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1955

San Diego County Water Authority

San Diego, California

REPORT ON
WATER SUPPLY FOR PROBABLE FUTURE
DEVELOPMENTS IN THE SAN DIEGO COUNTY
WATER AUTHORITY

BOARD OF ENGINEERS
RAYMOND A. HILL
JOHN S. LONGWELL
CARL R. RANKIN

SEPTEMBER 12, 1955

AND
REPORT ON
THE PROBABLE EXTENT OF AUTHORITY AREA,
THE AMOUNT AND SOURCE OF ADDITIONAL WATER
SUPPLY REQUIRED, AND THE SYSTEM REQUIRED TO
EFFICIENTLY DELIVER AUTHORITY WATER TO THE
AGENCIES COMPRISING THAT AREA

RICHARD S. HOLMGREN
General Manager and Chief Engineer

JUNE 1955

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WATER AUTHORITY
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WATER SUPPLY FOR PROBABLE FUTURE DEVELOPMENTS IN THE SAN DIEGO COUNTY WATER AUTHORITY

By

BOARD OF ENGINEERS

RAYMOND A. HILL
JOHN S. LONGWELL
CARL R. RANKIN

September 12, 1955

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WATER SUPPLY FOR PROBABLE FUTURE DEVELOPMENTS IN THE SAN DIEGO COUNTY WATER AUTHORITY

SCOPE

The following statement presents a review of a report submitted to the Board of Directors of the San Diego County Water Authority under date of June, 1955, by Richard S. Holmgren, General Manager and Chief Engineer, and entitled "Report on the Probable Extent of Authority Area, the Amount and Source of Additional Water Supply Required, and the System Required to Efficiently Deliver Authority Water to the Agencies Comprising that Area." In addition, a summary is given of investigations and studies carried on by the undersigned Board of Engineers relative to providing a water supply for the probable future developments in the San Diego County Water Authority. The work by this Board was authorized by the General Manager and Chief Engineer of the Authority in letter dated March 21, 1955.

The Board of Engineers had available for its use, preliminary drafts of the Report prepared by the Authority Staff, covering in general the various items under consideration. These have been reviewed and discussed in some detail with Messrs. Holmgren and Sloan, as have also numerous other phases of the many problems involved. Additional studies have been carried on and data has been assembled by the Authority Staff as requested, to assist the Board of Engineers in arriving at its conclusions.

Although all members of this Board have been familiar with, and more or less closely associated with the water supply situation in San Diego County over a period of many years, supplemental field trips were also made as required to become more familiar with actual present-day conditions.

On July 14, 1955, the Board of Engineers met with the General Manager and the members of the Engineering and Operations Committee of the Authority Board of Directors. At this meeting, many of the major problems confronting the Authority in the water supply field were discussed. The Committee evidenced special interest in regard to the policy to be followed by the Authority in connection with the construction and operation of branch lines and related facilities. In view of this interest, the Board of Engineers submitted to the General Manager, at his request, under date of July 19, 1955, a suggested policy regarding the construction of branch lines.

During the past year, the Authority Staff has been engaged upon a review of the many problems involved regarding future water requirements in the Authority and in this work has accumulated a great deal of valuable and pertinent information. The General Manager's report, as submitted to the Board of Directors, summarizes the results of these studies and investigations and presents the conclusions of the General Manager and his Staff regarding the many phases of the problems. The Report properly brings to the attention of the Board of Directors, the importance of the water supply situation in San Diego County, as well as the need for continued study with appropriate action by the Authority Board of Directors.

The Board of Engineers concurs with the Authority Staff as to the general problems involved, but it is not in agreement as to a number of the important basic premises.

Accordingly, the following statement will review the principal items involved and discuss the effect of the differences. It will also outline what further investigations and analyses should be made by the Authority Staff in order to develop material for arriving at appropriate conclusions and final action. The General Manager's Report will be discussed under the headings as listed in the summary and conclusions, with such additional comments as are deemed necessary.

ESTIMATED INCREASE IN AREA WITHIN THE AUTHORITY

Areas

As of June 30, 1955, the San Diego County Water Authority was composed of 16 public agencies having a total area of 351,697 acres. In addition, six areas are now considering annexation to the Authority and, if annexed, will increase the area by 138,340 acres, to a total of 490,037 acres.

Table 1 gives details regarding the names of the various agencies and areas making up the Authority and proposed for annexation, together with the dates of annexation and the acreages involved.

It will be noted that the area annexed or proposed for annexation in 1954 and 1955 is 327,040 acres as compared with a total in the Authority at the close of 1953 of 162,997 acres. The causes of this major annexation program are discussed in subsequent paragraphs.

Feather River Project

In 1951, the State Water Resources Board published a Report entitled "Feasibility of Feather River Project and Sacramento-San Joaquin Delta Division Projects Proposed as Features of the California Water Plan." This Report, among other things, proposed a conduit which would carry water from the Sacramento-San Joaquin Delta near Tracy, along the Westerly side of the San Joaquin Valley to the Tehachapi Mountains, then over and through the Tehachapi Mountains at about elevation 3,300 and around the Easterly side of the South Coastal Basin to Horse Thief Canyon in San Diego County, from which point the water would

flow some seven miles to Barrett Reservoir. In this plan, the State proposed to deliver for use in Southern California about 1,800,000 acre feet annually, of which two-thirds would be made available to the South Coastal Basin.

The State proposal to bring approximately 1,200,000 acre feet of Feather River Water into the South Coastal Basin as a supplement to the local supplies and those imported from Owens Valley and the Colorado River created a great deal of interest among Southern California water users and water utilities.

Action of Metropolitan Water District

Subsequently, the Metropolitan Water District took the position that, with its far-flung distribution facilities, the MWD would provide any required supplemental water within its service area. A policy statement to that effect was issued by the Board of Directors of the MWD under date of December 18, 1953, and is quoted herein:

"The Metropolitan Water District of Southern California is prepared, with its existing governmental powers and its present and projected distribution facilities, to provide its service area with adequate supplies of water to meet expanding and increasing needs in the years ahead. The District now is providing its service areas with a supplemental water supply from the Colorado River. When and as additional water resources are required to meet increasing needs for domestic, industrial, and municipal water, the Metropolitan Water District of Southern California will be prepared to deliver such supplies.

"Taxpayers and water users residing within the Metropolitan Water District of Southern California already have obligated themselves for the construction of an aqueduct supply and distribution system involving a cost in excess of $350,000,000. This system has been designed and constructed in a manner that permits orderly and economic extensions and enlargements to deliver the District's full share of Colorado River water as well as water from other sources as required in the years ahead. Establishment of overlapping

TABLE 1

SAN DIEGO COUNTY WATER AUTHORITY MEMBER AGENCIES AND AREAS CONSIDERING ANNEXATION

(As of June 30, 1955)

	Date of Membership		Agencies Annexed Total Area	
	Prior to 12-18-53	Subsequent to 12-18-53	Prior to 12-18-53	Subsequent to 12-18-53
Agency or Area	Date	Date	Acres	Acres
Escondido	10/ 9/50		1,940	
Fallbrook Public Utility District	6/ 9/44		8,192	
Lakeside Irrigation District	6/ 9/44		1,860	
La Mesa, Lemon Grove & Spring Valley Irrigation District	6/ 9/44		30,450	
National City	6/ 9/44		4,680	
Oceanside	6/ 9/44		8,095	
San Diego	6/ 9/44		78,175	
San Dieguito Irrigation District	12/13/48		4,009	
Santa Fe Irrigation District	12/13/48		10,106	
South Bay Irrigation District	11/ 3/52		15,490	
Bueno Colorado		6/11/54		47,400
Carlsbad		6/16/54		20,900
Rio San Diego		(1)		18,760(1)
Poway		4/21/54		10,800
Rainbow		4/10/54		33,900
Rincon		6/14/54		22,400
Valley Center		5/ 9/55		53,300
Ramona		(1)		20,600(1)
Rancho El Cajon		(1)		12,800(1)
Otay		(1)		60,000(1)
Imperial		(1)		13,900(1)
Pauma Valley		(1)		12,280(1)
Total Annexed Area (351,697)			162,997	188,700
Total Area Considering Annexation				138,340
Total For All Areas (490,037)			162,997	327,040

(1) Annexation under consideration only.

and paralleling governmental authorities and water distribution facilities to service Southern California areas would place a wasteful and unnecessary financial burden upon all of the people of California and, particularly the residents of Southern California."

Following this statement by MWD, together with the continuation of the dry cycle, numerous requests were made by various areas in San Diego County for annexation to the Authority. Since December, 1953, six public agencies have been annexed to the Authority, as shown in Table 1, with a total area of 188,700 acres, or more than the area making up the Authority to that date. These annexations have been requested and made, notwithstanding the fact that it was well known that there will not be available from the Colorado River supply, plus the local sources, sufficient water to take care of such proposed developments and notwithstanding the specific mention in the MWD policy statement that water would only be supplied "to meet increasing needs for domestic, industrial and municipal water." No provision was made for furnishing irrigation water. The action has apparently been taken on the assumption that additional water will be made available from other sources.

In view of this continued demand for annexation with its resulting increase in water supply requirements, the Authority has undertaken a survey to determine the probable ultimate area to be served by the Authority.

In doing this, the Authority Staff has considered only that part of the County lying West of the Mountains and which areas all drain to the Pacific. An elevation of approximately 1,600 feet above sea level was taken as the upper limit economically feasible for irrigation and urban development.

