be utilized in controlling salinity. To quote from the above mentioned report, page 115:

"Sacrificing the power features at Iron Canyon dam would, with other construction unchanged with the exception of the arrangement of outlets through the dam, supply a reserve storage of 364,600 acre-feet of water in Iron Canyon Reservoir to overcome, or alleviate, the salt

water menace in the delta region should such be desirable. Such use is not advocated, but it is demonstrated that there are possibilities along this line."

Should the irrigation feature likewise be disregarded, Iron Canyon would provide a net annual irrigation draft of 800,000 acre-feet or just about enough water to control salt water as low as the mouth of the river—provided the water could be carried past head gates and pumps on its way to tidal waters. Under this condition the power feature would be sacrificed to a larger extent. It is difficult to picture a dry year when water and power are both scarce, in which it would be possible to release a large quantity of water, disregarding its best use for power, and have the the riparian and appropriative users of water along the hundred and fifty miles of the Sacramento River permit this flow to pass by uninterrupted to tide water. The plan does not look practical.

Other reservoirs may be used for the same purpose, that of increasing the flow to control salt water. For example, a reservoir on Feather River has been suggested, another on the American at Folsom. Both of these reservoirs will have value for power development and that value will be greatly reduced if a large quantity of water is held for saline control. The most practical suggestion is in connection with a reservoir on Dry Creek, north of the Mokelumne, the water to be diverted from the Mokelumne River. The rights obtained by the East Bay Municipal Utility District for storage in Lancha Plana Reservoir practically eliminate this reservoir from consideration.

In connection with the proposal for storage and release of water, it should be remembered that the State Department of Engineering has made the suggestion as a temporary expedient, with the expectation that permanent relief would be brought about by the construction of the salt water barrier. This state of affairs would leave the delta lands dependent on a temporary right to be replaced by a permanent right which would be arranged for at some later time. With the growing condition of California and the certainty that the temporary supply will be invaded by increased diversions, this is a very precarious water right, not one which will satisfy the delta land owners. Furthermore, the plan does not consider users below the delta, either towns or industries.

New industries will not be attracted by any temporary improvement in water conditions. Some permanent solution must be reached. It is important to California to have the decision made at once so that the great industrial expansion now going on can be located to a maximum extent in this state.

WATER FROM OUTSIDE SOURCES

Water may be brought in from outside sources to supply the towns and industries along the Straits and Suisun Bay. It is not likely that the agricultural lands can be reclaimed by any outside source of water on account of the high cost. But for the uses of towns and factories it is possible to secure outside water.

Under present conditions water can not be drawn at any point on tide water without either running the risk of getting salt water or of interfering with rights already vested. It may be possible to pump during the fresh water period into reservoirs and to pipe the water thus

stored along the waterfront, supplying both domestic and industrial consumers. Reservoirs of good size are available in the Montezuma hills north of Suisun Bay and a few small reservoirs are found on the south side of the bay. No estimate has been made of the cost of this method. Surveys beyond the scope of this report would be required. It is known that the cost would be large, though cheaper than any other known source.

Other possible outside sources are:

Eel River—A supply which has been suggested for both San Francisco and east bay cities. The distance to Carquinez Strait is 125 miles. Harroun estimates the cost at $22,000,000 to carry 50,000,000 gallons daily to south sides of Carquinez Straits.

Conn Valley—A small tributary to Napa River with probable yield of 10,000,000 gallons daily. Cost not known but the supply would only furnish a part of present needs and would provide nothing for future growth.

Putah Creek—A tributary of Sacramento north of Dixon. Cost not known. About 50 miles north of Suisun Bay. Complicated with riparian claims. All storage at considerable distance in mountains.

Mokelumne or Cosumnes—Drainage Sierras north of Stockton. Cost unknown. Early rights conflicting. About 75 miles distant.

Pumped water from San Joaquin Valley—It has been suggested that the irrigation districts in the San Joaquin Valley could deliver pumped drainage water into the river to be pumped out above salt water limit and delivered to industries and towns along the bay through pipe lines.

East Bay Municipal Utility District—The main pipe line of this district parallels the bay shore from Antioch to Bay Point. To secure water from it the area must enter the district. The district has voted $64,000,000 to complete a 60 m.g d. supply. Water will be costly if the entire cost is collected from rates, and there is little incentive for Contra Costa County and towns to enter this organization. The water is too costly for the heavy industries, such as now are located along the waterfront.

All of these sources are so distant and costly that the supplies are more of the nature of domestic supplies than of cheap industrial water supplies such as are required in any large and growing industrial region. None of them solves the salt water problem as affecting construction along the waterfront and none of them can possibly be made available for agricultural industries on the bay lands.

THE BARRIER AS A UNIT IN THE STATE COORDINATED PLAN OF WATER CONSERVATION

A plan for the development and use of all waters of the state upon a coordinated plan has been presented in part to the Legislature of the State Department of Public Works. This plan provides for the storage and utilization of all water required in the Sacramento Valley and the transmission of excess water to the San Joaquin Valley for use on lands for which insufficient water can be supplied from local sources. The salt water barrier is a necessary unit in this plan, for water can not be carried through the delta with tidal flow bringing salt water in and out of the channels twice a day.

GENERAL DEVELOPMENT OF BAY REGION

The entire bay region is interested in the salt water problem in that the prosperity of the region immediately concerned affects the prosperity of the cities. The industrial territory along Carquinez Strait is essential to the well being of the whole state. The industries are fundamental to modern civilization. Oil, gasoline, lubricants, steel, fertilizers, sugar, leather, timber, soda, chlorine, fire-proof roofing, paper board, brick, tile, flour, mill feed, and the remaining varieties of manufactured products are necessities of modern existence. To have them abundant and cheap is greatly to the advantage of modern society.

Many of these factories would be classed as nuisances if located in a large city, on account of the odors. Carquinez Strait and Suisun Bay have regular winds which prevent a serious nuisance in this locality. Other communities are not so fortunately situated.

The ratio of factory employees to population of towns is about 1 to 4. This means that the population of the towns immediately surrounding the industries will grow as the industries thrive. This population in towns makes a market for the products of the cities and the multitude of manufacturing establishments which have located in the cities. The heavy industries in turn furnish raw material for use in the factories in the cities.

As a result of this interlocking of interests, the large cities of the bay region have a direct interest in seeing a salt water barrier established. Behind it, around the fresh water lake thus created, there will grow up a thriving community engaged in the production of essential materials which could not be produced within the cities themselves.

CALIFORNIA NOW IN THE INDUSTRIAL AGE

California is now in an age of industrial growth. Approximately one-third of the people of the state are engaged in manufacturing and mechanical industries as compared with less than 20 per cent engaged in agriculture, forestry and animal husbandry (the next largest class of workers). The present growth of the state is due largely to the activity in industrial matters.

Students of population growth recognize cycles of increase in population. There seems to be a definite limit to the number of people that can be reached in any set of circumstances. The growth of California very well illustrates three cycles of growth. In the early days of the state, mining was the attraction and the whole life of the community centered around the mines. As mining reached its climax in the seventies, agriculture came to the forefront and there was a continuous growth on this account. The agricultural era lasted until about 1915. In the meantime, through the discovery of oil and the unprecedented development of the electrical industry, cheap power was made available and manufacturing began to grow. At present there is very little actual increase in agricultural population but a large increase in industrial activities. So far as it is possible to see in the future, our growth will be industrial. Agriculturists have learned to grow more crops with less man power and there is comparatively little likelihood of any large increase in agricultural population. The problems of the state are nowadays to a large extent those of the people of the towns and cities and industrial areas.

DISTRIBUTION OF BARRIER COST

Several interests should share in the cost of this barrier. As has been shown, conditions now existing have been brought about by developments on the higher parts of the watershed, an area covering 32,000 square miles. The bay cities will be contributing to the salt water problem by diversions which they propose to make out of the watershed. The agricultural interests through both valleys are using fresh water in such a way as to contribute to the salt water troubles of the delta lands and the industrial territory. The power companies through use of water in the watershed also affect the problem, and in addition these companies are interested in the increase and prosperity of the industrial region. Other public utilities in this region have the same interest in its prosperity.

The problem is so large and its interests so widespread that it may be said to be state-wide in scope.

The federal government, through its control of navigation, as well as its general interest in the prosperity of the country, is likewise interested in the problem. The California Debris Commission and the River and Harbor work under the Chief of Engineers of the Army already are engaged in river improvement and in control of reclamation work so far as it affects navigation. It would appear reasonable, therefore, to have participation in this construction work by the federal government.

Local interests which will receive direct and tangible benefits from this barrier, such as the towns, cities and lands which can use water directly from the fresh water lake above the barrier, should contribute to the cost of the structure. The delta lands so far as they divert water from tide water levels should also be included in the area contributing because of benefits.

Railroads and vehicular traffic utilizing the barrier as foundation of a bridge should pay the value of this service. It seems reasonable that railroad and vehicular traffic could reasonably contribute a large sum for the use of the bridge.

It appears from examination of Young's estimates that the sum of $45,000,000 will complete a barrier with a bridge at a point near the upper end of Carquinez Strait. A detailed economic study should be made to determine the proportion of the cost that should be borne by each interest involved.

SUMMARY

1. Carquinez Strait marked approximately the boundary between salt and fresh water under natural conditions.

2. Prior to diversions for irrigation, Suisun Bay was brackish in late summer, and salt water may have penetrated as far as Antioch, but only for a few days at a time in years of lowest run-off.

3. If the water now diverted for irrigation and held in storage were released, natural conditions would again be brought about.

4. The dry year of 1918, in which the urge of war had encouraged heavy plantings of rice and other crops in the Sacramento Valley, resulted in penetration of salt water into the delta for a longer time and to a greater distance up-stream than ever known before.

5. Examination of available information shows that the yearly increased diversion of water, which had been going on since irrigation commenced in the valleys of California, had been gradually affecting

the movements of salt water. This slow effect was hardly noticed until 1918

6. Irrigation and storage are not solely responsible for the influx of salt water. The load of hydraulic mining debris deposited in the streams draining the Sierra Nevadas is a minor factor in the problem. As the sediment moves down-stream the tidal prism is changed and the movement of water is affected.

7. Leveeing and reclamation of marsh lands, around the bays and in the delta region, have had a slight effect upon tidal movements. The net effect of leveeing marsh land has been to decrease the tendency of salt water to flow up-stream.

8. Leveeing of basin lands and diversion of floods through by-pass channels has had an important effect in sending floods rapidly to tide water and in reducing the late-summer flow of water, which under natural conditions was stored and slowly released from basins.

9. Dredging, particularly in lower portions of the rivers and in the navigation channels of San Pablo Bay, has increased the tendency for salt water to flow up-stream. Dredging in Suisun Bay and in the deep-water channels to Stockton may have the same tendency. All increases in channel depth and in straightening of approach have a tendency to increase up-stream flow of salt water, though a quantitative estimate of this tendency can not be made.

10. Irrigation now diverts the entire low flow of all streams entering the San Joaquin Valley. The only flows reaching tide water in late summer and early fall are return waters—seepage from irrigation.

11. Pumping plants on the west side of the San Joaquin Valley, lifting water to the west side slopes, now divert more water during late summer than enters tide levels from the river. The San Joaquin delta under present conditions is dependent in late summer of dry years on flow from the Sacramento River. Additional pumping plants are being installed and there will be a greater tendency in the future than in the past for salt water to flow up-stream into the delta channels.

12. Irrigation in the Sacramento Valley in late summer diverts practically all the flow of streams entering the valley floor. The flow of the river at Sacramento, the head of tide water, is now largely return seepage or waste from canals. The low flow at Sacramento was 500 second-feet in 1920; 2750 in 1921; 3200 in 1922; 3100 in 1923; 705 in 1924; 2760 in 1925; 1330 in 1926; and 3420 in 1927.

13. The area irrigated in the delta of both rivers is now 360,000 acres. The quantity of water used by this land has not been determined with any accuracy. Comparing crops and other conditions affecting use of water, it is probable that the annual consumption approximates $1\frac{3}{4}$ acre-feet per annum. Twenty per cent of the annual amount is used in the summer months of greatest evaporation. At this rate the consumption of water by the delta area is at the rate of 2100 second-feet in the summer. This exceeds the flow into tide water by the river in all years of low flow.

14. Records of salt content of the water have been collected by the Division of Water Rights since 1917. The area of delta land surrounded by salt water (100 parts chlorine per 100,000) at high tide is shown in the following table:

Year	Approximate stream flow before diversions in per cent of normal	Area in delta surrounded by salt water—acres
1924	24	169,000
1925	74	8,500
1926	53	58,000
1927	100	5,000

15. Contrary to popular opinion, the period since 1918 has not been one of stagnation in irrigation development. A number of large storage reservoirs have been built and placed in operation since then. Of approximately 4,000,000 acre-feet of storage reservoirs on streams draining through Carquinez Strait, 55 per cent, or 2,725,000 acre-feet, have been built since 1920. Diversions of water, particularly on the lower San Joaquin River, have increased.

The area under irrigation has steadily increased in both valleys. In 1926 it is estimated that 1,250,000 acres were irrigated in the floor of the valley, with 3,900,000 acre-feet of water by diversions from streams draining toward Carquinez Strait. If mountain valleys and lands irrigated from wells are included, the total area irrigated is probably over 1,750,000 acres.

16. Further extensions of irrigated area are being planned in both valleys. Within the next five years the bay cities will have diverting capacity of about 185 second-feet and will control 431,000 acre-feet of storage reservoirs. These enterprises will tend to increase the salt-water menace. There is reason to expect the same menace of salt water as occurred in 1920, 1924 and 1926 to be present every year.

17. Salt water will penetrate the lower delta region every summer under present conditions. The distance water will flow up-stream will depend less and less upon the flow of streams into the valleys as the increase in use of water continues. About one-half of the delta is likely to be menaced any year. The area may extend beyond this line.

18. There is now no legal control of diversions, other than by the slow and costly process of litigation, except upon a few small tributary streams where the Division of Water Rights has completed adjudications. Litigation between lower users of water in the delta and upper riparian users and appropriators has been in progress for several years. Other litigation may be started. The legal processes are so slow, cumbersome and costly that little result is to be expected for many years, if ever.

The outcome of present litigation will be disastrous if the courts uphold the contentions of either of the parties to litigation. If the delta lands have riparian rights to the waters, a large area of land will have to release water, and storage reservoirs constructed by power companies will be decreased in efficiency and value. On the other hand, if the courts decide that riparian rights do not attach to lands on tide water, the delta will be further menaced by salt water and there will be grave danger of permanent injury to a large area of land.

19. The engineering study of a salt water barrier made by Walker Young of the Bureau of Reclamation, in cooperation with the Department of Public Works of the State of California, concludes that the construction of such a barrier is feasible. Investigations were made at

three sites—Point San Pablo. Dillon Point and Army Point. The estimated cost of the barrier with and without bridges is given in the table on page 60.

20. This barrier will maintain a fresh water reservoir free from tidal fluctuations and currents other than those caused by the flow of river water toward the sea. The level of water up-stream of barrier will be maintained at the highest practical level. Young estimates this level at elevation 2.5, U. S. G. S., or 6.0 on tide gage. It is probable that this height of water will be controlled by conditions of levees in the peat areas. As these levees become more stable the level can be increased. Flood levels will not be increased above those of floods in the past, in fact flood conditions will be improved in all but the most severe and protracted floods.

21. The salt water barrier, if built, will affect agriculture and the industries and activities along the bay and lower river as shown in the following statement:

A. AGRICULTURE

(a) A salt water barrier at Point San Pablo will make fresh water available for the irrigation of 51,000 acres of marsh and 48,000 acres of high land around San Pablo Bay. There is no known source of water for this area of land at present. If such lands are increased $50 an acre above cost of irrigation works, the total increase in value will be $4,950,000.

(b) A salt water barrier in Carquinez Strait or at Army Point will make fresh water available for 163,000 acres (marsh 70,000 acres; high lands 93,000 acres) around Suisun Bay. There is no other known source of water for this area. At $50 an acre, the increased value above cost of irrigation works will be $8,150,000.

(c) Either location of barrier will solve the irrigation problem for the lands now irrigated from tide waters in the delta and adjoining it. The area now watered is about 360,000 acres. The total area of irrigable lands is estimated as 458,000 acres. The area menaced by salt water is 169,000 acres. The value of this land is $35,000,000. Improvements at 20 per cent of land value add another $7,000,000.

There will be some increment in value to all the delta area from the security which the salt water barrier will bring about.

(d) The salt water barrier will benefit the areas up-stream from tidal lands by removal of litigation which is now a source of expense and annoyance and which is an obstacle to future projects.

SALT WATER BARRIER

Comparison of Estimated Costs for Alternate Design at Four Sites.

DISTINGUISHING FEATURES OF ASSUMPTIONS OF DESIGN

No.	Estimated Cost	Highway and Railway Bridge: Minimum Clearance at Locks	Piers: Decks	Piers: Towers	Locks: No.	Locks: Location	Flood Control Gates: No	Flood Control Gates: Size	Flood Control Gates: Location	Pier Width
					ARMY POINT-SUISUN POINT AND ARMY POINT-MARTINEZ					
1	$46,300,000		No Bridge		3	In Suisun Point	14 2	70x80 50x60	Partially in Suisun Pt.	20 Ft.
2	49,800,000	50 Ft.	Single	Concrete	3	In Suisun Point	do	do	Partially in Suisun Pt.	15-20
3	54,100,000	50 Ft.	Single	Concrete	3	In Suisun Point	30	50x60	Partially in Suisun Pt.	15 Ft.
4	55,900,000	50 Ft.	Single	Concrete	3	Offshore from Suisun Pt.	15	70x80	Partially in Suisun Pt.	20 Ft.
5	58,500,000	50 Ft.	Single	Concrete	3	Offshore from Suisun Pt.	30	50x60	Partially in Suisun Pt.	15 Ft.
6	77,300,000	50 Ft.	Single	Concrete	3	Offshore from Martinez	15	70x80	Offshore from Martinez	20 Ft.
					BENICIA-PORT COSTA					
7	40,200,000		No Bridge		4	In Benicia	30	50x60	Offshore from Benicia	15 Ft.
8	46,200,000	50 Ft.	Single	Concrete	4	In Benicia	30	50x60	Offshore from Benicia	15 Ft.
					DILLON POINT-ECKLEY					
9	38,900,000		No Bridge		4	In Dillon Point	15	70x80	Offshore from Eckley	50 Ft.
10	44,700,000	50 Ft	Double	Concrete	4	In Dillon Point	15	70x80	Offshore from Eckley	50 Ft.
11	44,900,000	50 Ft.	Double	Steel	4	In Dillon Point	15	70x80	Offshore from Eckley	50 Ft.
12	47,600,000	135 Ft	Double	Steel	4	In Dillon Point	15	70x80	Offshore from Eckley	50 Ft.
13	50,400,000	50 Ft.	Double	Concrete	4	In Dillon Point	21	70x80	Across Carquinez Sts.	50 Ft.
14	50,600,000	50 Ft.	Double	Steel	4	In Dillon Point	21	70x80	Across Carquinez Sts.	50 Ft.
15	53,300,000	135 Ft.	Double	Steel	4	In Dillon Point	21	70x80	Across Carquinez Sts.	50 Ft.
16	97,100,000	50 Ft.	Single	Concrete	4	In Dillon Point	15	70x80	In Dillon Point	20 Ft.
					POINT SAN PEDRO-POINT SAN PABLO					
17	66,000,000		No Bridge		5	In Point San Pablo	15	70x82	Offshore Pt. San Pablo	20 Ft.
18	75,200,000	50 Ft.	Single	Concrete	5	In Point San Pablo	15	70x82	Offshore Pt. San Pablo	20 Ft.
19	82,100,000	50 Ft.	Single	Concrete	5	In Point San Pablo	15	70x82	In Point San Pablo	20 Ft.

One estimate only is given for the Army Point-Martinez Location—Estimate No 6
This site was not drilled—Estimates based largely on assumed foundation conditions except for S P. Co. test pile data.

NOTE—At all sites except Dillon Point-Eckley, conditions are such that flood gates, locks, piers, etc, would be constructed in the dry behind coffer dams A limiting depth of 90 feet below mean sea level to rock surface is assumed for this method of construction The depths at Dillon Point-Eckley exceed this, and Estimates 9 to 15, inclusive, are based upon the placing of concrete under water by the tremie method using caisson gates for the final work on the Stoney Roller Gates. Estimate 16 uses construction methods comparable to those at the other sites as the flood gates are placed in Dillon Point.

(e) The salt water barrier is a step in the direction of carrying out the state's plan of supplying water to the southern San Joaquin Valley —a step in the coordinated plan of water development. It is the first portion of the project which should be built.

B. INDUSTRIES

Industries occupy a large area of land along the waterfront of San Francisco and San Pablo bays, Suisun Bay and Carquinez Strait. Between Oleum and Antioch there are seventeen large industrial plants and a number of smaller ones. On the north side of the straits there are two large industries besides the Mare Island Navy Yard and Benicia Arsenal.

These industries are of the "heavy" type, fundamental industries, which produce essential products necessary both in war and peace. Steel and iron, petroleum products, chemicals, fertilizers, powder and fuse works, leather, brick and tile, flour and feed, roofing lumber and wood products, fish, canned goods and sugar are produced in large quantities. The products of these works have an annual value of $250,000,000 Freight in and out of the district approximates 14,000,000 tons a year Expenditures for electric power average $800,000 a year The average number of employees is 8500, having an annual payroll of about $15,000,000. The portion of the population of towns and suburban territory dependent on these industries includes 30,000 inhabitants.

The industries are large users of water. At present ten million gallons a day are used, not including the navy yard or arsenal, and the annual increase in use by the establishments is one million gallons a day.

Immediately adjoining the industrial area above described are other large establishments which could receive benefit from the fresh water reservoir created above the barrier. If the zone along the waterfront to Richmond were included, the annual value of products for the whole territory would be $515,000,000, the number of employees 17,000; the annual payroll $29,000,000. A part of this area is within the East Bay Municipal District.

Since the salt water menace became widely advertised through the Antioch litigation, only one new industry of large size has been established in this territory The factories already established have continued to grow, but the uncertainty about fresh water has discouraged new industries seeking location. Fresh water in large quantities at low prices is essential to the prosperity of such establishments. Water from any existing utility or municipal district is too high in price for these "heavy" industrial plants.

Ordinarily such works locate where water can be had for the cost of pumping, and such manufacturing establishments will not go to any place where practically free water is not available There is no other location in California suitable for heavy industries where this condition can be created.

The establishment of new basic industries will be attracted by abundant cheap water If California does not provide the proper location, Seattle or Portland or some other northern locality will offer greater inducements and many industries will establish Pacific Coast branches in these northern cities. There are in these other states large areas of land where pure fresh water is abundant and may be had for

the cost of pumping from permanent running streams. Further than this, rates for water in the cities are cheaper than in California. Below are given the costs of 500,000 gallons of water in the principal Pacific Coast cities:

Cost of 500,000 Gallons of Water Per Month

San Francisco	$157.56
Oakland	161.71
Los Angeles	72.16
Stockton	54.50
Portland	44.11
Seattle	32.94

One of the greatest needs of the state today is a fresh water reservoir around which factories could be located with assurance of a permanent supply of water. Probably no single accomplishment in the construction program now under discussion would do more toward progress. More factories mean greater population and more local markets for agricultural produce, and the general level of prosperity of the state will be raised.

Salt water is detrimental to the piping and more costly to handle in factories of this sort. The increased annual cost to the users of saline water is estimated to be $300,000 a year through deterioration of equipment and piping in the industries now established. This sum capitalized at 6 per cent means the equivalent of an investment of $5,000,000.

Some of the industries, notably the sugar refinery at Crockett and the chemical works at Pittsburg and Nichol, require water free from saline matter. The presence of salt water in the river for long periods of each year has been the cause of much expense and annoyance in these establishments, and brings seriously to consideration the ability of these factories to continue to exist under the trying conditions.

The salt water barrier will remove the cause of additional expense to the plants now located here, will encourage their more rapid growth, and will offer a great incentive to new establishments to locate here Large industries require, in addition to large quantities of pure water, cheap power, efficient transportation facilities, preferably both by rail and water, and a good climate attractive to labor. The lower river and upper bay regions lack only water. The salt water barrier will supply this single deficiency. If the barrier is not built, California, without doubt, will lose many important factories.

C. DOMESTIC WATER SUPPLY

The domestic water supply of towns along the straits in Suisun Bay is high in price and limited in quantity. Vallejo, the only exception to this statement, recently has constructed Gordon Valley Reservoir on Suisun Creek, and has a permit to store 10,000 acre-feet and to divert 5000 acre-feet annually. Other towns have no large amount of water for future growth. In fact lack of available water has been a deterrent to the location of industries and the resultant increase in population.

A salt water barrier will solve the water difficulties. If the barrier is located at San Pablo Point, the entire area can be supplied with fresh water; if the barrier is located at Army Point or in Carquinez Strait, all towns on Suisun Bay and in the lower river will be on fresh water; towns below the barrier, such as Crockett, can be readily supplied with short pipelines heading above the barrier.

Either barrier will be of benefit to the city of Sacramento in preventing the upflow of tide and reducing the menace of sewage water being carried toward the water intake

D. TRAFFIC ACROSS STRAIT

Routes of travel between northern and southern parts of the state naturally pass through Carquinez Strait. The Southern Pacific Company maintains ferries for trains between Benicia and Port Costa and for passengers between Vallejo Junction and Vallejo. The Sacramento-San Francisco Railroad maintains a train ferry from Mallard to Chipps Island. A bridge for vehicular traffic now crosses the strait just below Crockett. A ferry for automobiles and passengers is maintained between Martinez and Benicia.

At Richmond an automobile ferry is in operation a short distance below the site of the proposed salt water barrier at Point San Pablo.

A barrier at San Pablo can be made to serve as a bridge. There are now two applications for bridge permits near this place The estimated cost of these bridges is from $10,000,000 to $20,000,000. The difference between the cost of a barrier with and without bridge is estimated by Young to be $9,000,000.

At Army Point a bridge 50 feet above water increases the cost $3,500,000; at Benicia a bridge 50 feet above water level increases the cost $6,000,000; at Dillon Point a bridge with a clearance of 50 feet increases the cost $3,800,000; a bridge with clearance of 135 feet increases the cost $8,700,000. Approximate figures indicate that a railroad bridge near the location of the present Southern Pacific ferry between Benicia and Port Costa will cost in excess of $10,000,000. Upon this estimate railroad transportation could bear a part of the cost of barrier. Vehicular traffic is growing so rapidly that there will be need for a second bridge across the straits within a few years.

E. POWER COMPANIES

The power companies are interested in the salt water problem because it has decreased their market for power by discouraging new plants from locating here and by reducing the growth of those already established.

The litigation over water rights may seriously affect their plants supplied from storage in the mountains.

F. FISHING INDUSTRY

Fishing in the bay and rivers is important. Salmon, shad and striped bass are important commercial fish. Smelt and smaller fish are important in furnishing food for commercial varieties. Sturgeon are nearly extinct, but it is the endeavor of the Fish and Game Commission to prevent complete extinction and to encourage increases in this species.