The results of the Staff's land classification survey are given in Table 1 of the General Manager's Report and may, in general, be summarized as follows:

Gross ultimate Authority area	821,021 acres
Probable area to be served	527,222 acres
Area served in 1954	164,135 acres

The Board of Engineers has reviewed the land classification made by the Authority Staff, by study of topographic maps and by general field examination of most of the agencies and areas. The Board believes that the classification, although somewhat on the optimistic side as to future development, is consistent with the accuracy of the information available and can be used as the basis for a preliminary estimate of future water requirements.

Attention should, however, be called to a number of items which might materially change the results:

1. No detailed field surveys and corresponding land classification and utilization investigations were made. Accordingly, it may eventually develop that the areas designated suitable for use will be changed on the basis of later and more complete information.

2. Much of the land at the higher elevations and back from the Coastal Areas is quite rough and will be difficult to develop.

3. Development will, for the most part, take place adjacent to San Diego and along the Coastal Plain. The interior lands will develop slowly due to rough topography, high cost of water, and distance from metropolitan areas.

4. No consideration has been given to the probable ability of the land owners to pay for water. This will be an important factor in the rougher and more isolated sections.

5. Should the U. S. Government relinquish all or part of its lands now reserved for military installations, the area suitable for ultimate development may be substantially increased.

PROBABLE WATER REQUIREMENTS OF AREA

The Staff estimate of ultimate water consumption for the area under consideration is given in Table 1 of the General Manager's Report, as 788,100 acre feet per annum. This would be applied to 527,222 acres as the estimate ultimate "probable areas to be served." It corresponds to an average of about 1.50 acre feet per acre.

The Board of Engineers has made an independent study of the probable ultimate water requirements. In doing this, each agency or area has been considered. Population studies have been made for the City of San Diego, using an assumed area of 77,000 acres, as shown in Table 1 of the Staff Report. Water requirements for the other agencies and areas have been based largely on an assumed ultimate use in the amount of 1.3 acre feet per acre, with some adjustments for special conditions. This figure has been based on data collected by the Authority on the La Mesa, Fallbrook and Vista Districts, as given in Table 2 herein.

The results of the Board studies show an estimated ultimate consumption for the net area, as listed in Table 1 of the General Manager's Report, of about 11% less than determined by the Staff. This is considered to be a reasonable check on the Staff's estimate as to ultimate consumption in view of the uncertainties involved.

Attention is, however, called to the fact that the preferential right of the Authority in the MWD Colorado River supply is 112,000 acre feet per annum, assuming full development and availability of the full MWD right in the Colorado. Under these conditions, the supply now in sight to meet the ultimate requirements of the Authority is as follows:

TABLE 2

ANNUAL USE OF WATER IN REPRESENTATIVE AUTHORITY MEMBER AGENCIES

Year	Fallbrook Public Utility District			Vista Irrigation District			La Mesa Irrigation District		
	Area Served	Water Used	Duty	Area Served	Water Used	Duty	Area Served	Water Used	Duty
	Acres	Ac. Ft.	Ac. Ft. per Ac.	Acres	Ac. Ft.	Ac. Ft. per Ac.	Acres	Ac. Ft.	Ac. Ft. per Ac.
1947-48	2,500	3,471	1.39	12,774	13,407	1.05	7,800	10,290	1.32
1948-49	3,500	3,613	1.03	12,806	11,344	0.89	12,374	9,325	0.75
1949-50	3,850	5,379	1.40	12,773	11,977	0.94	12,721	10,204	0.80
1950-51	5,000	5,777	1.16	12,775	13,484	1.06	13,233	11,412	0.86
1951-52	6,700	5,803	0.87	12,798	7,572	0.59	13,360	9,858	0.74
1952-53	8,192	6,635	0.81	12,789	11,171	0.87	13,834	13,524	0.98
1953-54	8,192	7,606	0.93	12,628	11,672	0.92	14,096	15,519	1.10
1954-55	8,192	8,001	0.98	12,783	12,707	0.99	14,312	15,557	1.09

Ultimate Authority requirements — Estimated by Staff		788,100 A.F. per Annum
Authority Preferential Right in Colorado River supply	112,000 A.F.	
Estimated Safe Yield of local sources (Table 1 — General Manager's Report)	106,600 A.F.	
		218,600 A.F. per Annum
Deficiency		569,500 A.F. per Annum

In other words, for the full development of the estimated ultimate area within the Authority, it will be necessary to import about 569,500 acre feet per annum over and above the maximum possible supply from local sources plus that to be obtained through the MWD from the Colorado River.

Probable use of water, during the next 45 years, as estimated by the Authority Staff, is shown in Table 1 and Plate 2 of the General Manager's Report. The actual use of water within the Authority during the period 1943 to 1955, together with the estimated use from 1955 to 1990, from the General Manager's Report, are presented by Plate A herein. It will be noted that the Staff estimate of use shows a very rapid increase. This apparently has been developed on the assumption that the annexation of additional areas will continue and that the use of water in those areas will advance at a substantial rate far in excess of the trend during the period 1949-1954. Such a trend is shown on Plate A.

In view of the topographic conditions throughout a large portion of the Authority area, uncertainties as to available water supply and relatively high cost of water, it is difficult to understand how such a high rate of increase can be expected to develop. It should also be noted from Plate A that during the period 1946-1950, following World War II, the use of water remained practically stationary. Similar conditions may occur in the future.

Assuming, however, that the estimated future use of water, as shown by the Staff Report, is representative of conditions that may be expected, then it will be observed from Plate A herein that the entire supply to the Authority, with present facilities, will be exhausted by 1959. This is based on the assumption that the full capacity of the present Aqueduct can be utilized plus the local safe yield. Should the supply available through the Aqueduct be limited to the Authority's Preferential Right, plus local safe yield, then the supply would be exhausted by 1957. The total supplies available under these conditions are:

Supply	Aqueduct Capacity	Preferential Right
	(Quantities in acre feet per annum)	
Aqueduct	141,000	112,000
Safe yield of local supplies	106,600	106,600
Total	247,600	218,600

The Board of Engineers is in agreement with the General Manager's Report, as regards the statement that any additional water to be obtained in the near future, over and above that supplied through the Aqueduct and the local sources, must be obtained from the MWD through additional aqueduct facilities. Since the existing Aqueduct is of ample size to more than supply the preferential right of the Authority in the Colorado River supply of the MWD, then any additional water obtained from the MWD through the Colorado River Aqueduct must be sur-

TABLE 3

WATER REQUIREMENTS AND AVAILABLE SUPPLIES IN MWD ULTIMATE SERVICE AREA EXCLUDING SAN DIEGO COUNTY WATER AUTHORITY

Requirements	
Ultimate water requirements—Los Angeles, Orange, Riverside and San Bernardino Counties	3,902,000 A. F. per annum
Ultimate area to be served	1,762,500 Acres
Average use of water per acre served	2.21 Acre Feet
Available Supplies	
MWD from Colorado River—No curtailment (1)	1,150,000 A. F. per annum
Owens Valley Aqueduct	319,000 A. F. per annum
Safe yield of local sources in Los Angeles, Orange, Riverside and San Bernardino Counties	791,700 A. F. per annum
Total Available Supplies	2,260,700 A. F. per annum

(1) From Bulletin #2—Allowance of 5% made for transmission losses and outages.

plus water over and above that needed by other agencies in the MWD.

MWD Surplus

The Authority Staff has made an estimate of the surplus water that may be available from the MWD. This is shown in the General Manager's Report on Plate 3, which indicates that a surplus will exist in the MWD Aqueduct until some time past 1970.

In view of the importance of determining, within reasonable limits, how long such surplus water may be available to the Authority from MWD, an independent study has been made by this Board.

Information and data for making such a study have been obtained from the published reports of the MWD and from Bulletin No. 2 recently published by the State Water Resources Board and entitled "Water Utilization and Requirements of California." Chapter 6 of the Bulletin deals with the South Coastal Area and presents data on the probable future ultimate water demands in that area, together with available supplies and related data.

From Bulletin No. 2, the ultimate water requirements for the area estimated to be served ultimately by the MWD in Los Angeles, Orange, Riverside and San Bernardino Counties have been determined, together with the estimated safe yield of the local supplies within such a service area and the water available by importation, through the Owens Valley and Colorado River Aqueducts.

In developing this data from Bulletin No. 2, it has been necessary to make some adjustments so that it will apply to the probable ultimate MWD service area including the four Counties mentioned in the previous paragraph, but excluding San Diego County. This has been required, due to the fact that the data in Bulletin No. 2 was developed for hydrographic units which do not conform to the MWD service area.

The basic data, so obtained from Bulletin No. 2 are given in Table 3.

Information on past use of water within the MWD is given in the reports of that District. Plate B herein shows the annual use of water within the District for the years 1935 to 1954, inclusive. During 1954, a large amount of water was delivered to Orange County for recharging of the underground basin. The amount supplied by the MWD was as shown in the 1954 Report, about 50,000 acre feet. It has been assumed that this is a temporary use only and accordingly the 1954 consumption was reduced by that amount. To this adjusted 1954 water production for the present MWD service area, there has been added 330,000 acre feet which represents the estimated amount of water used in 1954 by the areas within the ultimate MWD service area, other than San Diego County, but not yet annexed to the MWD. This gives a total adjusted use during 1954 within the ultimate MWD service area, including San Diego County, of 1,637,000 acre feet.

To determine the probable use of water within the MWD service area, excluding San Diego County, during the period 1954 to 1980, it has been first assumed that such use will increase at the same rate estimated for the Authority area, as shown on Plate 2 of the General Manager's Report and also presented on Plate A herein. To make this determination, the estimated use of water in the Authority for representative years beyond 1954 has been expressed as a percentage of the ultimate use. These percentages have then been applied to the balance of the MWD, excluding San Diego County. The use in the MWD has been assumed to increase at the same rate the Authority use is estimated to increase beyond the point where the present use in the MWD, except San Diego County, is the same percentage of the ultimate as in the Authority.

It was found that the 1954 use in the MWD, other than San Diego County, was the same percentage of ultimate, namely 38%, as estimated to occur in the Authority for 1963. Accordingly, the estimated rate of water use increase in the Authority beyond 1963 was applied to the balance of the MWD beyond 1954.

The estimated annual uses of water in the Authority during the period 1954-1980, as shown in the General Manager's Report, were then added to those obtained for the balance of the MWD ultimate service area. The total estimated uses for the entire MWD ultimate service area were thus obtained. The results are shown as the upper curve on Plate B.

To determine the supply available for this entire ultimate service area under the MWD, the amount of safe yield, as estimated for the Authority and shown in Table 1 of the General Manager's Report, namely, 106,600 acre feet per annum, has been added to the supply estimated in Bulletin No. 2 of the State Water Resources Board as available in Los Angeles, Orange, Riverside and San Bernardino Counties and referreed to in previous paragraphs. Then we have the following total available supply for the entire MWD ultimate service area:

Estimated ultimate water supply available for Los Angeles, Orange, Riverside and San Bernardino Counties	2,260,700 A.F. per annum
Estimated safe yield of local supplies in San Diego County Water Authority	106.600 A.F. per annum
Total	2,367,300 A.F. per annum

The total estimated available supply for the five County area to be served by the MWD is shown as the horizontal line on Plate B.

Under these assumed conditions, it will be observed that the entire water supply available for the five County MWD service area, would be required by the year 1960. In other words, by the time that the water supply presently available to the San Diego County Water Authority is exhausted, as estimated by the Authority and shown in Table 1 of the General Manager's Report, the water supply available in the entire service area of the MWD, including the five Counties, Los Angeles, Orange,

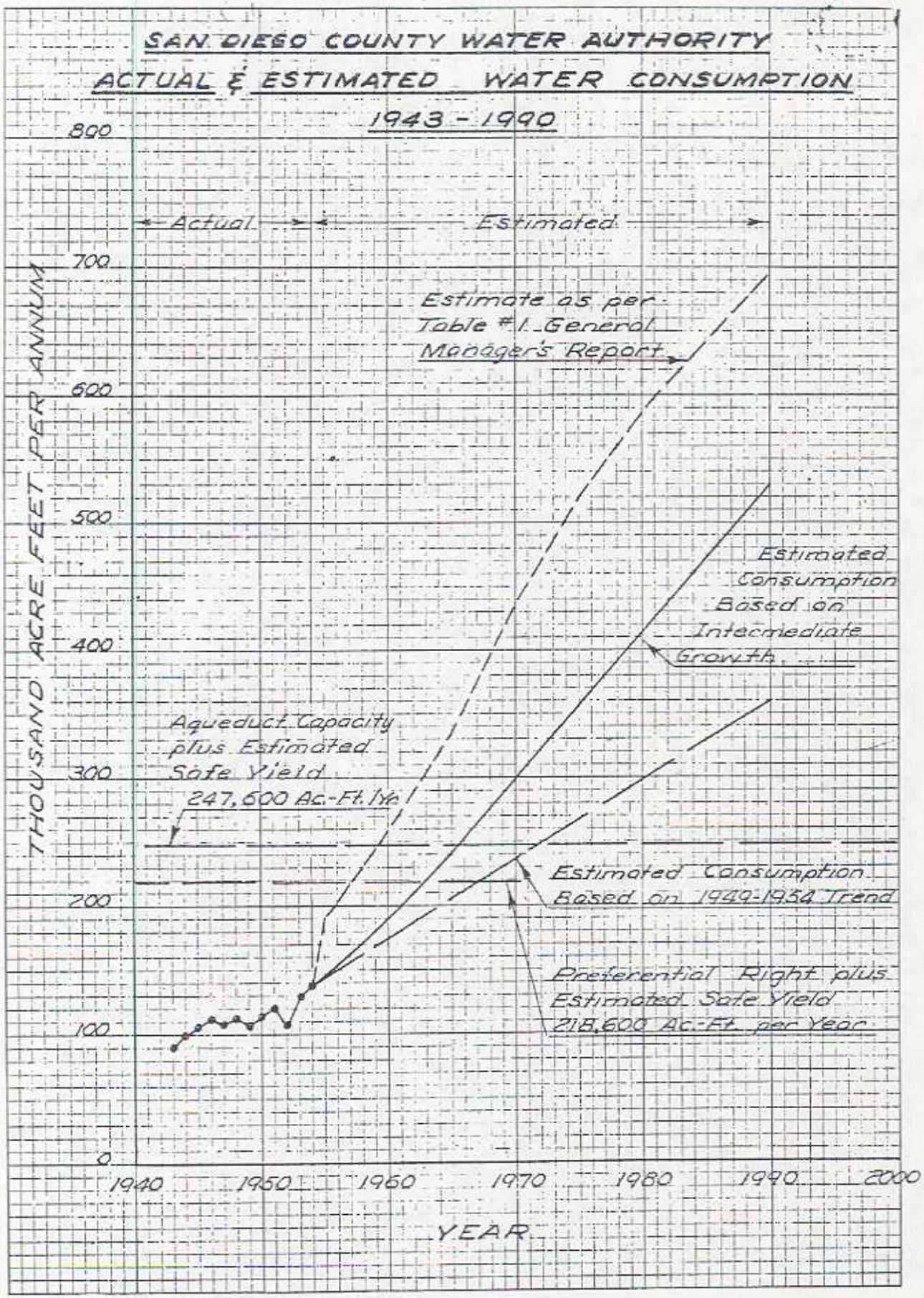
SAN DIEGO COUNTY WATER AUTHORITY
ACTUAL & ESTIMATED WATER CONSUMPTION
1943 - 1990
Actual
Estimated
Estimate as per Table #1 General Manager's Report
Estimated Consumption Based on Intermediate Growth
Aqueduct Capacity plus Estimated Safe Yield 247,600 Ac.-Ft./Yr.
Estimated Consumption Based on 1949-1954 Trend
Preferential Right plus Estimated Safe Yield 218,600 Ac.-Ft. per Year
THOUSAND ACRE FEET PER ANNUM
800
700
600
500
400
300
200
100
0
1940
1950
1960
1970
1980
1990
2000
YEAR

PLATE A

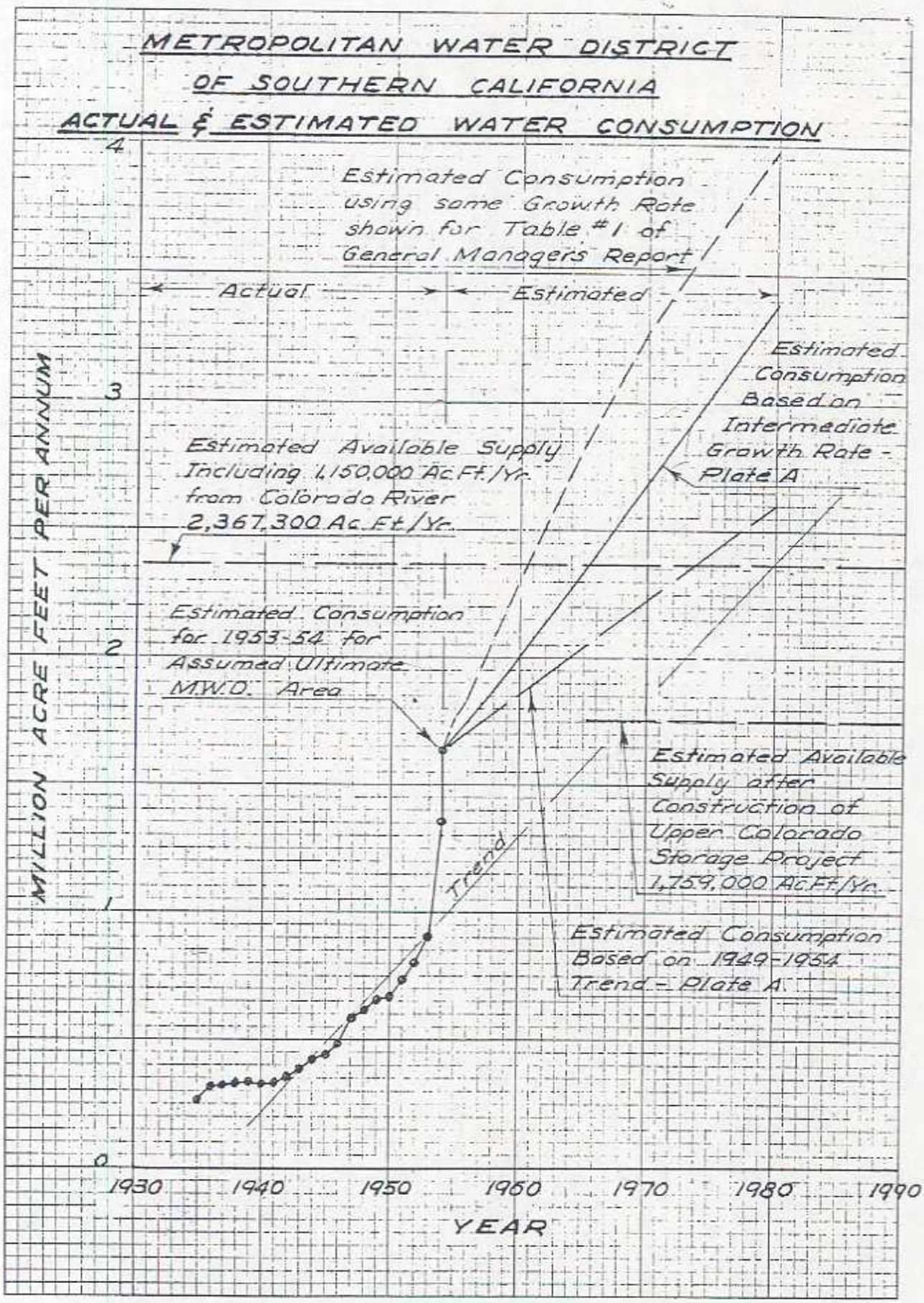
METROPOLITAN WATER DISTRICT
OF SOUTHERN CALIFORNIA
ACTUAL & ESTIMATED WATER CONSUMPTION
Estimated Consumption using some Growth Rate shown for Table #1 of General Managers Report
Actual
Estimated
Estimated Consumption Based on Intermediate Growth Rate - Plate A
Estimated Available Supply Including 1,150,000 Ac.Ft./Yr. from Colorado River 2,367,300 Ac.Ft./Yr.
Estimated Consumption for 1953-54 for Assumed Ultimate M.W.D. Area
Estimated Available Supply after Construction of Upper Colorado Storage Project 1,759,000 Ac.Ft./Yr.
Trend
Estimated Consumption Based on 1949-1954 Trend - Plate A
MILLION ACRE FEET PER ANNUM
0
1
2
3
4
1930
1940
1950
1960
1970
1980
1990
YEAR