The salt water barrier will be an obstacle to migrating fish during low water season. Young's plans provide for fishways and it is his belief that fish will use the locks and that on the whole the barrier will not obstruct the migration. Objection to any forms of barrier will be raised by the fishing industry. Wherever the structure is built there will naturally be some obstruction to free migration of the fish. It is probable, however, that the structure can be so designed and operated as to do only a small amount of damage.

G. NAVIGATION

Any barrier is an obstacle to free movement of vessels, and it is to be expected that owners of vessels will object to the project. This objection arises from the delays caused by using locks and the danger of handling vessels in such restricted quarters, particularly in foggy periods.

As to delays, it may be said that ordinarily the time lost in transit through locks will be regained by the freedom from adverse currents above the locks. While this will depend upon the place to which the vessel is bound, it is believed that for the great bulk of traffic the delay is likely to be small.

The danger to vessels maneuvering in approach to locks is of course real, but with the safeguards now provided for vessels the risk is small and there are compensating advantages. The ability to dock without tidal currents, as would be true above the barrier, is both a saving in time and reduction of risk. The cleansing action of fresh water upon the bottoms of ocean-going vessels is valuable.

The fear that the barrier will cause silting in channels or create changes in the Golden Gate bar does not seem to be well founded. Sediment moves almost entirely at flood times when the barrier will be open and the current constantly down-stream. The movement of sediment will probably be facilitated rather than retarded.

Owners of shipping facilities are of course interested in the growth and prosperity of the communities served The industrial area which will grow up around the fresh water reservoir above the barrier will produce freight for vessels at a greatly increased rate. The depth of water through Suisun Bay and to Stockton will be increased to 26 feet under the plan already adopted by congress. The depth of channel will be ample for from 73 to 88 per cent of the vessels normally entering the Golden Gate during a year.

In considering the location of the barrier, the extent of shipping is important. The farther downstream the greater the traffic through locks, the greater quantity of water required for lock operation, and the greater will be the objection by the shipping interests. In this regard the upper location of the barrier will meet with the least objection.

The Navy Yard is above San Pablo site and naval officers will probably be impressed with the difficulties presented by the barrier in time of war. Here we have another and important reason for the selection of the upper site.

H. STRUCTURE BUILT IN WATER

Teredos and other wood-destroying animals have caused damage to structures in San Francisco Bay waters in excess of $25,000,000 since 1914, according to estimates made by the San Francisco May Marine Piling Committee. In the upper bay region teredos have gone as far as Antioch. All structures built in water which may become brackish must be constructed of treated piles or of concrete. Brackish water carried up by tides will continue to cause greater expense in all structures built in water and greater maintenance costs. It is difficult to measure this damage in dollars, but it is a very considerable sum annually.

A salt water barrier will reduce the maintenance cost of structures and will make it practical to build structures as economically as was done prior to the invasion of salt water.

SOLUTION OF THE SALT WATER PROBLEM

23. The salt water problem may be partially solved in several ways, but completely only in one way. Conditions may be ameliorated by storage and release of water from reservoirs to push back the salt water or water supply from outside sources may be brought in to supply fresh water through conduits or pipes.

The only satisfactory solution of the problem is the salt water barrier. These methods are briefly discussed below:

STORAGE AND RELEASE TO PUSH BACK SALT WATER

24. This method of solving the salt water problem has been suggested in several recent publications of the Department of Public Works. Examination in detail of the proposals shows that "salt water control" means the supplying of water of less than 100 parts chlorine per 100,000 to the delta lands.

Emmaton on the Sacramento River and Jersey Island on the San Joaquin are the limits of control and no suggestion has been made that it is practical to release water to supply Antioch or any of the lower industrial area. This, in fact, leaves out of consideration the area now most seriously damaged.

Studies by the Division of Water Rights based on records including the year 1925 show that to control salinity below 100 parts chlorine per 100,000, the combined flow of Sacramento River at Sacramento and the San Joaquin at Vernalis (both points about head of tide water in late summer) must exceed the following figures:

For control at	*Cubic feet per second*
Emmaton and Jersey Island	3500
Antioch	5000
Collinsville	5500
O. & A. Ferry	6000

These quantities will depend to some extent upon the months preceding the period when control is desired, and will, of course, vary with the diversions below the points of measurements. Furthermore, storage of water above tide level will affect the matter by limiting the distance salt water is forced downstream by spring floods.

To effectively supply these quantities of water will require very large storage capacity in dry years.

In 1924 storage in excess of a million acre-feet would have been required to control salinity at the O. & A. Ferry and 200,000 acre-feet at Emmaton and Jersey.

Storage in large amount would be needed about half the years at Emmaton and Jersey, and every year for control at the O. & A. Ferry.

The above is under the assumption that storage and diversions in these two valleys does not increase. As shown earlier, this condition has already been violated, for there has never been such increased activity in building storage reservoirs as in the period since 1924. Many reservoirs are planned for construction in the near future. Furthermore, diversions increase every year.

Estimates of the quantities required for storage control must therefore be continuously revised upwards.

Release of stored water, to control salinity, will occur in dry parts of the year and to greatest extent in dry years. To effectively control the right of storage and release, all riparian owners below the reservoir must agree to the arrangement. As the law now stands, the use of such a reservoir may be enjoined and it will be impossible to prevent—except through litigation—the riparian owners from diverting the released water. The difficulty can be removed by condemnation of rights along the stream. The problem looks too large for human accomplishment in any reasonable time and at reasonable cost.

To one acquainted with water problems in California, it does not seem reasonable to expect that in the dry part of a dry year a flow of 5000 or more feet per second would be allowed to pass pumps and ditches, under which crops were suffering, in order that salt water could be pushed back into the ocean. As to the cost of storage reservoirs to accomplish the release for salt control, there is little definite information which permits a comparison of costs. The following statements are of interest:

Kennett Reservoir is proposed by the State Department of Public Works as a unit in the "Coordinated Plan." (See Bulletin 13 of the Department of Public Works, 1928.) The recommended reservoir capacity is 2,940,000 acre-feet; the estimated cost of dam and rights of way is $55,000,000; of power plant $25,000,000; a total of $80,000,000. With allowances for prior rights, the mean annual irrigation yield of reservoir will be 2,838,000 acre-feet. In minimum years the deficiency would be large; 19 per cent in 1920; 42 per cent in 1924. If this reservoir were depended upon for salinity control, the entire available supply would be needed to control salt water at the mouth of the river, leaving no water for the area depending on this reservoir for irrigation. In other words, the very year when the reservoir is most needed it would be of little practical use. Furthermore, Kennett is not practicable unless operated to generate electric power. If the water is held and released for salt water control, the power value is greatly decreased.

Iron Canyon Reservoir is proposed as a secondary unit in the "Coordinated Plan." (See Bul. 13, Dept. of Public Works.) The recommended capacity is 1,121,900 acre-feet; the cost of dam and power plant is estimated as $26,000,000; the canal system to utilize this water is estimated at $30,000. The reservoir may be utilized in controlling salinity. To quote from the above mentioned report, page 115:

"Sacrificing the power feature at Iron Canyon dam would, with other construction unchanged with the exception of the arrangement of outlets through the dam, supply a reserve storage of 364,600 acre-feet of water in Iron Canyon reservoir to overcome, or alleviate, the salt water menace in the delta region should such be desirable. Such use is not advocated, but it is demonstrated that there are possibilities along this line."

Should the irrigation feature likewise be disregarded, Iron Canyon would provide a net annual irrigation draft of 800,000 acre-feet or just about enough water to control salt water as low as the mouth of the river—provided the water could be carried past head gates and pumps on its way to tidal waters. Under this condition the power feature

would be sacrificed to a larger extent. It is difficult to picture a dry year when water and power are both scarce, in which it would be possible to release a large quantity of water, disregarding its best use for power, and have the riparian and appropriative users of water along the hundred and fifty miles of the Sacramento River permit this flow to pass by uninterrupted to tide water. The plan does not look practical.

Other reservoirs may be used for the same purpose, that of increasing the flow to control salt water. For example, a reservoir on Feather River has been suggested, and another on the American at Folsom. Both of these reservoirs will have value for power development and that value will be greatly reduced if a large quantity of water is held for saline control The most practical suggestion is in connection with a reservoir on Dry Creek, north of the Mokelumne, the water to be diverted from the Mokelumne River. The rights obtained by the East Bay Municipal Utility District for storage in Lancha Plana Reservoir practically eliminate this reservoir from consideration. In connection with the proposal for storage and release of water, it should be remembered that the State Department of Engineering has made the suggestion as a temporary expedient, with the expectation that permanent relief would be brought about by the construction of the salt water barrier. This state of affairs would leave the delta lands dependent on a temporary right to be replaced by a permanent right which would be arranged for at some later time. With the growing condition of California and the certainty that the temporary supply will be invaded by increased diversions, this is a very precarious water right, not one which will satisfy the delta land owners. Furthermore, the plan does not consider users below the delta, either towns or industries.

New industries will not be attracted by any temporary improvement in water conditions. Some permanent solution must be reached. It is important to California to have the decision made at once so that the great industrial expansion now going on can be located to a maximum extent in this state.

WATER FROM OUTSIDE SOURCES

25. Under present conditions the towns and industrial area can not look to any place within tide water level for a source of water. Above tide levels the following are the principal supplies which may be considered:

Eel River,
Conn Valley,
Putah Creek,
Mokelumne or Cosumnes,
Pumped water from irrigation districts, San Joaquin Valley,
East Bay Municipal Utility District.

All of these sources may be considered, but as all are distant, with long pipe lines and other costly works, they will be able to supply water only at relatively high cost, prohibitory to the types of factories now located in Contra Costa and Solano counties. Piping water across these straits will be a very costly and difficult affair. The barrier removes the necessity of any pipe line crossing.

LOCATION OF BARRIER

26. For the purpose of providing fresh water to cities, industries and agriculture on adjoining land, the lowest location of the barrier accomplishes the most. However, water supply, cost and convenience to other interests must be considered before the location can be selected. The following may be said on these points:

Water Supply. The attached tables give the requirements for fresh water above the barrier upon the assumption that development is complete. These figures, in part, are taken from the Young report—in part are the results of studies made for this investigation.

Requirements for the full year are:		
Army Point	1,160,000	acre-feet
Point San Pablo	2,024,000	acre-feet
Difference	864,000	acre-feet
For the irrigation period May to September, inclusive, the requirements are:		
Army Point	638,000	acre-feet
Point San Pablo	1,236,000	acre-feet

Additional storage on the headwaters will be required to supply the barrier at San Pablo.

Cost. Young's estimate of cost of barrier with bridge of clearance of 50 feet is as follows:

Point San Pablo	$75,200,000
Army Point	49,800,000
Difference	$25,400,000

Convenience of Other Interests. San Pablo site is below the Mare Island Navy Yard, a great obstacle. Navy men will be against the project. Shipping interests will be more inconvenienced with the lower site occupied. At present about two-thirds of the vessels that pass Point San Pablo continue upstream above Army Point. The San Pablo site will be a convenience to vehicular traffic. The Army Point site will be convenient for both vehicular and railroad traffic, though at present vehicular traffic is cared for by the Carquinez Bridge.

FINAL CONCLUSION

27. If the salt water barrier is built at Army Point to carry vehicles and railroads, and the proper part of the cost paid by these interests, the salt water problem can be solved permanently and cheaper than by any other solution that has been suggested.

The cost of a bridge for rail and automobile traffic at Army Point can not be determined without more work than is possible in an investigation such as this. It can be safely said, however, that the cost will exceed $10,000,000. Automobile traffic over the Carquinez Bridge (which has been in use less than a year) is at the rate of approximately 1,100,000 automobiles a year and is growing rapidly. There will be economic justification for an auto bridge at Benicia before it can be built. Automobile traffic will justify an expenditure of over $10,000,000. The two combined will be over $20,000,000. If this figure is taken as the value to transportation, there will be left, approximately, an equal sum to be paid by other benefits.

Iron Canyon Reservoir, the only definite storage reservoir suggested for temporary control, will cost $26,000,000 The salt water barrier would permanently solve the difficulties for a smaller sum.

TABLE 1

Average Miles Traveled by Water Barge California-Hawaiian Sugar Company

Year	Jan	Feb	Mar.	Apr	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec
1908	19.8	11.6	12 5	14 0	12 9	16 7	26.3	26.8	33.2	27.1	24.8	25.7
1909	6 9	0	4 5	7.7	5.0	4 7	10.5	19 4	23.2	24.2	21 0	11.7
1910	9.6	10 0	3.8	3 0	6 4	10.8	20 4	26.7	27.6	25 4	24.6	19.7
1911	11 6	2 3	16.2	1 0	2.1	0 7	5.7	16.4	23.2	24 5	24 7	25 5
1912	22 0	16.1	14.5	12.7	8 8	7.1	17.6	24.7	24 4	24 2	19.0	18 5
1913	16 4	13.6	13.2	9 9	6 9	10.3	21.0	25.7	26.6	27 8	26.1	20.4
1914	2.1	1 2	1 6	2 5	2 2	3.4	10 3	20 0	24 4	24.5	23 9	23 7
1915	16.4	2.3	3 1	4 3	2 6	3.7	12.6	20.8	24.4	24.2	23 0	17 5
1916	4.9	0.5	1 0	2.3	6 4	5 8	13 2	22 6	25 0	21.7	21.2	15 4
1917	16.0	13 1	6 5	6.3	3 5	4.8	15 5	24.9	26.2	26 0	25.1	24.4
1918	24.3	15.1	9 6	6.2	9.2	15.0	27.0	38.5	37 2	23 0	23.1	21 0
1919	20.4	9 4	7 7	5.7	4 3	14 1	35 3	37 7	37.7	26 8	25 7	25 5
1920	23.8	24.0	17.2	12 0	12.9	17.4	26 0					

TABLE 3

Commercial Fishing—San Pablo and Suisun Bays and Sacramento and San Joaquin Rivers

(Varieties)

Year	Salmon Native	Shad Planted	Striped Bass Planted	Total Pounds
1919	4 529,048	1,573,713	759,733	6,862,494
1920	3,860,312	1,409,322	668,290	5,937,924
1921	2,511,127	797,128	599,698	3,907,953
1922	1,765,066	1,109,445	682,717	3,557,228
1923	2,243,945	1,285,334	906,869	4,436,148
1924	2,640,110	1,538,735	658,244	4,837,089
1925	2,778,846	2,439,441	836,301	6,054,588
1926	1,261,776	902,202	749,573	2,913,551
1927	920,471	4,103,012	644,789	5,668,272
Total, 9 Years	22,510,701	15,158,332	6,506,214	44,175,247
Mean	2,501,189	1,684,259	722,913	4,908,361

The run of fish will vary from year to year in accordance with weather, feed and unknown factors.