PLATE B

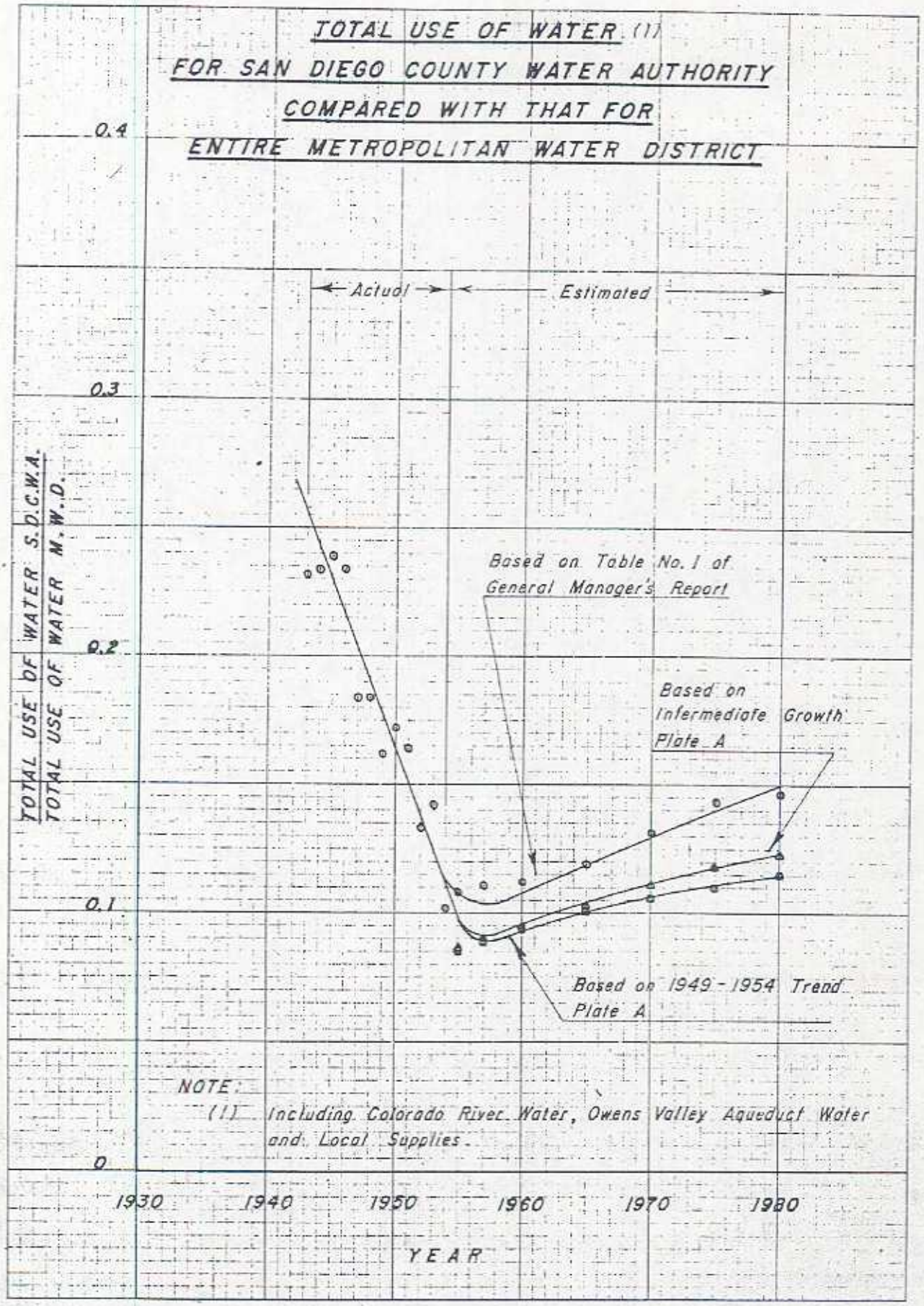
TOTAL USE OF WATER (1)
FOR SAN DIEGO COUNTY WATER AUTHORITY
COMPARED WITH THAT FOR
ENTIRE METROPOLITAN WATER DISTRICT
Actual
Estimated
Based on Table No. 1 of General Manager's Report
Based on Intermediate Growth Plate A
Based on 1949 - 1954 Trend Plate A
NOTE:
(1) Including Colorado River Water, Owens Valley Aqueduct Water and Local Supplies.
TOTAL USE OF WATER S.D.C.W.A.
TOTAL USE OF WATER M.W.D.
0.4
0.3
0.2
0.1
0
1930
1940
1950
1960
1970
1980
YEAR

PLATE C

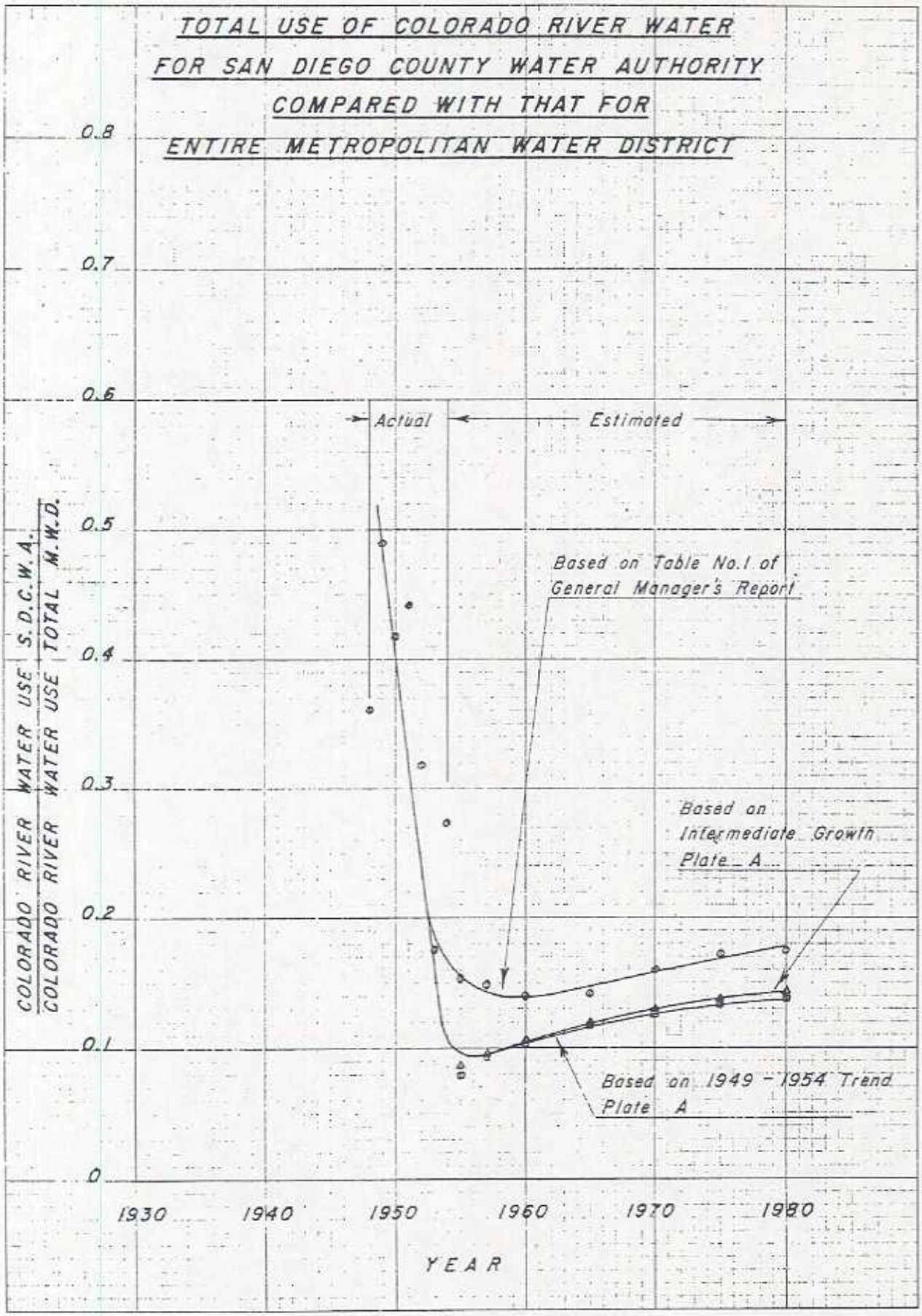
TOTAL USE OF COLORADO RIVER WATER
FOR SAN DIEGO COUNTY WATER AUTHORITY
COMPARED WITH THAT FOR
ENTIRE METROPOLITAN WATER DISTRICT
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Actual
Estimated
Based on Table No. 1 of
General Manager's Report
Based on
Intermediate Growth
Plate A
Based on 1949 - 1954 Trend
Plate A
COLORADO RIVER WATER USE S.D.C.W.A.
COLORADO RIVER WATER USE TOTAL M.W.D.
1930
1940
1950
1960
1970
1980
YEAR

PLATE D

Riverside, San Bernardino and San Diego, will also be exhausted. This indicates that no surplus water will be available to the San Diego County Water Authority, under the assumed conditions, after 1960.

The assumption that the other areas within the ultimate MWD service area, will increase their use of water as rapidly as that assumed for San Diego County, is believed to be reasonable. In fact, the increase in use of water within the area served by the MWD outside of San Diego County, has been even more rapid during the past 20 years than has been the increase in San Diego County. There is no reason to believe that this situation will not continue.

If, on the other hand, we assume that the rate of increase in water consumption within the Authority will be more in line with the general trend over the past 15 years than the presently estimated future consumption, and lie in between the trend for the period 1949 to 1954, and the requirements as estimated by the Authority Staff, then we would obtain a future use somewhat as shown by the middle curve on Plate A. This would indicate that the presently available supply from the Colorado River Aqueduct and local sources would meet the demands in the Authority until about the year 1965.

Assuming that this trend of growth would obtain in San Diego County and also in the balance of the service area of the MWD, then, following the same procedures as used in developing the upper curve on Plate B, we obtain the future consumption for the entire MWD in the five Counties, as is shown by the middle curve on Plate B. Under this assumption, it will be observed that surplus water would be available in the MWD Colorado River Aqueduct until about the year 1966.

A third study has been similarly made on the basis of an estimated use of water in the Authority beyond 1954, following the 1949-1954 trend as shown in the lower curve on Plate A. This curve indicates that the present sources available to the Authority would meet requirements until about 1972.

If this trend of increase is applied to the balance of the MWD ultimate area outside of San Diego County, as done in the two previous cases, then the total requirements for the ultimate MWD including the SDCWA, would be as shown by the lower curve on Plate B. With these conditions, surplus water would be available in the Colorado River Aqueduct of the MWD until about 1974.

The relationship between the total water production in the Authority and that for the entire MWD for the years 1943 to 1954, is shown on Plate C. Production in the Authority area dropped from about 23% of that in the entire MWD in 1943 to 10% in 1954.

Under ultimate conditions, the relationship is estimated to be as follows:

Estimated ultimate annual consumption in Authority	788,100 Ac. Ft.
Estimated ultimate annual consumption in MWD (excluding San Diego County)	3,902,000 Ac. Ft.
Total ultimate annual MWD consumption	4,690,100 Ac. Ft.

Relation: $\frac{\text{Authority Consumption}}{\text{Total MWD Consumption}} = 0.168$

In other words, for assumed ultimate conditions, the use of water in the Authority is estimated to be 17% of that in the entire ultimate MWD, including San Diego County Water Authority.

During the period 1954-1980, the relationship between Authority and total MWD use has been determined for each of the three conditions illustrated on Plates A and B, namely:

1. Using same rate of consumption growth in MWD other than SDCWA, as shown for SDCWA in Table 1 of the General Manager's Report.
2. Using same rate of consumption growth in MWD other than SDCWA, as shown for SDCWA on Plate A and designated "Intermediate Growth."
3. Using same rate of consumption growth in MWD other than SDCWA as shown for SDCWA on Plate A and designated "1949-54 Trend."

The relationships so determined are shown on Plate C.

Plate C brings out clearly the fact that, although the water consumption in the Authority has been increasing steadily, the percentage of consumption in the Authority as related to that in the total MWD including the SDCWA, has been decreasing and in 1954 was below that which it is assumed will exist ultimately. This means that the balance of the MWD, other than the SDCWA, has had a faster rate of growth than in the Authority.

The probable relationship for the period 1954-1980, as shown by the curves on Plate C, indicates that the growth estimated in Table 1 of the General Manager's Report is too rapid, as the 1954-1980 position is not in general agreement with the actual records for 1943-1954. It seems probable that the future use will be somewhere between the upper and lower curves.

A further anlaysis of actual and estimated water consumption is presented on Plate D. This Plate shows the relationship between the use of Colorado River Water in the Authority and in the entire MWD, including the SDCWA. Between 1949 and 1954, the percentage of Colorado River Water used in the Authority has gradually lowered from 49% to 27%. Assuming that it will be possible to eventually divert the full claim of the MWD to Colorado

D

River water, namely, 1,212,000 acre feet per annum, it is expected that the Authority will have the preferential right to about 10% of that amount.

In the years 1954 to 1980, the relationship for such use has been determined on the same basis as for Plate C, and the resulting curves are shown on Plate D.

Here again, it is indicated that the growth in the entire MWD has been faster in the entire MWD than in the SDCWA. Also, the Plate shows that the assumptions for a more moderate increase in Authority water use, than used in Table 1 of the General Manager's Report, agrees more closely with the actual conditions existing during the period of record, 1948-1954.

The conclusion to be drawn from the data presented and discussed in the previous paragraphs, is that if we assume the same rate of increase in future water consumption for the ultimate MWD service area outside of San Diego County as is assumed to take place within the Authority, then by the time that the presently available supply in the San Diego County Water Authority from the Colorado River Aqueduct and local sources is exhausted, it is quite probable that there will be no surplus water available to the Authority from the MWD through the Colorado River Aqueduct.

In view of these conditions, it is recommended that the Authority, in cooperation with the MWD and the State Engineer's Office, make a complete study of the probable ultimate requirements within the estimated ultimate service area of the MWD, and also of the probable trend in the increase of water requirements during the next 25 years. The information used by this Board relative to the ultimate water requirements in the MWD and the future trend of development, has been obtained from Bulletin No. 2 recently issued by the State Water Resources Board. Some adjustment of the data contained therein has been necessary in view of the fact that the hydrographic units for which the data has been prepared do not agree exactly with the area to be served ultimately by the MWD. A careful analysis, in cooperation with the MWD, might show somewhat different results. This is of such importance to the San Diego County Water Authority that no time should be lost in undertaking such a study.

SOURCES OF WATER AVAILABLE TO AUTHORITY

Metropolitan Water District of Southern California

The possibilities of obtaining surplus water from the Colorado River Aqueduct of the MWD have been discussed in some detail in the previous sections. Pending the results of the suggested cooperative study with the MWD Staff as to what surplus water, if any, may be available for the Authority, it will be advisable to hold in abeyance any conclusions as to the ability of the Authority to obtain additional water from the MWD. It should be stated, however, that the MWD, through its Colorado River Aqueduct, offers the only possibility of obtaining additional water in any amount, within any reasonable period of years. If such surplus can not be made available, then the plans of the Authority must be adjusted to the full utilization of the presently available supply from the Colorado River Aqueduct and from the local sources.

Colorado River Problems

A further complication as regard the future water supply for the San Diego County Water Authority from MWD is presented in the water right situation on the Colorado River itself. This situation will be reviewed briefly in the following paragraphs.

Legislation is now pending for the U. S. Congress which would authorize the construction of the Glenn Canyon and other dams on the Colorado River and its tributaries, together with related irrigation works. The construction of these facilities in the Upper Basin, that is above Lee Ferry, if the present plans of the Federal Government are carried out, may seriously reduce the amount of water available to the Lower Basin, decrease the amount of water for diversion for use in California and consequently prevent the annual diversion of 1,212,000 acre feet per annum by the MWD.

This situation has been outlined in a paper presented by Raymond A. Hill, a member of this Board, before a meeting of the Sacramento Section, American Society of Civil Engineers, in Sacramento, December 7, 1954, and entitled "Colorado River Deficits." Some of the data contained in that paper will be set forth in the following paragraphs.

The Colorado River Compact, among other things, provides that "the States of the upper division will not cause the flow of the River at Lee Ferry to be depleted below an aggregate of 75 million acre feet for any period of ten consecutive years, reckoned in continuing progressive series beginning with the first day of October next succeeding ratification of this contract." Accordingly, regardless of what water may be available in the Upper Basin, and it now appears that it will be less than was anticipated at the time of the Compact, the Lower Basin can not count definitely on more than an average of 7,500,000 acre feet per annum, or 75,000,000 in each ten consecutive years at Lee Ferry.