A low or high run for one year may not mean absolute evidence of either increase or decrease in the species

For example, the extremely low run of salmon in 1927 does not necessarily mean still lower run in 1928, and similarly with shad in reverse tendency.

However, there seems to be a general decrease in salmon, probably an increase in shad, and a static condition in striped bass.

TABLE 2

Combined Flow of Sacramento and San Joaquin Tributaries

(Flow in Second-Feet)

Year	Jan	Feb.	Mar.	Apr.	May	June	July	Aug	Sept.	Oct.	Nov.	Dec.
1916	66,670	92,200	99,830	88,621	73,060	55,619	23,900	11,112	9,300	12,261	11,522	19,986
1917	16,712	56,000	34,521	71,153	69,307	63,407	20,082	9,787	8,309	7,875	8,639	11,071
1918	9,180	21,849	50,360	51,091	39,145	32,183	9,563	6,885	8,621	13,041	11,956	12,118
1919	19,653	58,664	44,948	63,700	65,666	18,261	8,975	7,275	7,049	7,733	7,172	11,460
1920	9,075	9,550	26,759	41,822	49,582	27,104	9,931	6,722	6,059	8,557	39,737	48,539
1921	73,000	58,400	69,470	55,291	65,385	50,246	15,606	8,297	7,435	7,589	8,389	19,407
1922	17,560	50,030	41,389	61,190	109,494	82,327	20,879	9,022	7,329	8,334	11,828	35,715
1923	29,742	22,089	23,785	55,290	54,199	31,844	17,138	9,798	8,809	10,004	7,810	7,919
1924	8,617	19,248	10,222	15,623	14,438	7,007	5,981	5,601	5,171	7,056	13,214	15,029
1925	15,018	89,005	34,394	63,127	59,990	32,824	13,486	9,030	8,535	8,626	9,361	11,720
1926	13,056	57,377	26,323	60,494	30,503	13,603	9,732	8,522	7,364	7,730	32,243	31,338
1927	35,293	109,044	54,556	75,100	59,973	45,353	16,984	11,349	10,652			

No allowance for power storage or regulation

Combination of

Sacramento at Red Bluff,
Feather at Oroville,
Yuba at Smartsville,
Bear at Van Trent,
American at Fair Oaks,

and

Mokelumne at Clements,
Stanislaus at Knights Ferry,
Tuolumne at La Grange,
Merced at Exchequer,
San Joaquin at Friant.

TABLE 4

Population of Bay Counties—U. S. Census

	1920	1910	1900	1890	1880	1870	1860	1850
State	3,426,861	2,377,459	1,485,053	1,213,398	864,694	560,247	379,994	92,597
Alameda	344,171	246,131	130,197	93,864	62,976	24,237	8,927	
Contra Costa	53,889	31,674	18,046	13,515	12,525	8,461	5,328	
Marin	27,342	25,114	15,702	13,072	11,324	6,903	3,334	323
Napa	20,678	19,800	16,451	16,411	13,235	7,163	5,521	405
Sacramento	91,029	67,806	45,915	40,339	34,390	26,830	24,142	9,087
San Francisco	506,676	416,912	342,782	298,997	233,959	149,473	56,802	
San Joaquin	79,905	50,731	35,452	28,629	24,349	21,050	9,435	3,647
San Mateo	36,781	26,585	12,094	10,087	8,669	6,635	3,214	
Solano	40,602	27,559	24,143	20,946	18,475	16,871	7,169	

TABLE 5

School Enrollment Bay Shore Districts—Contra Costa County

Elementary Schools:	1915	1921	1927
Oakley	85	118	158
Antioch	333	454	731
Pittsburg	668	1,122	1,485
Bay Point	85	----	162
Martinez	403	792	1,068
Port Costa	122	108	75
Carquinez (Crockett)	447	572	617
Selby	72	99	128
Rodeo	108	132	198
Pinole Hercules	227	258	217
San Pablo	182	227	282
Richmond	2,288	3,380	3,997
Total Elementary	5,020	7,262	9,118
High Schools:			
Antioch	105	142	149
Pittsburg			133
Alhambra, Martinez	77	121	294
John Swett, Crockett	86	119	206
Richmond	242	655	754
Total High School	510	1,037	1,586
Total both	5,530	8,299	10,704

TABLE 6

Water-Borne Traffic, U. S. Engineering Department Data

(Total movement, tonnage and values in thousands of tons and thousands of dollars)

Year	Suisun Bay Tons	Suisun Bay Value	Carquinez Strait Tons	Carquinez Strait Value	San Pablo Bay Tons	San Pablo Bay Value	Grand Total Tons	Grand Total Value
1917	No Data		Incl. in San Pablo		11,946	$212,592		
1918	No Data		Incl. in San Pablo		4,330	152,206		
1919	305	$7,034	Incl. in San Pablo		4,634	184,476	4,939	$191,510
1920	433	13,877	2,079	$97,991	1,696	54,620	4,208	166,488
1921	562	19,670	1,720		2,019	96,177	4,301	
1922	1,329	32,006	No Data		2,652	118,234		
1923	2,659	43,764	No Data		2,466	109,022		
1924	2,341	51,066	No Data		4,200	156,999		
1925	4,204	88,670	7,673	183,000	4,754	234,409	16,631	506,079
1926	4,205	90,687	7,844	135,522	4,667	260,920	16,716	487,129

Totals are only shown where data are complete for all divisions.

In addition to above, in 1926, there was a total of 1,752,000 tons valued at $124,077,616 to or from the Sacramento and San Joaquin rivers, most of which passed through Carquinez Strait. However, all of this having origin and destination in the above Bay division, it appears there also.

Railroad ferry freight traffic across Carquinez Strait was, in 1925, 2,706,000 tons; in 1926, 2,650,000 tons.

TABLE No. 7

Ocean-Going Water-Borne Traffic, U. S. Engineering Department Data

(Tonnage in thousands of tons and values in thousands of dollars)

Year	Suisun Bay Tons	Suisun Bay Value	Carquinez Strait Tons	Carquinez Strait Value	San Pablo Bay Tons	San Pablo Bay Value	Grand total Tons	Grand total Value
1925	2,659	$43,823	5,188	$147,485	4,011	$66,999	11,858	$258,307
1926	2,495	41,173	4,264	107,228	3,866	58,942	10,625	207,343

Data do not permit a separation of bay business from ocean-going business previous to 1925, and Carquinez Straits data are entirely lacking for the years

The magnitude of the petroleum products traffic and the proportion of the total it occupies are obvious when the following tables are compared with the above

Year	Suisun Bay Tons	Suisun Bay Value	Carquinez Strait Tons	Carquinez Strait Value	San Pablo Bay Tons	San Pablo Bay Value	Grand total Tons	Grand total Value
1925	2,464	$34,391	4,415	$49,562	3,837	$45,715	10,716	$129,667
1926	2,168	33,663	3,409	40,454	3,708	43,837	9,285	117,954
OUTGOING BAY AND OCEAN WATER-BORNE PETROLEUM PRODUCTS								
1925	547	$20,811	2,949	$38,217	1,019	$19,783	4,515	$78,811
1926	615	29,989	2,746	35,197	940	23,837	4,301	89,023

Does not include Standard Oil Co Richmond plants.

TABLE No. 8

Sacramento and San Joaquin River Traffic, U. S. Engineering Department Data

(Tonnage and values)

Year	Sacramento River Tons	Sacramento River Value	San Joaquin River Tons	San Joaquin River Value
1910	496,147	$29,522,151	631,681	$32,878,108
1911	505,285	32,139,048	600,128	35,768,215
1912	477,292	27,755,325	632,591	38,854,539
1913	733,594	35,856,791	820,399	38,341,174
1914	721,090	38,211,760	772,156	35,479,741
1915	766,935	38,027,703	831,234	36,358,240
1916	875,780	46,908,093	824,222	42,179,160
1917	947,690	96,820,992	1,890,856	50,367,760
1918	1,053,510	113,991,123	2,114,382	65,204,825
1919	1,666,025	78,601,238	647,156	54,100,043
1920	1,377,700	53,946,146	692,306	42,203,211
1921	976,596	52,092,263	646,657	37,263,122
1922	1,291,135	60,606,728	678,751	34,291,675
1923	1,264,821	62,470,235	697,773	38,027,909
1924	1,796,104	58,662,997	727,499	38,185,313
1925	1,427,230	80,500,145	849,687	47,192,499
1926	1,222,993	85,315,284	934,809	56,455,662

Contains also movements between river points only.

TABLE No. 9

Water Requirements for Operation of Salt Water Barrier When Fully Developed

(Quantities in second-feet)

POINT SAN PABLO

	1	2	3	4	5	6	7	8	9	10	11	12
Fish ladder	35	35	35	35	35	35	35	35	35	35	35	35
Industries, etc.	322	322	322	322	322	322	322	322	322	322	322	322
Gate leakage	166	166	166	166	166	166	166	166	166	166	166	166
Oper locks	705	705	705	705	705	705	705	705	705	705	705	705
Evaporation	250	300	450	650	950	1,200	1,250	1,170	1,020	800	500	200
Irrigation	---	---	---	---	610	1,680	2,290	1,910	1,150	---	---	---
Flushing	200	200	200	200	200	200	200	200	200	200	200	200
Totals S. F.	1,678	1,728	1,878	2,078	2,988	4,308	4,968	4,508	3,598	2,228	1,928	1,628

TABLE No. 10

Water Requirements for Operations of Salt Water Barrier When Fully Developed

(Quantities in second-feet)

ARMY POINT

	1	2	3	4	5	6	7	8	9	10	11	12
Fish ladder	35	35	35	35	35	35	35	35	35	35	35	35
Industries, etc.	155	155	155	155	155	155	155	155	155	155	155	155
Gate leakage	166	166	166	166	166	166	166	166	166	166	166	166
Oper. locks	246	246	246	246	246	246	246	246	246	246	246	246
Evaporation	110	146	200	288	422	530	555	522	455	355	222	89
Irrigation	---	---	---	---	380	1,050	1,430	1,190	710	---	---	---
Flushing	200	200	200	200	200	200	200	200	200	200	200	200
Totals, S F	912	948	1,002	1,090	1,604	2,382	2,787	2,514	1,967	1,157	1,024	891

TABLE 11

Water Requirements Above Salt Water Barrier When Fully Developed

(Quantities in acre-feet)

	Army point	Point San Pablo
January	56,000	102,500
February	52,500	95,500
March	62,000	115,000
April	65,000	123,000
May	98,500	184,000
June	147,500	256,000
July	171,000	305,000
August	154,000	277,000
September	117,000	214,000
October	71,000	137,000
November	61,000	115,000
December	54,500	100,000
Totals	1,110,000	2,024,000

EXHIBIT "D"

MEMORANDUM
To
THE JOINT LEGISLATIVE COMMITTEE
TO INVESTIGATE THE
WATER RESOURCES OF CALIFORNIA

By

A. M. BARTON
Chief Engineer and General Manager
State Reclamation Board
of California

State Office Building
Sacramento, California

November 30, 1928.

Joint Legislative Committee to Investigate
the Water Resources of California,
Mr. B. S. Crittenden, Chairman,
139 North A Street,
Tracy, California.

DEAR SIR:

On November 20th the writer appeared before your honorable committee in behalf of the American River Flood Control District and, after dwelling briefly on some of the phases of the American River situation, was granted the privilege of presenting a more complete and detailed statement in written form.

It is now manifest that to serve the most broadly beneficial public interests, the scope of the American River development must be extended to that of a major project. As such, it must necessarily have an important bearing upon interests other than those pertaining to the controlling of floods. It is therefore proposed to discuss also certain other relevant features which appear to warrant the serious consideration of your committee.

In order, however, that our primary purpose may not be obscured, it is desired at the outset to define the issue with which we are principally concerned and to direct your attention to the magnitude of the stakes involved therein. The area within the boundaries of the American River Flood Control District, some 22,500 acres, includes the cities of Sacramento and North Sacramento. The population of this area is estimated at 104,000 and the assessed property valuation is approximately $105.000,000. No later than last spring the American River again vented its fury on this region and about 13,000 acres were flooded to depths up to twelve feet. The levees of Sacramento held, but the unprotected city north of the American suffered heavy losses of property and at least one death was directly attributable to the flood. Railroads and highways were submerged and for a period of days there was no traffic over the roads leading north and east from Sacramento.

This is by no means the first time these conditions have obtained and there is no assurance whatever that within the next three months a thousand families may be forced from their homes. The State of California has aided in the reclamation of about one million acres of agricultural land. When one considers this fact, it seems incredible that the just demands of a rapidly growing community immediately adjacent to the capital shall go unheeded.

For the past four years the development of the American River at Folsom has claimed the attention of those interested in conservancy measures and in particular, those concerned with flood control by storage regulation. At the last Legislature an act was passed specifically defining the obligations of any private interests to be traded with by the state in return for control of certain of its properties at the Folsom penitentiary. This act in effect burdens the promoters with the expense incidental to the installation and operation of flood control features which must necessarily be incorporated in the dam in order to accomplish the desirable purposes. It also comprehends the solution of the salinity problem of the delta region.

Since this act was drawn, radical changes have occured in the situation both as to flood abatement and salinity control and an urgency heretofore not sensed has become apparent. The flood of March, 1928, has most forcibly brought home to the people a full realization of the menace which exists in the uncontrolled flow of the American River and vigorous action is now being had by the American River Flood Control District in an endeavor to solve the flood control problem. To those who have studied the situation it is obvious that the most economical solution involves regulation of flood flows by storage. It is further obvious that the provision of such regulation can not long be deferred. The rapidly growing community north of the American River is wholly at the mercy of the vagaries of that stream. The loss of life, destruction of property and adverse publicity suffered by the capital of this state in the recent flood is freshly in the minds of those most vitally interested. Development is being retarded. To defer action is to invite a disaster, recovery from which may not be accomplished in generations.

Those who have suffered from the incursion of salt water in the delta region have entertained great hope for the early construction of a salt water barrier. The plan has been fully investigated by state and federal engineering forces. These investigations reveal that the probable cost would vary from $45,000,000 to $90,000,000 according to the site selected. It was hoped that a considerable proportion of this cost would be borne by transportation interests in return for use of the proposed structure as a bridge across the straits. This hope has been dispelled by an announcement of the Southern Pacific Company which settles the issue by proceeding with the immediate construction of a bridge near the Carquinez ferry. Thus it appears that immediate amelioration of the salt water nuisance can be had only by the releasing of impounded waters.

A practical acceptance of this condition is now evinced by the attitude of the delta interests. These interests now propose the formation of a delta conservancy district, the major purpose of which will be to provide a means for sharing in the cost of storage works proposed under the coordinated plan or any other works capable of remedying the situation. This has all the appearance of a broad-minded proposal. It should, to our notion, receive the sympathetic support of all state agencies and be hastened to an early consummation.

The dilemma with which that region is confronted has been forced upon it by a natural and orderly agricultural development of the Sacramento and San Joaquin valleys. The holders of up-stream agricultural lands have taken water as they pleased and now insist that the delta, although admittedly injured, must solve its own problem and meet the costs incidental to such solution. Tremendous stakes are involved in the delta controversy, involving an area of approximately 600,000 acres from which is derived an annual crop production of between $50,000,000 and $70,000,000. The most valuable agricultural land of the state is in this region and permanent damages due to the infiltration of salt water have already attained vast proportions.

By standing on their riparian rights and vigorously pressing the suits now filed, the delta interests can jeopardize every appropriator in the two valleys. The outcome of such litigation is, of course, uncertain but it cannot fail to result in at least a temporary paralysis of development and great expense.

Fortunately, the inclination of the delta is toward constructive measures. This is indicated by the spirit of the proposed district and the apparent willingness of the land to contribute toward a storage or conservancy project.

It is noted that the delta interests have looked toward the proposed Kennett and Iron Canyon reservoirs as a possible solution of their problems. Our purpose is to bring most emphatically to the attention of all parties the fact that the construction of either of these reservoirs would in no measure provide control of flood waters where such control is most necessary and urgent, the American River area.

It is, of course, true that the construction of either of these units of the coordinated conservancy plan will go far toward solving the salinity problem and, at the same time, be beneficial to the irrigation, navigation and flood control interests of the upper valley. But public policy demands that any development of natural resources shall be so planned as to confer the greatest benefits to the greatest number of beneficiaries and, further, shall be timed so far as is humanly possible, to meet their urgent requirements.

During a normal summer the salinity problem is not acute; the greatest necessity for augmented flow occurs during seasons of subnormal precipitation and this necessity coincides with the maximum requirement for irrigation water. Appropriations from the Sacramento River now amount to nearly double the low flow of the stream. As the development of the upper valley progresses, these appropriations must be increased and it becomes apparent that during a critical season such as 1924, draft from the river would seriously diminish the amount of water dedicated to salinity control. In such case state regulation would become necessary and restriction of diversions could be accomplished only by a close policing of the entire stream. The first concern of the proposed delta district is to secure unimpaired delivery of water, the storage cost of which is partially borne by it.

Flood flow regulation by these upper reservoirs is desirable but will not become absolutely essential until development of the upper valley region has progressed to such a point that the present defenses are inadequate and unless the present rate of development is greatly accelerated, this lies many years in the future.

Irrigation has progressed rapidly in the upper Sacramento Valley. Prior to 1911, diversions from the river were insignificant but with the stimulus of war time prices, great strides were made in the use of water. In nearly every case appropriations were made far in excess of immediate requirements and many years must elapse before development is so intensive as to require that all the water appropriated be actually put to beneficial use. It seems proper that conservation and regulation of the use of the present stream flow should be practiced before a great expenditure is made primarily for an added supply. We are inclined to the opinion that the irrigation interests may best be served by a consolidation of their present position rather than by any great immediate expansion. If an expansion of irrigated land is desirable it seems reasonable that areas without any supply should be provided for first.

The major American River project.

During the past summer further investigation on the American River has indicated that the Auburn Reservoir may be developed in

conjunction with the Folsom Reservoir. The combined capacities of these storage units is 953,000 acre-feet. The Coloma Reservoir which at the date of this memorandum is being further studied, has a capacity of 750,000 acre-feet. There is reason to believe that a satisfactory dam site will be found and if this proves to be the case, the combined storage capacity of the development will be 1,700,000 acre-feet.

Operated as flood control works the Folsom and Auburn units are capable of safely reducing flow down the American River to a maximum of 80,000 second-feet. The inclusion of Coloma Reservoir in the plan will effect a further reduction to a maximum of 60,000 second-feet without interference with the power output.

A method of water release from Folsom and Auburn reservoirs can be devised whereby salinity can be controlled to Emmaton and Jersey in all years, including the critical season of 1924, with but a slight reduction in power yield. The addition of Coloma Reservoir will provide control fully in line with any sane requirement of the delta interests.

The outstanding advantage to be gained through the adoption of the American River development as the first unit of the coordinated plan rather than one on the upper Sacramento River is that of early consummation. We have endeavored to indicate the urgency of the situation both as regards flood control and abatement of the salinity menace. Development at Kennett or Iron Canyon will in no manner alleviate the deplorable situation which exists along the American River and only by a stretching of the imagination can one visualize aid to the delta within the next generation from these sources.

It seems obvious that either of the great developments of the upper Sacramento must be carried forward as state-owned projects. The writer presents no brief for or against public ownership and wishes to avoid any participation in injecting this highly controversial subject into the problem before us. However, the situation appears to demand recognition of the fact that publicly owned entities have not the faculty of moving rapidly. The uncertainties surrounding the upper Sacramento projects—legislative, legal and financial—are such that only a confirmed optimist would hope for the beginning of construction within the next decade. And ten years more might well be required to bring the project to completion

It has been suggested that early construction of the American River project might retard the upper Sacramento project by saturation of the power market. Our contention, based upon a close study of available statistics, is that the output from the American will long since have been absorbed before the Sacramento power comes on the market

The primary purposes of Kennett reservoir in the coordinated plan is to make up the deficiency which exists in the water supply of the San Joaquin Valley. Power production is but a means to that end Flood control and the abatement of the salinity menace are benefits of secondary importance. Salinity control and irrigation of the San Joaquin Valley are contradictory in effect; the one requires that impounded water be passed down the river channel to the sea, while the other presupposes diversion. *Why, then, is it not logical to provide on the American a development which shall be specifically dedicated to salinity control and allow the Kennett project to fulfill the purpose for which it was originally conceived?*

The matter of immediate absorption of the power output from the American project is to our belief wholly within the power of the state administration. We have been advised as to the attitude of the Pacific Gas and Electric Company in the matter of state conservancy measures. We are informed as to the increment of demand upon its system and can visualize no physical obstacle relating to absorption at a satisfactory rate. Armed with this knowledge, the task of the administration in this matter does not appear difficult; it is our belief that it can not only guarantee absorption at a satisfactory rate, but can so influence the rate at which power is to be purchased as to greatly decrease the suggested contribution to the construction fund and at the same time insure a proper and legitimate profit to the promoters and their financial backers.

Briefly stated, the power consumers of the state will share in paying for the benefits to be conferred through flood regulation and salinity control, but it is not to be inferred that their cost will in any measure be increased. Predicated upon the data now at hand, the production costs from this project will be approximately the same as from Kennett or Iron Canyon and being much nearer to load centers, no great transmission costs or losses are involved No power development project occupies a more advantageous position with relation to the points of use.

The desirable purposes sought by the several interests can be accomplished by a concentration of development on the American River for the next few years, and, being without cost to the parties benefited, its most violent opponent can not demonstrate the plan to be untimely or not in accordance with sound economic doctrines.

Advantages to American River Flood Control District.

The outstanding advantages to be gained by the American River Flood Control District through the regulation of flood discharges by the American project are those which bear directly upon the cost of reclamation. They may be summarized as follows:

Decreased size of flood channel.—Without regulation the required flood channel will be 2400 feet wide; it is economically impossible to continue such a channel to the easterly boundary of the district and some 3000 acres of excellent river bottom land would be denied protection under such a plan. The construction of Folsom Reservoir *alone* will permit the reduction of flood channel width to 1000 feet and the levees can be extended to protect all land in the district.

Under the recently approved federal legislation (Curry bill), it would appear that the State of California would be obligated to acquire such lands as are necessary within by-passes for projects yet to be constructed, of which the American River Flood Control District is a part. The rights to be acquired have been tentatively appraised at an average of $200 per acre and may be considerably greater. The 2400-foot flood channel contains approximately 1200 acres and the 1000-foot channel about 650 acres. It is therefore obvious that the saving to the state through the adoption of the narrower channel will be at least $110,000.

Decreased channel maintenance.—The permanent saving through maintenance of a smaller channel which will devolve upon the state will be considerable, both as to the removal of obstructions to flow in the overflow portion and the removal of detritus from the river bed.

Channel sedimentation is one of the important engineering problems which must be solved by the district. While the laws governing the transportation of debris by running water are not generally understood, it is unanimously agreed that the scouring effect of a continuously maintained large flow is greater than that of occasional great floods. The matter of channel maintenance is important. It was thoroughly argued at hearings on the plan of reclamation sponsored by Messrs. Tibbals and Percival, and many agree that deficiencies in this regard accounted for the failure of the plan.

Partial use of flood channel.—The revenue resulting from use of portions of the flood channel may properly be expected to yield a revenue to the state. It becomes apparent that, with regulation, the frequency of floods in excess of the capacity of the present river channel will be greatly decreased and that some of the flood channel lands may be put to a practically continuous agricultural use. The limited industrial use which may be had for lands subject to intermittent floods will also be extended.

Decreased length of bridges.—Regardless of the width of flood channel adopted, all obstructions to flow must be removed. The existing railroad fills must be replaced by trestles and where necessary the grades must be raised to conform to the proposed flood planes. While the advantages of the lesser channel width are obvious, the district at this time is not prepared to make a statement as to the allocation of these costs.

The highway leading northerly from the Twelfth Street Bridge is one of the main arteries of travel from Sacramento and traffic counts have indicated that between 11,500 and 12,000 vehicles pass over it every day. To obviate grade crossings at the two railroad intersections, subways have been constructed. These are flooded whenever the American River leaves its banks and a flood discharge which might otherwise do very little damage suspends traffic for several days after the high water has receded. For this reason, the present location is regarded as temporary. If the 2400-foot flood channel is found necessary, the Highway Commission proposes an elevated structure passing over the railroad tracks with a maximum height above ground of about 45 feet. With the 1000-foot channel the present location can be used, it being necessary only to substitute a short trestle between the Twelfth Street Bridge and the proposed levee.

The Highway Commission engineers have estimated the cost of the long overhead crossing at $787,000. The shorter structure would cost less than $100,000, making the saving on this item alone $687,000.

Aside from matters pertaining to cost and maintenance, decreased lengths of trestles are desirable from the point of view of the traveling public Causeways are dangerous, time consuming and subject to congestion They represent most of the detrimental features which highway engineers endeavor to avoid and in these cases are particularly obnoxious on account of the density of traffic.

Loss of assessable area.—The wider flood channel which will be necessary without reservoir regulation, will contain approximately 15 per cent of the total area of the district. Land along the river, being lowest in elevation, will probably be assessed at a maximum rate. It therefore

appears that the loss in assessed valuation through adoption of the wider channel may approach 25 per cent of the total for the district. This, of course, has the effect of increasing the charges against the remaining area and to that extent renders the acceptance of the project by the people more doubtful.

Regardless of its width any flood channel along the American River will constitute an eyesore and will forever be a barrier to the development of the two municipalities. As their expansion continues, this area will become more valuable and the economic loss will become more acute and more obvious. Many broad visioned people anticipate the ultimate consolidation of the two cities and in view of the rate of expansion in the last decade it seems not unreasonable to believe that such a consolidation will receive serious consideration within the next few years. A wide flood channel will go far toward defeating such a movement.

Improved chance for passage of bond issue. The benefits from flood protection become tangible only at infrequent intervals, and except in times of stress, it is difficult to impress upon the average voter the desirability and necessity for such protection. Herein lies the district's greatest problem. During the last few years, the people of Sacramento have rejected in whole or in part several issues, all of which provided for the construction of works which would have been tangible in aspect and of continuous and definite use to the taxpayer. No less than three bond issues will have been presented during 1928 and if any are successful, taxation must be increased. Other issues being contemplated for 1929, the district must face unfavorable psychological reactions resulting from them.