It now appears, however, there is a possibility that the releases past Lee Ferry may be increased by an amount equal to the following items:

½ of required Treaty delivery to Mexico = ½ × 1,500,000 =	750,000 Ac. Ft. per annum
½ of estimated operating wastes past the International Boundary = ½ × 200,000 =	100,000 Ac. Ft.
Total	850,000 Ac. Ft. per annum

If such an increase is agreed upon, the average annual flow passing Lee Ferry after construction of the upper Colorado River storage project and related works would become 7,500,000 + 850,000 =

8,350,000 acre feet per annum. This may be taken as the probable maximum future flow past Lee Ferry.

The "Historical Depletions of Colorado River" for the period 1944-45 to 1953-54 are shown in Table 4 herein. From this Table and related data, a summary of conditions on the River for a year similar to 1953-54, with full development of the upper Colorado Storage Project, may be determined:

Flow past Lee Ferry		8,350,000 Ac. Ft.
Depletion—Lee Ferry to International Boundary	6,000,000 Ac. Ft.	
Required Treaty delivery to Mexico	1,500,000 Ac. Ft.	
Operating waste past International Boundary	200,000 Ac. Ft.	7,700,000 Ac. Ft.
Maximum increase in diversions—Lee Ferry to International Boundary		650,000 Ac. Ft.

The data presented in Table 4 and in the previous paragraphs clearly shows that when the Upper Colorado River Storage Project is constructed and the flows at Lee Ferry are regulated to comply with the Colorado River Compact, with possible additions as referred to in Table 4, compliance with the Mexican Treaty and with allowance for reasonable waste past the International Boundary which, from a practical operating standpoint, can not be avoided, it will be possible to divert only 650,000 acre feet per annum from the River between Lee Ferry and the International Boundary in addition to that actually used during 1953-54.

If it is assumed that of the 650,000 acre feet of maximum possible increase in depletions, the MWD may be able to obtain 324,000 acre feet, or about one-half, and this is an optimistic viewpoint, then under full development of the Upper Colorado River Storage Project, the MWD would be able to divert only 570,000 acre feet per annum, or about 43% of the MWD Aqueduct capacity, as shown below:

MWD diversion from Colorado River—1953-54	246,000 Acre Feet
Maximum possible ultimate annual increase	324,000 Acre Feet
Maximum MWD—Ultimate Annual Diversion	570,000 Acre Feet

TABLE 4

HISTORICAL DEPLETIONS OF COLORADO RIVER

(Quantities in Millions of Acre Feet)

Year Ending Sept. 30	Flow at Lee Ferry	Change In Storage	Flow Across International Boundary	Depletion Lee Ferry To Boundary	Depletion In Year	Maximum Increase
a.	b.	c.	d.	e.	0 2 4 6	(1)
1944-45	11.54	−1.23	8.69	4.08		2.57
1945-46	8.74	−2.62	6.72	4.64		2.01
1946-47	13.51	+2.62	6.28	4.61		2.04
1947-48	13.69	+0.37	8.19	5.13		1.52
1948-49	14.36	+0.81	8.73	4.82		1.83
1949-50	11.06	−1.97	7.63	5.40		1.25
1950-51	9.83	+0.34	3.52	5.97		0.68
1951-52	17.98	+3.65	8.50	5.83		0.82
1952-53	8.82	−4.46	7.33	5.95		0.70
1953-54	6.15	−4.29	4.44	6.00		0.65
10-Year Average	11.57	−0.68	7.00	5.24		1.41
Last 5-Yr. Average	10.77	−1.35	6.29	5.83		0.82

(1) Maximum possible increase in depletion between Lee Ferry and International Boundary based on Upper Colorado River Storage Project in service and deliveries at Lee Ferry equal to 75,000,000 acre feet in each consecutive 10 years plus one-half of (deliveries to Mexico, such deliveries equalling 1,500,000 a.f. per year treaty minimum plus 200,000 a.f. per year operating wastes).

Under such conditions, the maximum supply available within the MWD including SDCWA, would be:

MWD—From Colorado River—95% of 570,000=	542,000 Ac. Ft. per Annum
Safe yield of local sources in Los Angeles, Orange, Riverside and San Bernardino Counties	791,700 Ac. Ft. per Annum
Safe yield of local sources in SDCWA	106,600 Ac. Ft. per Annum
Total	1,759,300 Ac. Ft. per Annum

It is, of course, uncertain as to when the Upper Colorado Storage Project will be constructed, but if it is assumed to be complete and in operation in about 15 years, or by 1970, then following that year the total supply available for the MWD would be 1,759,000 acre feet per annum, as shown in the previous paragraphs.

By plotting this available supply on Plate B, it will be noted that such a reduction in supply would result in a very serious situation throughout the MWD, as it would cause a large curtailment in the amount of water available under any of the various assumed conditions of future use.

Under these conditions, it follows that, unless arrangements can be worked out by the MWD for obtaining water from some other source, the construction of the Upper Colorado River Storage Project and related works will reduce the amount of water available for diversion from the Colorado River to such an extent that the total consumption within the MWD, including San Diego County Water Authority, can not be increased appreciably over that now used.

The importance of this situation to the San Diego County Water Authority can not be too strongly emphasized. Plate B shows that very little surplus water from the Colorado River Aqueduct of MWD will be available to the Authority under the assumed condition providing for diversion from the Colorado of the MWD claimed right of 1,212,000 acre feet per annum. The reduction of this annual diversion following construction of the Upper Colorado River Storage Project means that, when this occurs, and possibly by 1970, it will not be possible for the SDCWA to obtain more than about one-half of its preferential right of 112,000 acre feet per annum. This is less than was imported through the San Diego Aqueduct in 1954-55.

It is urged that the Colorado River situation be thoroughly reviewed with the MWD and that definite steps be taken by the SDCWA toward resolving the problems involved. This should be done before any action is started toward providing additional aqueduct capacity.

It should also be understood that there is now pending before the U. S. Supreme Court, a suit brought by the State of Arizona against the State of California, involving the use of waters from the Colorado and Gila Rivers. If this suit should be decided in favor of Arizona, the amount of water available for use in California, from the Colorado River, may be reduced below that claimed by California. This could still further affect the diversions of the MWD at Parker Dam.

A further item to be considered in connection with the use of Colorado River water is the matter of quality. The opinion has been expressed by some that as developments take place in the Upper Basin of the Colorado and the flow past Lee Ferry is reduced, the mineral content of the water will be increased and the supply may ultimately become somewhat undesirable for municipal and irrigation use. It is estimated by some that the chloride content of the water under such conditions will be substantially increased and may be a serious hazard to downstream users. It is suggested that this matter be reviewed by the Authority in cooperation with the MWD.

Feather River Project

Reference was made on Page 1 to the 1951 Report on the so-called Feather River Project as released by the State Water Resources Board. A second report dated February, 1955, has now been prepared entitled "Program for Financing and Constructing the Feather River Project as the Initial Unit of the California Water Plan." The 1955 report presents the project in more detail than covered in 1951 and incorporates the results of studies and investigations which have been carried on during the four year interim.

Five general plans and financial analyses are presented in the Report covering the following principal features:

1. Oroville Dam on Feather River near Oroville, together with an after-bay dam and power plants.
2. A channel across Sacramento-San Joaquin Delta to a pumping plant west of Tracy.
3. An adequct along the westerly side of San Joaquin Valley, extending by alternative routes to Southern California.
4. An aqueduct to service areas in Alameda, Santa Clara, and San Benito Counties.

Table 5 herein summarizes the five plans presented in the 1955 Report, gives data regarding the amount of water proposed for delivery, the total estimated cost for each plan of the project, and the suggested charge per acre foot for water at point of delivery. It should be understood that the charges for water are merely the opinion of the Division of Water Resources, as to how much the consumers in the different areas can afford to pay for water. The amount of money to be repaid for sale of water will only take care of a portion of the cost of the project. The Report proposes that the balance of the cost be assumed by the State as a whole, and be financed through a State-wide bond issue. In other words, the suggested charges for water at point of delivery, as shown in Table 5, represent only a portion of the cost of the water to the individual agencies.

Plan No. 1 involves the high line route, delivering

TABLE 5

1955 FEATHER RIVER PROJECT REPORT [1]
SUMMARY OF ALTERNATE PLANS FOR DELIVERY OF WATER TO SOUTHERN CALIFORNIA AND SAN DIEGO COUNTY

Description	Length of Aqueduct	WATER DELIVERIES AND COST								Total
		North San Joaquin Valley		South San Joaquin Valley		Alameda, Santa Clara and San Benito Counties		Southern California		
		Annual Water Delv'd	Cost per A. F.	Annual Water Delv'd	Cost per A. F.	Annual Water Delv'd	Cost per A. F.	Annual Water Delv'd	Cost per A. F.	Estimated Cost
	Miles	A. F.	$	A. F.	$	A. F.	$	A. F.	$	$
1. High line route from Delta to Barrett Reservoir	585 [2]	1,490,000	8.00	350,000	9.00	240,000	22.50	1,800,000	45.00	1,592,908,000
2. High line route from Delta to San Bernardino	458 [3]	1,490,000	7.00	350,000	8.00	240,000	20.00	1,800,000	35.00	1,491,147,000
3. High line route from Delta to Castaic Creek Reservoir	343 [4]	1,490,000	7.00	350,000	8.00	240,000	17.50	1,800,000	25.00	1,395,522,000
4. High line route from Delta to Devils Den and extensions to Wheeler ridge and via coastal line to Castaic Creek Reservoir	480 [5]	1,490,000	8.00	926,000	9.00	240,000	20.00	1,224,000	45.00	1,549,988,000
5. High line route from Delta to Pastoria Creek and via long tunnel line to Castaic Creek Reservoir	343 [6]	1,490,000	8.00	926,000	9.00	240,000	20.00	1,224,000	35.00	1,381,841,000
Completion Dates		1959		1959		1961		1976		

[1] Dated February, 1955. Prepared by State Division of Water Resources.
[2] From pumping plant #1 on Italian Slough to Horse Thief Canyon.
[3] From pumping plant #1 on Italian Slough to San Bernardino. (Page 16, Feather River Report.)
[4] From pumping plant #1 on Italian Slough to Castaic Creek Reservoir.
[5] From pumping plant #1 on Italian Slough to Castaic Creek Reservoir (not including extension to Wheeler Ridge).
[6] From pumping plant #1 on Italian Slough to Castaic Creek Reservoir.

water through to Barrett Reservoir in San Diego County, and is much the same as presented in the original 1951 Report. Table 5 shows that it is proposed to deliver 1,800,000 acre feet annually to Southern California. Of this, the Report indicates that 600,000 would be delivered for irrigation in Antelope Valley, and 1,200,000 acre feet for use in the South Coastal Basin, including parts of Santa Barbara, Ventura, Los Angeles, Orange, Riverside, San Bernardino and San Diego Counties.