It seems obvious that, to be successful, the cost of the project must be held to an absolute minimum. This is possible only with regulation by reservoirs. The people of the district are quite generally aware that such regulation is feasible and economical and failure of the negotiations between the state and Kieffer et al. will have a decidedly adverse effect upon the chances for the success of a bond election.

Urgency of the situation.

Those interested in flood abatement, salinity control and irrigation supply have given practically unanimous endorsement to the coordinated water conservancy plan which is now being given careful study by your committee. All recognize the many difficulties in its consummation, but all are principally concerned with the matters of cost and time element.

As regards flood regulation and salinity control the situation amounts to an emergency. The position of American River Flood Control District certainly demands prompt action and obviously enough of the land holders of the delta can not and will not tolerate an indefiinite continuance of the situation which has been forced upon them. The solution offered by the proposed major project on the American River is to all practical purposes, immediate in its effects; it requires very little or no expenditure of public funds and, if shrewdly haudled, can be put into operation in such a manner as to insure lasting benefits to the state.

The conditions which obtained at the time of the enactment of the so-called Folsom bill have radically changed. The flood discharge upon

which the State Reclamation Board and California Debris Commission designed its plans was 128,000 second-feet; the flood of March, 1928, at its crest exceeded 180,000 second-feet. An unexpected element has been introduced by the proposed upper reservoirs, which combined with the Folsom plan would appear to offer a final solution to both flood and salinity problems. Unanticipated difficulties have been encountered in reconciling the economics of the project with existing legislation, the burdens specifically imposed being greater than the prospective revenue from power appears to warrant.

A suggestion has been made as to the propriety of securing legislation at the coming session, to validate any contract which may be made with the private interests involved in the American River situation and to effect the formation of the delta district proposed by Mr. Hadsell. We can conceive no legislation more essential under existing conditions or more broadly beneficial to the Sacramento Valley and we can not refrain from earnestly recommending such action.

Conclusions.

1. It is believed that immediate public policy can be better served by storage on the American River, than on the Sacramento; this belief being founded on the following grounds:

(a) There would be no interference with the passage of water intended for salinity control. A regulated flow of 4000 second-feet being possible during seasons of critical salinity, the delta region will be freshened nearly to the Sacramento Short Line ferry.

(b) Protection from inundation will be afforded to the thickly settled and rapidly growing city of North Sacramento, which is now wholly unprotected. Ultimate regulation to a maximum flow of 60,000 second-feet being possible, the American River problem will be solved and a menace to the city of Sacramento will be definitely removed.

(c) A great block of power will be made available at a cost not in excess of that to be produced by proposed upper Sacramento developments.

2. It is believed that the state is confronted with a situation having all the aspects of an emergency:

(a) The delta interests will no longer tolerate the destruction of property and loss of income due to the encroachment of salt water and unless some definite and constructive measures are adopted toward ameliorating the situation, disastrous litigation will ensue.

(b) A determination in the matter of American River Flood Control District must be had at the earliest possible moment and unless a reduction of cost is made possible through storage regulation the people will probably reject the project.

(c) Construction of storage works by the state is so uncertain and so subject to delay as to warrant its rejection as a possible solution. The introduction of a political football into the situation will in no measure benefit the parties now injured or subject to injury.

3. A solution of the obstacles to the signing of a contract with some responsible organization should be diligently sought and, if the solution is not found, the obstacles should be removed by further legislative enactment.

(a) Some such contract is the key to the entire situation. No one can foresee the course of events or anticipate the outcome of controversial elements contained in a discussion of the coordinated plan of water development.

(b) Such a contract clears the way for the consummation of the larger project which to the best of our present knowledge, solves this important problem which now confronts the state.

(c) The American River project involves no great expenditure of public funds and its benefits may be had with a minimum of delay.

Respectfully submitted.

A. M. BARTON,
Chief Engineer and General Manager,
State Reclamation Board.

SUPPLEMENTAL REPORT OF COMMITTEE

(Submitted to the Legislature April 9, 1929.)

The report of this committee presented to the Legislature on January 18, 1929, set for the methods pursued by it in the study of the water problems of this state and certain general conclusions arrived at. Also, certain projects or proposed undertakings for the immediate and later development of sources of water supply, storage and distribution were enumerated, but without particular regard to the financing of the same, and without recommending whether such work should be undertaken by the state or by the state and federal government, or by district plan, either through a combination of counties, cities, or other political subdivisions.

Since the submission of such report your committee has given further consideration to the basic principles or policies which it believes and accordingly recommends should govern or control in the gradual and ultimate realization and accomplishment and fullest utilization of the coordinated plan referred in the previous report of this committee and Bulletin No. 12 of the State Engineer's Office; and your committee also recommends the construction of certain units thereof as hereinafter set forth.

The comprehensive study made by the State Engineer's Office since 1921 has supplied the state with a fund of detailed and technical engineering data and information with reference to the water supply, resources, and needs of the various sections of the state and the engineering features involved in securing a more equal distribution of water from the areas of excess to areas of deficiency, that is and will be of incalculable value to this state. Many sections of the state have already reached their fullest development unless additional water supply can be furnished; and, indeed, certain large areas are in a state of decline and retrogression because withdrawal of water from sources of supply in excess of their replenishment. This is notably true in the South San Joaquin Basin, where thousands of acres and millions of dollars worth of property, highly productive if supplied with sufficient water at not prohibitive rates, are facing ultimate exhaustion of water supply through steady and constantly sinking water levels. Likewise, the seriousness of the condition prevailing in the great delta area of the Sacramento and San Joaquin will become more and more acute should further withdrawal of waters occur in the upper reaches of the Sacramento and San Joaquin rivers. We observe vast areas of the state, and masses of people locked in litigation that is rendering further development impossible, and which will produce results of inestimable damages irrespective of which side may be successful in such litigation. In fact, it is evident that state aid of some sort is imperative. The solution, if possible, of the immediate problem facing these vast areas of the two great valleys, presents matters of such diversified and varied importance that the adoption of certain general yet basic principles by the state seems necessary.

The ultimate development of this state will be largely dependent upon the fullest use of its water resources. The total water supply of

California is hardly sufficient for its ultimate needs. The day will come when the state will find a need and use for every drop of water that falls within the territorial limits. The easily developed waters are now in full use and practically exhausted. The future must depend on storage and more expensive supplies. The conservation and most complete use of water will be vital to the future prosperity of the state, and as already indicated, the demand for more water in vast areas is even now most urgent. Years of threatening shortage in rainfall, as the present year indicates it will be, causes apprehension as to the consequences that necessarily and inevitably follow.

Past methods of use and development of our water resources indicate that the course of least cost has been followed, and that without regard to the fullest and most beneficial use thereof. No general or coordinated plan has been followed with reference to the development of water resources. In view of the magnitude of the areas affected, the diversity of uses to which the water resources of our state can and should be put, the number of streams available as future sources of supply, and the diversity of ownership of existing projects, and the inseparable direct interest of the millions of people who live in or tributary to the areas affected, it seems to necessarily follow that only under a state policy will it be possible to coordinate the future development of the state's water resources and secure the maximum conservation thereof and economic benefit therefrom.

It is accordingly suggested and recommended that the state adopt a policy for the maximum conservation and economic use of its waters as follows:

1. Conservation.

It shall be the policy of the state to conserve, or to encourage and direct the conservation of the waters of the state, both surface and underground, for public use and protection, and to the end that such waters may be put to the greatest beneficial use, whether through public, quasi public or private agencies, by storage, control, diversion, transportation, spreading, and any other means.

2. Coordination of Development.

It shall be the policy of the state that future development of water resources in California shall be coordinated in its physical, economic and other aspects to the fullest extent practicable with due regard to ultimate costs and maximum uses and benefits. With reference to such coordination two important factors are recognized:

(a) The coordination of all uses of water, including domestic, municipal, irrigation, industrial, flood control, navigation, power, mining, salinity control and other uses that may arise.

(Typical project, involving such coordinated use is Kennett Project, infra.)

(b) The coordination of water supplies between the time and place of origin and time and place of use, and by means of transportation of water in excess of the needs of the water sheds of origin from such water

sheds to areas of deficient water supply to correct unequal geographic distribution.

(This is indicated in the proposed transportation of waters from the North Sacramento Basin to the South San Joaquin Basin, as set forth in Bulletin No 12, and infra.)

3. State Direction.

It shall be the policy of the state to assume the direction and control of the formulation, outlining, execution and operation of the general plan contemplated herein. This does not necessarily mean that the state must undertake construction and maintain the units of such plan; and whether or not the state undertakes such construction or maintenance, or whether it be done through other public, quasi public, or private agencies, the state shall assume direction and control thereof, shall not allow development inimical to its adopted policies, and shall encourage development by public agencies or private initiative in accord with or not in conflict with such policies.

4. It shall be the policy of the state to extend to areas of surplus water, from which, under the coordination policy or the development thereof, areas of deficient water may obtain a supply. Definite and valid assurance that such areas of surplus from which water is or may be taken shall have a right to ample water for their ultimate needs, superior and prior to that of the areas of deficiency to make use of such surplus. In the event of impounding water by storage, such areas or water sheds from which water is taken shall be entitled to use their prior water rights accorded hereunder, upon payment or agreement to pay such consideration for waters used therefrom as may be reasonable and proper under all the circumstances and conditions relating thereto, making due allowance for the initial prior right of such areas to such surplus waters.

5. Assurance to Areas of Deficiency.

It shall be the policy of the state to extend to areas of deficient water, which under the coordinated policy have obtained water from the areas of surplus, assurance of physical availability of permanent supplies by means of a progressive plan of construction of storage and other units as required by the needs of all areas, both those of surplus and deficiency, dependent upon the sources under consideration, this policy to be secondary to and limited by No. 4 above.

6. Control of Water Rights.

It shall be the policy of the state that control of water rights, water and the use thereof in this state, in so far as the same does not interfere with vested rights therein or thereto, be reserved to the State of California and shall not be exercised by the national government except in its proper regulation of navigable waters for the benefit of navigation alone.

7. Protection of Water Rights.

It shall be the policy of the state that future water rights granted by the state shall be in accord with the policies herein set forth; the water filings heretofore or hereafter made by the state shall be maintained and waived in favor of projects in accordance or not in conflict with plans or policies herein set forth.

8. Private Interests.

It shall be the policy of the state that the future plans, developments, projects and physical units of any and all private parties, companies, corporations, public or municipal utilities, or other agencies, shall con form to and not conflict with any policy set forth herein.

9. Reservation of Sites and Rights of Way.

It shall be the policy of the state that the sites for the necessary physical units, as may from time to time be required as necessary for the consummation of the policies set forth herein, shall be acquired by purchase, donation or by cooperation with the federal government, state, county, and other agencies, or the exercise of eminent domain, or by agreement or by any other means deemed necessary.

10. Apportionment of Costs.

It shall be the policy of the state that the costs of the execution of a plan under the policies set forth shall be apportioned according to benefits received. State assistance shall be given in accordance with state-wide benefit. Full utilization of available by-products, such as sale of hydro-electric power shall be made, to the end that projects or units may be self-financed to the fullest extent possible.

11. Federal Aid.

It shall be the policy of the state that federal contributions shall be requested by the state upon the basis of navigation, flood control, irrigation and other benefits that would accrue to the nation at large.

12. It shall be the policy of the state to make contributions to flood control, storage, or other projects, in conformity with and in the proportions hereto made, to isolated projects, not included in the coordinated plan proper.

(Example Los Angeles Flood Control, proposed Santa Ana Flood Control infra, page 193)

13. Distribution of Water.

It shall be the policy of the state that the state shall administer the distribution of water in accordance with respective rights thereto, and as may be necessary to assure successful operation of a plan executed under these policies.

14. Supervision of Dams.

It shall be the policy of the state that the state shall supervise the design, construction and operation of dams over a minimum size to be determined by law, in the interest of public safety.

15. Federal Departments.

It shall be the policy of the state that the federal government and its several departments shall be notified of the adoption of these policies herein included, and of plans thereunder, and be requested to assist the State of California in the execution of these policies and plans by granting of permits and licenses on government lands so as to conform with the state's policy and plan.

16. State Departments.

It shall be the policy of the state that all departments of the government of the State of California shall be notified of the adoption of these policies herein included and of plans thereunder, and any and all works under the control or direction of such departments shall conform to said policies and plans or shall not be in conflict therewith.

17. Plan.

It shall be the policy of the state to adopt a coordinated plan for the execution of the policies herein set forth, the same being substantially as set forth in Bulletin No. 12, subject to policies herein recommended and any modification that may hereafter be deemed necessary and proper.

18. Administrative Machinery.

It shall be the policy of the state that adequate and appropriate administrative machinery be created, and necessary appropriations be made for the execution of the policies set forth herein.

The ultimate accomplishment of such coordinated plan will necessarily require many years. The construction of units thereunder should be progressive and in accordance with the needs of the state and as economic conditions may warrant. The plan must be pursued upon fairly conservative grounds with due regard to the ability of the people and the state to bear the costs thereof and to pay for the same, and the capacity of the state and the available markets of the world to consume the products thereof to the reasonable advantage of the producers and agricultural interests involved.

PARTICULAR PROJECTS DEMANDING IMMEDIATE CONSIDERATION

Your committee endeavored to give full consideration to study the major water problems in all sections of the state.

This included the proposed aqueduct from Colorado River to the metropolitan area in southern California, as well as the problems in San Bernardino, Riverside, Orange and San Diego counties. The consideration was state-wide and not sectional. But there was no intent or desire to force or recommend state contribution or force or claim state control in projects or undertakings where such aid or contribution was not desired. In fact, where municipalities or combinations thereof, or districts, or political subdivisions, desire or are capable of undertaking and carrying through the construction of units or projects without state aid, such course is to be commended.