As far as the San Diego County Water Authority is concerned, Plan No. 1 is not a feasible or practical project. As shown in Table 6, 95% of the estimated ultimate water requirements for irrigation and urban development in the San Diego County Water Authority will be used on lands which lie below elevation 1,000, and 80% would be supplied to lands below elevation 750, whereas the high line route—Plan No. 1—would cross the San Jacinto Tunnel with a hydraulic gradient elevation of 3,020, deliver water to Lake Henshaw at elevation 2,750, and to Horse Thief Canyon at elevation 2,600. The hydraulic gradient of the MWD Colorado River Aqueduct at the West Portal of the San Jacinto Tunnel is at about elevation 1,550.

The capital expenditures involved in constructing a high line conduit from San Bernardino to Horse Thief Canyon would be excessively high due to the very rugged terrain and the large amount of tunnel work involved. The power which could be developed by dropping the water down to the service area would in no manner offset the increased cost of construction.

Distribution facilities for the Authority have been based on the present Aqueduct and plans are under consideration for a second aqueduct heading at the West Portal of the San Jacinto Tunnel.

To provide for distribution from the high line conduit would require expensive additional distributing works and would serve very little more area.

It is our opinion that it will be far more economical for the Authority to distribute from Aqueduct No. 1 and a line such as proposed Aqueduct No. 2, taking water from a point in the vicinity of the West Portal of the MWD San Jacinto Tunnel.

Plan No. 2 of the Feather River Project, as shown on Table 5, fits in most satisfactory of any of the plans presented by the State Division of Water Resources. In meeting the requirements of the Authority, water could readily be transported from San Bernardino to the West Portal of the San Jacinto Tunnel, and there diverted to the Authority through the existing Aqueduct and any proposed future aqueduct.

Details regarding the development of the Feather River Project are, of course, very indefinite, but are of great concern to the San Diego County Water Authority and other Agencies in Southern California. As previously demonstrated herein, and as pointed out in the General Manager's Report to the Board of Directors of the Authority, there is urgent demand for additional water to meet the ultimate requirements of the Authority area. The Feather River Project offers a plan for at least taking care of part of these requirements. At the present time, it appears to be the most favorable one. It is our belief that the Authority, in cooperation with the MWD, and other agencies in Southern California, should do everything possible to continue the investigations of the Feather River Project, in an effort to work out a satisfactory solution.

TABLE 6

SAN DIEGO COUNTY WATER AUTHORITY ESTIMATED ULTIMATE WATER REQUIREMENTS BELOW VARIOUS ELEVATIONS

Elevation	Water Requirements For Lands Below Assumed Elevations	
Feet	Acre Feet Per Annum	% of Total
0		
100	95,000	12.1
200	190,000	24.1
300	280,000	35.5
400	370,000	47.0
500	455,000	57.7
600	535,000	67.9
700	610,000	77.4
800	675,000	85.7
900	715,000	90.7
1,000	740,000	93.9
1,100	755,000	95.8
1,200	765,000	97.1
1,300	775,000	98.3
1,400	780,000	99.0
1,500	785,000	99.6
1,600	788,000	100.0

Reclamation of Sewage

Under date of September, 1952, a Board of Engineers employed by San Diego County, submitted a "Report on the Collection, Treatment and Disposal of the Sewage of San Diego County, California." Three chapters of the Report are devoted to the subject of reclamation of water for sewage and a complete review is given of reclamation possibilities in San Diego Bay area, and also in the North Coastal area. Estimates were prepared of the capital cost for installing the necessary reclamation works and also the annual cost, including both plant operation and distribution to the area of use. The Report indicates that the greatest quantities of reclaimed sewage could be used in the areas where there is a considerable amount of irrigation. This applies to the Chula Vista, Spring Valley, El Cajon and Mis-

sion Valley areas. It was estimated that the cost of reclaimed water would vary from $20 to $50 per acre foot. The areas, however, where such water could be used are rapidly changing from agricultural to urban, and it will apparently be only a relatively short time until the water requirements will be largely urban in nature. Under such conditions, there would be no market for reclaimed sewage.

In Balboa Park there is an opportunity to reclaim sewage and use the water for park irrigation. This practice is followed in Golden Gate Park, San Francisco. However, the price for Balboa Park is high—$55.40 per acre foot—or about 17c per thousand gallons.

In any event, the amount of water involved in sewage reclamation, as planned, is comparatively small, and whether or not any reclamation is practiced, the over-all water problem of the Authority would not be seriously affected.

It is believed, however, that this subject of sewage reclamation should continue to receive the attention of the other local public agencies, in an effort to work out some plan whereby advantage can be taken of the comparatively large flows now being wasted into the Ocean. It is entirely possible, perhaps at some time in the future, it may become absolutely essential that this water be reclaimed and utilized.

Imperial Valley

The General Manager's Report has discussed at some length the possibility of reclaiming and importing water from Imperial Valley.

The plan presented involves the utilization of water now wasted into the Salton Sea through the Alamo and New Rivers. The Report states that such water has a chloride content of about 2,200 parts per million, and that with processes now being developed, there is a possibility that such water could be conditioned to reduce the chloride content to about 500 parts per million, at a cost of about $15 per acre foot.

It is proposed that such demineralized water be delivered to the Imperial Irrigation District, at suitable locations and, in exchange, the Authority would take water from the Imperial Irrigation District Canal System at the West side of the Valley, and from that location transport the water through conduits with pumping facilities adequate to lift the water approximately 3,000 feet in order to pass through the mountains in tunnels to its service area on the West side.

This is a most interesting proposal, and is one which should be kept in mind as presenting a possibility for a future supply. There are, however, uncertainties as to the effectiveness and cost of demineralization, arrangements with the Imperial Irrigation District, and the high cost of pumping and transporting the water to the service area. The estimates presented indicate that the cost per acre foot would be too high for favorable consideration at this time. Should power be made available at lower figures than those at which it can now be purchased, then this project may deserve serious consideration at some future time.

Conversion of Sea Water to Fresh Water

Intensive investigations are now being carried on by the Department of the Interior and others throughout the country, in an effort to develop a process whereby sea water can be economically converted to fresh water. Progress is being made along that line, but thus far the costs are still far too high to justify any hope that a favorable process may be made available within the near future.

The status of the investigations along this line are outlined in the General Manager's Report, and we are in agreement with his conclusion that "continued close contact with advances being made by this pre-search program is indicated."

SYSTEM EXPANSION

Aqueduct

Under the heading "Probable Water Requirements of the Area," as discussed on Page 3 and subsequent pages, it has been shown that there is serious doubt at the present time as to how much surplus water may be available for the Authority from the Colorado River Aqueduct. Further investigations, however, in cooperation with the MWD, may show that some surplus will exist and that it can be depended upon for a reasonable number of years.

Assuming that such a surplus will exist, the proposal in the General Manager's Report to construct a second aqueduct line from the West Portal of the San Jacinto Tunnel, paralleling the existing aqueduct as far as the San Luis Rey River, and then swinging to a new location further to the West, and terminating at Lower Otay Reservoir, is believed to be sound planning.

The location is, of course, preliminary and further field investigations may result in changes to improve service or reduce costs. In general, however, the location appears to be well chosen. It passes through the heart of the service area, thereby reducing the cost of the lateral system, provides connection with existing storage facilities, has inter-connections with Aqueduct No. 1, and terminates at Lower Otay Reservoir, from which adjacent areas may be served.

A second aqueduct in the proposed location is desirable from another standpoint, namely, that it will fit in with the utilization of a supply from the Feather River Project should such a project be constructed. If water is made available from the Feather River Project at San Bernardino, or in that general vicinity, no problems would be involved, as the construction of a conduit from the San Bernardino Power Plant, as referred to in Plan No. 2 of the Feather River Project, would be entirely feasible. In case the Feather River conduit should be continued as far South as the Colorado River Aqueduct of MWD, water could be made available for the San Diego Aqueduct at the West Portal of the San Jacinto Tunnel.

Further, it should be mentioned that the proposed

location of Aqueduct No. 2, heading at the West Portal of the San Jacinto Tunnel, ties in with the only possible source of additional water supply under existing conditions.