Accordingly, when the city of Los Angeles and other southern California cities expressed their preference to finance, own and operate the proposed aqueduct without assistance from the state they confirmed the policy that has heretofore prevailed in all sections of the state with

reference to municipalities furnishing their municipal needs in this respect, and enabled the committee to feel that it could and should properly abandon any further claim by individuals that such aqueduct be considered a state project.

Kennett and San Joaquin Valley Projects.

Your committee herein reaffirms its conclusions set forth in its preliminary report that the Kennett Dam should be constructed for the primary purpose of relieving the salinity problem in the Delta, and the furnishing of water to the San Joaquin Valley by means of dams, pumping plants, aqueducts and levees, as mentioned and described in our former report, because of the critical conditions that exist in such areas. We further believe that because of the magnitude of the undertaking; the extent and diversity of the areas affected and the benefits to be derived, that these projects are of state-wide interest, and should be constructed by the state through the lending of its credit at the earliest possible time. Through the sale of electric power that can be generated by installation of a power house at the dam, a large part, if not all of the cost thereof as well as interest charges thereon, can be realized. This has been demonstrated in such district projects as the Merced, South San Joaquin and Oakdale, Nevada and other irrigation districts.

In arriving at our conclusions on methods of financing these projects, among other things it is necessary to consider the following facts and conditions: Kennett Dam, if constructed, should not be operated alone for primary power. It should be operated in the interest of navigation, flood control, furnishing of water to San Joaquin Valley and fresh water to the delta, and as near as possible to industrial plants located along Carquinez Strait, as well as for power. In fact the sale of power is the most available source of revenue. But the other uses and benefits indicated make available sources of revenue that will contribute substantially to the costs.

Such construction and operation of this dam will tend to solve the critical water problems in the Big Basin of northern California and the bay section as far as Antioch. As new areas are developed in the Sacramento Basin through use of waters from this source, contribution and payment should be made, therefore, upon a reasonable basis having due regard to original prior right to such water, and as the saline question is removed from the delta area, land values there will be reestablished and some payment should be made to state for the benefits thus conferred.

This method of operation of the dam, however, will make it less attractive as a project to be constructed and operated by private interests because of the diminution of the quantity of primary power due to the uses of water for other purposes just mentioned.

The construction of Kennett by the state, even though operated for the purposes mentioned, will, however, bring returns to the state of a very substantial amount from the sale of power which may be generated as a by-product.

The cost of Kennett dam and pump house and the reservoir site will be the sum of $70,000,000. This amount was arrived at after careful study by the State Engineer and a large board of consulting engineers.

Likewise, it was determined that the San Joaquin project mentioned will cost $24,000,000.

Kennett Dam when constructed will accomplish the following:

It will supply the Sacramento River, and the channels in and about the delta of the San Joaquin and Sacramento Rivers as far as Antioch with a supply of additional water over and above that now actually used by lands taking water from the river channels during the dry months of July, August and September, and make available for exportation into the lower San Joaquin Valley through an exchanged water, after providing and guaranteeing not less than 5,000 second-feet and the delta at Antioch, sufficient water to relieve the needs of that section.

It will also lower the flood level of the Sacramento, which will increase the factor of safety from overflow, benefiting navigation above Sacramento, solving the salt water problem as far as Antioch, and making it available for the industrial sites along Carquinez Strait by a conduit. The industries there located have expressed a willingness to pay a reasonable price for water thus made available for their use. Because of the foregoing, and the aid to navigation and flood control substantial aid might properly be expected of and received from the various sources of revenue that will be thus available, the Kennett project is practically self-financing.

The critical conditions mentioned in our previous report are the direct result of the natural development which has taken place during the past 40 years, in which municipalities, districts, power companies, and agriculture generally have participated. It is obvious that should additional water be taken from these rivers which are now depleted by such development until this condition has been changed, these critical problems will go from bad to worse.

The state is interested in correcting these conditions and making possible future development as the economic needs require, of all of the remaining waters arising in the water sheds surrounding the Big Basin of northern California. These facts and conditions warrant some state contribution at least to the extent that the project will not finance itself.

We recommend then that the state submit to the people the proposition of issuing and selling bonds of the State of California in sufficient amounts to construct these units.

The San Joaquin unit is dependent for its ultimate usefulness to the fullest extent upon the completion of the proposed exchange of waters as indicated in Bulletin 12. Certain practical difficulties are suggested with reference thereto, but they do not appear to be unsurmountable. In fact, exchanges of water under somewhat similar conditions have been made in other states and in view of conditions existing in this state, the same results should be possible herein.

However, the sale of any bonds for the undertaking of such work, should bonds be voted therefor, should not be made until the necessary agreements have been executed which will accomplish or enable the state to effect the exchange of waters contemplated. And the areas ultimately benefited should be so organized in districts, otherwise, that they might contract for and undertake to pay a fair share of the costs incident to securing and furnishing the water to the deficient area.

The particular projects herein specifically mentioned must be considered and developed in accord with general policies to be adopted by

the state as indicated herein, and subject to the express rights and priorities mentioned.

PARTICULAR PROJECTS DEMANDING IMMEDIATE CONSIDERATION

SANTA ANA RIVER PROJECT

The Santa Ana River Project mentioned in our previous report is a joint flood control and conservation project. It involves the complete development of the Santa Ana River and its tributaries and the protection of highly improved districts from overflow and flood damage. The cities and rural districts of three of our largest and most highly developed counties are directly interested and involved

Not only have the districts within these counties suffered great and irreparable injury as the result of winter seasonal floods, but thousands of acres of highly improved lands depend entirely upon this river and its tributaries for their water supply.

Not only does this river and its tributaries furnish the surface supply for irrigation and domestic use in these counties, but also is the direct and only source for all of the underground water upon which this vast territory depends. The water levels in this territory have greatly receded, and unless conservation of the winter floods is affected, great damage will be sustained.

The engineering department of the state has worked out a plan for the complete development of this river and its tributaries which will effectively protect against storm damage and conserve all winter flood water so that it may be put to beneficial use. The cost of this development is estimated by the State Engineer as thirty million dollars. The plan involves the construction of dams in the higher reaches of the tributaries of this river, as well as at or near Prado, in Orange County.

The state has heretofore adopted and approved a policy of contributing to such projects. The Sacramento Valley and the Los Angeles flood control are perhaps the most outstanding examples where such policy has been applied.

In the application of this policy it has been the practice of the state to require contribution from those receiving benefits.

In the case of the Los Angeles flood control, the contribution was 50 per cent by the state and 50 per cent by the district benefited. In the Sacramento Valley the contribution was one-third by the state, one-third by the government, and one-third by the district. We believe that a proper contribution by the state for the Santa Ana River development would be fifty per cent of the entire cost, leaving 50 per cent to be borne and paid for by the counties and districts benefited. By applying this principle it would be proper for the state to make a contribution of fifteen million dollars toward this development, leaving the balance to be borne and paid by the interested districts. Like other projects recommended, the state would be benefited by increased revenues derived from additional improvements made possible by protection from floods and the complete conservation of the flood waters of this great river system.

The total cost of these three projects then would be the sum of $109,000,000. Of these three projects Kennett Dam will furnish power, the sale of which will be remunerative, and it is estimated that the power from this dam will bring in annually to the state the sum of $4,500,000. This power should be disposed of so as to repay the bonds and interest to such an extent as possible.

It is obvious that the cost to the state, should these bonds be refunded from time to time, would be very little, after the Kennett Dam is in operation. The increased value in the property of the state, the benefit to municipalities and industry would be enormous and benefits direct and indirect would be reflected throughout the state.

We recommend that the project consisting of Kennett and the system of pumping plants, conduits, and levees, heretofore mentioned for the San Joaquin Valley, on the conditions mentioned and that $15,000,000 for flood control and conservation in the Santa Ana River and its tributaries be submitted forthwith to the people of the state in the form of a bond issue to finance the same, at the earliest practicable time.

SALT WATER BARRIER

The salt water barrier has received very careful consideration during the past eight years by the State Engineer and the Consulting Board of Engineers and by this committee. Data taken from Mr. Walker Young's report and a report by Mr. Thomas H. Mean is set forth in our previous report.

Without doubt, the salt water barrier is an integral unit in any plan which the state may adopt for the fullest conservation and use of the fresh water of the Sacramento. This will be true after the water withdrawals down the San Joaquin, endanger the 5,000 second-foot minimum which is to be guaranteed the delta region.

Even with the construction of additional units such as American, Feather, Bear and Yuba River units, the demand of the Sacramento and San Joaquin area may be such as to require the salt water barrier. When such need shall exist, however, the barrier should be built.

The State Engineer and consulting engineers in the state report have continuously refused to recommend the salt water barrier as one of the first units to be constructed by the state on the ground that the Kennett project would produce greater benefits at a less expense to the state.

During the past few months various proposals have been advanced by those interested in the construction of the salt water barrier relative to financing same and additional uses to be considered, such as transfer of Sacramento River water to southern California. And latest suggestion of use of such water in southern California presents problems of sufficiency of supply, engineering and financing that are of such magnitude that intelligent action thereon at this time is out of the question. The conditions prevailing in the delta, Sacramento and San Joaquin basins are of such critical nature that further delay in granting or at least recommending remedial measures seems unwarranted.

We believe that the relief which will be afforded to the delta region, should the Kennett unit herein recommended be constructed, will be of such wide beneficial effect, not only to agricultural, but as well to all other, including industrial interests located at or near Carquinez Strait that the recommendations made herein should have the unqualified sup-

port of the entire delta and metropolitan area. It seems advisable to undertake these projects as recommended, and secure the benefits to accrue therefrom, rather than to overload our recommendations with projects which at this time would jeopardize the adoption or approval of any projects whatever by the people.

Therefore, it would seem at this time that the salt water barrier should not be included in the initial bond issue. It is evident that more study and investigation should be given to it to ascertain for a certainty which location should be chosen; the effect of its operation on navigation; the benefits which would be derived by particular areas; the effect upon the levee system of the delta; and that a more definite and satisfactory investigation be made during the coming biennium, to the end that there would be more unanimity in the conclusions of the engineers. We recommend that a further study and investigation of this proposed project be made by some competent body and report thereon made to the next session of the Legislature.

AMERICAN RIVER

We affirm our conclusions in regard to the development of the American River watershed. This appears to possess attractive features as a supplementary unit to Kennett Dam in the coordinate plan and with prospects of private financing should eliminate state charges and at the same time yield a return that will materially aid the state in carrying the cost of the San Joaquin unit. We urge the diligent prosecution of negotiations by state agencies to the end that flood menaces from the American River water shed be removed as soon as possible.

FEDERAL AID

We feel that the federal government is interested in the development of Kennett, upon the grounds of its well established policies regarding navigation and flood control. Therefore, every effort should be put forth upon the adoption of the program of construction hereinbefore mentioned to obtain federal aid.

Whenever such federal aid is obtained it should inure to the benefit of the state in repayment of the amount of money which the state may have advanced or reducing the amount of bonds to be sold in the construction of Kennett and the San Joaquin Valley project.

We recommend that the Legislature memorialize congress to at once investigate the needs for this development and to approve the same and appropriate such sum or sums as it deems just in the premises.

We recommend that bills, resolutions, constitutional amendments or other measures be prepared necessary for the carrying out of the recommendations hereinbefore made.

Respectfully submitted.

Senators: H. C. NELSON.
RALPH E. SWING.
EDWIN A. MUELLER.

Assemblymen: B. S. CRITTENDEN.
VAN BERNARD.
FRANK W. MIXTER.
E. G. ADAMS (possible appendix).

SUPPLEMENTAL REPORT OF RALPH E. SWING

I concur in the majority report, but it does not adequately express the policy which I believe the state should pursue with reference to its water resources.

It is an admitted fact that unless these resources are conserved and all flood waters made available for use, the state will soon reach its maximum development.

In a comparatively few years we have seen communities converted into vast metropolitan areas and industrial districts, and villages transformed into large and thriving cities. The use of water has of necessity kept pace with this growth, and frequently at the expense of the farming and urban areas.

The right to the use of practically all available water has already passed into private ownership, and the development of nearly all projects which offer any return upon the investment has been carried to completion in the interest of those financing the project The cream, so to speak, of all the state's water resources has been skimmed off by private interests, leaving only that which, because of its remoteness from point of use or inaccessability, is unattractive for private development, yet the conservation of which is necessary if the state's growth is to continue.

Investigation has conclusively established that there is annually during the flood season enough water wasted to provide for all reasonable and necessary uses for complete state development.

Private capital can not be enlisted for the conservation of flood waters where the financial return is little or none. It therefore devolves upon the state to undertake the protection of its own future and its own resources. While I do not favor the state embarking in commercial ventures or undertaking projects which can well be carried on by its citizens, I do feel that conservation of all flood waters for use within the state is a proper field for state intervention. A reasonable plan for carrying this policy into effect should extend over a period of years, and should be more or less definite in its first inception so that the projects not provided for in the first expenditure would be assured proper consideration as the needs of the state require their respective development.

It is my belief that the state's activities should be twofold in nature: (a) The construction of such dams as may be necessary throughout the state to conserve and hold back all surface waters not necessary for the supplying of vested rights, both surface and subsurface, and thus make these excess waters available as a supplemental supply for those already claiming rights to the use thereof, as well as making available the unappropriated excess for new development and for supplying uses not now established The entire cost of such development would of necessity be a state charge, for there would be no direct return, except such incidental return as may be derived from the sale or rental of power rights or from the rental of excess water, which would be small in comparison with the cost.

(b) In those instances where water is conserved and retained in any reservoir constructed by the state over and above that necessary for

the supplying of all rights within the water shed, the state should have power to transport such unappropriated excess to districts of deficiency, and thus make available in such deficient districts new water, or at least a supply not naturally tributary thereto. When able, the district or territory benefited by the transfer of such water should pay the cost of transportation, but in many instances the communities thus have served may not be financially able to carry the burden In such cases it would be proper for the state to adopt a policy of making the transfer of such unappropriated water upon condition that the benefited district or territory pay all or at least a part of the cost of such transportation in annual charges or rentals. The moneys so received, together with that which may be received from the sale of power rights, should go into the development fund to aid in retiring bonds which may necessarily be voted for such developments.

The logical plan for carrying out such a policy would be to submit the entire general scheme for full development of the water resources of the state to the voters for their approval or rejection, and in the proposition submitted should be included a direction to the Legislature to provide from year to year the funds necessary to carry on such development as the state's needs should require. Of course it would not be either necessary or advisable to vote bonds in any specific sum for such purpose, but authority could very well be reposed in the Legislature to authorize the issuance of bonds in such amounts and at such times as might be necessary to carry on such development, extending over a period of years, the most urgent projects being given earliest consideration. The Department of Public Works or some other department of the state government could be empowered to prepare and submit to the Legislature recommendations as to the developments which should take place in the succeeding biennium and submit a budget of the amount of money necessary for carrying out such recommendations.

This plan would cause complete development and would insure all parts of the state receiving proper consideration of their respective interests.

The plan would necessarily have to be incorporated in a constitutional amendment so drafted that the coordinated water development scheme referred to in the reports of the state engineer and such other projects as may be deemed necessary to carry out the plan above suggested, could be approved by the voters, with the proviso that the work should be carried on as the state's development may require, and in such constitutional amendment the Legislature could be empowered and authorized to cause bonds to be issued and sold in such amount and at such times as may be necessary to meet the budget as recommended by the state department. Such bonds, of course, should not be authorized by the Legislature except by a two-thirds vote, thus insuring the voters that money would not be expended except for projects which were strictly within the policy above referred to. Perhaps it would be well to insert in such amendment authorization for the immediate construction of those projects which this committee has in its report deemed sufficiently urgent to require immediate development. Such a plan should meet the demand of all who are

interested in a complete development of the water projects and at the same time insure immediate development of those projects now claimed to be necessary.

Unless some such plan is followed, I fear the voting of bonds for a particular project may result in a contented feeling in the territories thus favored, so that the voters of those favored districts would not be vitally concerned in future proposals, and might perhaps be inclined not to support them, whereas, if the entire plan of progressive development were submitted, all districts within the state would be equally interested, for each would know that eventually the development of all the state's water resources would be carried to completion, and that they would thereby receive their proper benefit. I feel constrained to urge upon the Legislature a very careful consideration of such a plan before coming to a final determination in the premises.

Respectfully submitted.

RALPH E. SWING.

I concur with such parts of the foregoing report as are consistent with the separate report filed by me herewith:

The committee appointed under and by virtue of Assembly Concurrent Resolution No. 30 was charged with the duty of seeking and digesting all available and adequate information to enable members thereof to consider a state-wide plan for the conservation and use of the water of the state.

In the preliminary report submitted by your committee to the Legislature of the State of California, dated January 18, 1929, the conclusions and recommendations of the committee were that the coordinated plan for the development of water resources as summarized in Bulletin 12, summary of "Report of the Water Resources of California and a Coordinated Plan for Their Development," as filed with the Legislature in 1927, by the State Engineer and the Department of Public Works, Division of Engineering and Irrigation, be approved as the plan and policy to be followed by the state, subject, of course, to such modifications and changes as further studies would make advisable.

In the report submitted to the Legislature in January of this year, the following projects were deemed necessary:

(1) Kennett Dam, approximate cost of which will be	$70,000,000
(2) Salt water barrier at or near Army Point crossing from the easterly shores of Solano County to the westerly shores of Contra Costa County, at or near Suisun Bay, the approximate cost of which will be	50,000,000
(3) San Joaquin Valley dams, pumping plants, aqueducts, and levees for the purpose of pumping and transporting water from the Sacramento River to the San Joaquin River, the approximate cost of which will be	24,000,000
(4) Santa Ana flood control consistent with the policy as applied to the Sacramento River and Los Angeles flood control, the approximate cost of which will be	10,000,000
(5) Los Angeles aqueduct	150,000,000

Your committee, pursuant to the directory portion of Assembly Concurrent Resolution No. 30 was informally of the opinion that a coordinated plan for the statewide conservation and use of the waters

of the state demanded a state-wide bond issue large enough to construct the five units recommended in the report submitted to the Legislature of the State of California in January of this year.

But spokesmen, purporting to speak for the city of Los Angeles and other southern California cities, stated that it was the preference of Los Angeles and vicinity to finance, own and operate the proposed acqueduct described in No. 5 above without any assistance from the state.

The attitude of the Water and Power Bureau of Los Angeles County and the spokesmen for the south created a situation which eliminated a balanced program upon which a state-wide bond issue could be predicated.

Until the attitude of Los Angeles had become definite with regard to its view to own, operate, and pay for the aqueduct without assistance from the state, the committee informally was committed to the salt water barrier as a part of a balanced state program.

After the committee bowed to the will of the local authorities in Los Angeles who did not desire to be interfered with in the construction of, or the administration of their local water problems, even though the cost of the aqueduct will be greater inasmuch as the committee has acceded to their views, the question then arose as to the expedient way in which to interest the state in the water problems of the state without the benefit of a balanced program.

Construction of the bay barrier will establish on the San Francisco Bay probably the greatest industrial area on the Pacific coast enhancing property values and creating wealth throughout the entire San Francisco Bay section and central California and northern California. Suggestion has been made by opponents of the barrier that Los Angeles would oppose the report if the barrier were included, on the theory that the barrier will create and establish this great industrial area; but we are unwilling to subscribe to any such proposal and question very much its wisdom and the desirability of the people of Los Angeles to create any such impression. Knowing the people of that section as I believe I do, I feel confident that they will not be guided by any such selfish, narrow or questionable consideration and that they would join with the people of other sections of the State of California and help keep alive the spirit of a great California and one California.

THE ELIMINATION OF THE BARRIER, THEREFORE, FROM THE PROGRAM AT THIS TIME IS ACCOMPLISHED NOT BECAUSE OF THE LACK OF MERIT OR NECESSITY OF THE BARRIER, BUT BECAUSE OF POLITICAL EXPEDIENCY.

The statement in the foregoing report to the effect that should the Kennett unit be constructed, it will be of such beneficial effect not only to agriculture, but as well to all other, including industrial interests located at or near Carquinez Strait, is not founded on fact or on sound engineering judgment as can be demonstrated by the opinions of competent engineers.

The correctness of the statement above referred to is proven by an examination of the Walker Young report filed in the office of the State Engineer, and the report of Thomas H. Means, incorporated

in the report submitted to the Legislature of the State of California, January 18, 1929, being Exhibit "C" therein.

Kennett Dam is not large enough to hold water at 100 parts per million chlorine at Antioch in a dry year, even without taking 3000 second-feet to the San Joaquin. The Kennett Dam alone with the San Joaquin pump will speed up the time at which salt water reached Antioch each year and will give the territory below Antioch practically permanent salt water. Too, the proposed water to be held at Antioch is ten times too salty for industrial use and four times too salty for continued agricultural use.

In 1927, a year with rainfall above normal, for a period of over four months, the water at Antioch would have been at the limit proposed. In 1924, a short water year, to maintain water of this quality at Antioch it would have taken 50 per cent of all the streams that flow into the drainage area flowing into Carquinez Strait to maintain the water at Antioch at the proposed limits—a manifest impossibility.

If 3000 second-feet of water was taken into the San Joaquin from the Sacramento, in the years 1918, 1920, 1923, 1924, and 1926, and probably 1929, the Kennett Dam would not be large enough to have maintained the proposed salinity at Antioch.

The irrigation season in this district normally starts in May. In a normal year, the salt water would reach Antioch, under this plan, on July 1, giving only two months in which land could be irrigated. In dry years, the salt water would reach Antioch soon enough so that the water could not be used at all for irrigation.

With construction of the Stockton channel, the salt water will flow into the delta even quicker and further aggravate the present condition.

The statement in the supplementary report to the effect that the salt water barrier should not be included in the initial bond issue for the reasons therein set forth, is erroneous. Walker Young, U. S. Reclamation Engineer, and one of the outstanding engineers to have considered the salt water barrier, states that the erection of the barrier will not have a detrimental effect upon the levees. The Young report was compiled after 18 months study and investigation and has been on file in the office of the State Engineer for more than sixteen months. This work was done at a cost of $85,000, to which industry contributed most generously. The report never has been published, notwithstanding frequent requests having been made for its publication, and is only available at times in the office of the State Engineer. This report unqualifiedly recommends the barrier. See also page 151, report of the joint committee of the Senate and Assembly dealing with the water problems of the state, submitted to the Legislature on January 18, 1929.

I have an authoritative statement that the Kennett Dam will not put five thousand second-feet of fresh water at Antioch, but that amount of water will be placed seven or eight miles above Antioch. This will create a situation in the delta which will find sixteen hundred pounds of salt to every one million pounds of fresh water, enough to contaminate with salt the entire lower delta area. It will also be necessary for the industries at Pittsburg, Avon, Martinez, Bay Point, and the California Hawaiian Sugar Refinery at Crockett, and the Union Oil Company at Oleum, to construct an aqueduct 34 miles long

at a cost of approximately ten millions of dollars in order to reach the fresh water proposed above.

The salt water barrier is of greater state-wide value in the improvement of water conditions in California than any other project recommended by the committee. The immense quantity of fresh water which would serve to reclaim 175,000 acres of agricultural lands would be available should the salt water barrier be constructed. Water sufficient to supply the San Joaquin Valley would be possible without interfering with the normal flow of the Sacramento River. It is generally conceded that the fresh water problem of the San Joaquin Valley will not be fully remedied with the construction of the Kennett Dam alone. It is conceded that only by the construction of the barrier will the problems of the San Joaquin Valley be definitely and finally solved.

There would be abundant water to augment the municipal water supply of the southern cities of the state including Los Angeles. The hand of good fellowship carrying a water supply helpful to the south will mean a unified, prosperous California; a state indivisible.

The salt water which has rendered precarious the situation of the delta country would be entirely alleviated.

A highway bridge is also made possible to amortize $10,000,000 of the cost Sale of water to industries, municipalities, and agriculture assessments made on the reclaimed land will also assist in the cost of the barrier. Suggestion has been made that an appropriation of $15,000,000 may be secured from the federal government, who will be interested from the standpoint of the benefit that will result to navigation through the construction of the barrier.

Therefore, it can readily be seen that the barrier will be practically self-financing. It should in future be deemed advisable to construct the barrier at Dillon Point, which is several miles below Army Point as recommended in the report of January 18, 1929. The barrier may be constructed at $15,000,000 less cost.

Traffic studies show that a second bridge across Carquinez Strait to accommodate automobile traffic will be needed long before the barrier can be constructed, so that if the barrier is built at Dillon Point the revenue from the highway bridge will still be available.

The San Joaquin Valley as a matter of law or of right cannot claim the waters of the upper Sacramento River, and has no right to any portion of Kennett revenue to pay for its pump and lift system. We should keep in mind the fact that Kennett is designed primarily for flood control purposes and for storage of water for irrigation. The sale of power is simply a happy incident that will bring a certain amount of revenue. We must keep in mind always the knowledge that as water is released for irrigation purposes it will diminish the quantity of power that might be developed and thereby curtail the revenue to be received from that source. The revenue of Kennett, if any thereof is to be allocated to any other project, should be allocated to the barrier, as it is naturally and geographically a part of and has to do with the water of the Sacramento River.

Agricultural stimulus by reason of the fresh water behind the barrier, would be such as to reclaim areas now dormant for agricultural purposes in Solano, Contra Costa, Sonoma, Napa, Marin, and

Alameda counties, and would make these and counties adjacent thereto among the most productive agricultural areas of the state.

Industries north of Carquinez Strait and areas south thereof would thrive. Alameda County and the city and county of San Francisco would be materially benefited. Eminent engineers such as Walker Young, Thos. H. Means, C. E. Grunsky, and Vincent Wright, have all subscribed to the theory outlined above.

The industrial area of Contra Costa County from Antioch to Richmond is producing $550,000,000 annually in manufactured products and gives employment to more than 18,000 persons with an annual pay roll of $30,000,000. The agricultural area, immediately adjacent to it is producing $110,000,000 annually.

I submit, therefore, that this great area that is contributing so much to the prosperity of California can not be ignored, and that political expediency has no place in the spirit or action of the people of the great State of California.

I recommend that the state submit to the people of the state the proposition of issuing and selling bonds of the State of California in the sum of $159,000,000 to cover the four units, to wit: Kennett Dam, Bay Barrier, Pumping and Lift system for San Joaquin Valley and the Santa Ana Flood Control.

I submit that bills, resolutions, constitutional amendments or other measures should be prepared for carrying out the recommendations made herein.

WILL R. SHARKEY.

SUPPLEMENTAL STATEMENT OF E. G. ADAMS

I do not concur in that part of Senator Sharkey's minority report in which he suggests political expediency as the reason the salt water barrier is not recommended as among the first units of the coordinated plan to be financed and built.

I do, however, believe that the importance and necessity of the barrier, particularly at a lower point than Army Point, has been underestimated by the majority of the committee. I believe the barrier would be a sound and justified economic investment for all of California at this time. I believe further that the conceded need for a foreign water supply for southern California should be substantially recognized by the state at this time by provision in the initial bond issue for state aid to such projects of state-wide interest as the aqueduct from the Colorado River to the Coastal Plain and the All-American Canal and that the committee should not have accepted as the unquestioned conviction of the people of southern California the declarations and decisions of the individuals and groups mentioned by Senator Sharkey.

But the partial, or commencement program, contemplated in the final report of the committee, which report I have signed, will have my whole-hearted support.

E. G. ADAMS,
Assemblyman, 49th District.

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