The General Manager's Report proposes a second San Diego Aqueduct with a capacity of about 500 cubic feet per second, at the upper end and diminishing at certain definite points, as it passes to the South and as the requirements decrease. Based on data presented in previous sections regarding the probable future requirements, availability of surplus water from the MWD and the Colorado River problems, it is our opinion that the capacity of a second aqueduct should be materially smaller than 500 c.f.s. It would appear that under these conditions, the capacity should not be more than 200 c.f.s., or about the same as the existing Aqueduct. Determination of the proper capacity, however, can not be made until after the amount of water available has been ascertained.

Regardless of what size of aqueduct may be constructed, it will be highly desirable to utilize terminal storage facilities at Lower Otay Reservoir, and to make deliveries of water to Lake Hodges, Murray Reservoir and Sweetwater Reservoir. Accordingly, the matter of storage at Lower Otay should be carefully reviewed with the proper representatives of the City of San Diego, in an effort to work out a plan satisfactory to all concerned. Similarly, a program should be developed, covering the deliveries of water at Lake Hodges, Murray Reservoir and Sweetwater Reservoir, with the agencies involved.

Attention should also be given to the need for storage near the West Portal of the San Jacinto Tunnel for the purpose of providing a reserve supply for the Authority, in case the MWD Aqueduct should be out of service. In addition, the requirements for regulating storage along the Aqueduct route should be reviewed.

In the design of the second aqueduct, special attention should be given to maintaining a hydraulic gradient closely in parallel with that of Aqueduct No. 1 so that water may be transferred from either one to the other through interconnections. This will require careful study as to the location and size of all inter-connections. It will also require that careful operational studies be made for representative years under assumed future water requirement conditions, in order to determine the proper size of Aqueduct No. 2, interconnections with Aqueduct No. 1, storage reservoirs and related facilities, and to provide the most satisfactory operating conditions.

In this connection, consideration should also be given to the provision of facilities whereby Authority storage in San Vicente Reservoir can be made available to the Agencies near the lower end of Aqueduct No. 1 during periods when the entire supply of Aqueduct No. 1 may be used up in making deliveries to the upstream agencies. It will also be advisable to study the possible use of El Capitan Reservoir for additional Aqueduct storage. This will require further cooperation with the City of San Diego.

The General Manager's Report has assumed that the first section of Aqueduct No. 2 from the West Portal of the San Jacinto Tunnel to the San Luis Rey River, a distance of 36.3 miles, would be constructed, owned and operated by the MWD. The balance of the aqueduct onto Lower Otay Reservoir, a distance of 53.7 miles, is to be constructed, owned and operated by the Authority. This was the arrangement followed in connection with the construction of Aqueduct No. 1.

Aqueduct capacity has been provided in Aqueduct No. 1 for supplying to the San Diego County Water Authority its entire preferential right in the Colorado River Aqueduct supply. In view of this condition and uncertainties regarding the amount of surplus water, and the length of time that it may be available from the MWD, together with the uncertainties as to the availability of the full supply to the MWD from the Colorado River, it is important that a definite understanding should be developed between the Authority and the MWD as to the construction of the first 36.3 miles of the No. 2 Aqueduct from the San Jacinto Tunnel to the San Luis Rey River. The construction of this section of Aqueduct No. 2 will involve a substantial sum of money, and early determination will be required as to the method of financing this section.

No discussion need be given herein regarding the estimated cost of the proposed Aqueduct No. 2, due to the fact that its capacity should be substantially smaller than plannned and since other changes may be necessary which will affect ultimate costs.

Branch Lines

The General Manager's Report gives full consideration to, and discussion of the branch lines required for serving the various agencies making up the Authority, in line with the expansion program which has been under way during the past few years.

When the first barrel of the San Diego Aqueduct was constructed, Aqueduct extensions and branches were installed by and at the expense of the Authority to provide water for agencies which could not be served directly from the Aqueduct, or from storage facilities owned by the Agencies to which water could be supplied from the Aqueduct. The lines so installed were:

1. Fallbrook-Oceanside Branch, to serve the Fallbrook Public Utility District and the City of Oceanside;
2. La Mesa-Sweetwater extension, to serve the La Mesa, Lemon Grove and Spring Valley Irrigation District, the Lakeside Irrigation District, National City, and the South Bay Irrigation District.

In 1948, after the original construction was completed, the Authority Board adopted a policy to the effect that all future annexed agencies must provide and operate, at their own expense, any laterals required to bring water from the Aqueduct to their respective areas.

On July 14, 1955, this Board of Engineers met with the Authority's Engineering and Operations Committee and the General Manager, for a general

discussion of water supply problems. During the course of this meeting, considerable attention was given to the establishment of a policy regarding the construction and operation of branch lines. The Board of Engineers has reviewed the subject, and under date of July 19, 1955, forwarded a letter to the General Manager of the Authority recommending limited participation by the Authority in the construction of Branch Lines.

Since that time the Board of Directors of the Authority has, under date of August 18, 1955, taken the following action:

> ". . . that the Board of Directors reaffirm the present policy of the Water Authority to the effect that any lines necessary to serve member agencies shall be constructed at the expense of such agencies, provided that if the agencies elect to take delivery at a location other than the Aqueduct, they shall finance the construction of a line from such point of delivery to the Aqueduct, according to the specifications of the Authority, and upon completion turn over such line to the Authority for operation and maintenance."

COST ESTIMATES

Estimates of cost have been set forth in the General Manager's Report for all of the various features involved in providing an additional water supply under the assumed conditions.

The Board of Engineers has reviewed the estimate with particular attention to the unit costs. These have been found, in general, somewhat above the present trend. The works proposed could undoubtedly be constructed safely within the estimates.

Since further studies will be required to develop complete information on the amount of surplus water that may be available to the Authority from the MWD Colorado River supply, and since the size of any second aqueduct and its related facilities will be changed, no detail discussion will be presented herein regarding the cost estimates.

CONCLUSIONS

In line with the discussions presented in the previous sections, the following general conclusions are presented:

Areas

1. The gross ultimate area of the Authority—821,021 acres, as shown in Table 1 of the General Manager's Report—is believed to be all that should be included. It should be further reviewed by the Authority Staff, having in mind the possible elimination of some of the higher and rougher lands.

2. Disposition by the Federal Government of all or part of the lands in Camp Pendleton and other military bases may tend to increase the area of the Authority service.

3. The General Manager's Report estimates the "Probable Area to be Served" as 527,222 acres. This is as high as can be expected and may be eventually reduced in the higher and more rugged sections. Much of the area back from San Diego and the Coastal Area will be very slow in developing. It is possible, however, that the area may be increased at some time in the future by relinquishment of federally-owned lands.

4. The Authority estimate of ultimate water requirements for the suggested service area appears to be reasonable, but it should be understood that the availability of the supply is very uncertain at this time.

5. Water requirements as estimated by the Authority for the period 1955-1980 are definiteily higher than can be expected, based on past experience, and should be adjusted.

6. If the same rate of water requirement increase, as developed by the Authority for the period 1955-1980, is applied to the balance of the probable ultimate service area of MWD in Los Angeles, Orange, Riverside and San Bernardino Counties, then no surplus Colorado River water will be available to the Authority after about 1960.

7. If the estimated Authority future water requirements are modified to provide for a more conservative increase with Aqueduct No. 1 meeting all demands until about 1965, then assuming that the balance of the MWD service area develops at the same rate, surplus water in the MWD Aqueduct will be available to the Authority until about 1966.

8. If the trend of water use in the Authority for the period 1949-1954 should continue in the future and should this same rate of consumption increase apply also to the entire MWD other than the SDCWA, then a surplus of Colorado River water would exist and be available to the Authority until about 1974, providing the Upper Colorado River Storage Project is not constructed in the meantime.

9. Conclusions 6, 7 and 8 are based on data presented in Bulletin No. 2 of the State Water Resources Board. Data contained therein relative to MWD service area water supply and water requirements should be reviewed by the MWD and the State Engineer's Office.

10. If data on which Conclusions 6, 7 and 8 are based is correct, there will be little surplus water available in MWD Colorado River Aqueduct for the Authority, regardless of the rate at which future use will increase.

11. Under these conditions, the present San Diego Aqueduct, plus the local sources, must furnish practically all the water supply for the San Diego County Water Authority until some other major source can be developed.

12. To avoid future water shortages, under conditions as set forth in Conclusions 6 to 11, inclusive, no further annexations should be made to the Authority pending a more thorough and complete analysis of water supply problems. In addition, to the

extent legally possible, the actual service area of the Authority should be limited to the better lands.

Sources of Supply

13. Plan No. 2 of the Feather River Project, extended to deliver water at the West Portal of San Jacinto Tunnel, is the most desirable for the Authority.

14. Plan No. 1 high line route to Barrett Reservoir is not practical.

15. The Authority should cooperate fully with the MWD and other agencies in working out a solution of the Feather River Project.

16. When the Upper Colorado River Storage Project is constructed and in operation, there will not be a sufficient flow in the River below Lee Ferry to supply the full right of the MWD, namely, 1,212,000 acre feet per annum. It is quite probable that the flow will not take care of more than about one half of the full right.

17. In order to obtain its full right in the Colorado of 1,212,000 acre feet per annum, it will be necessary for the MWD to make other arrangements to replace the deficiency resulting from the construction of the Upper Colorado River Storage Project.

18. Any reduction in the Colorado River Aqueduct diversions will mean a proportionate decrease in the amount of water available to the SDCWA through the existing Aqueduct. Its effect on the Authority would be disastrous. Accordingly, early action should be taken by the Authority in cooperation with the MWD and other agencies toward working out a solution.

System Expansion

19. The proposed location of Aqueduct No. 2 is well chosen.

20. Cost estimates and financial program can not be considered at this time, pending revision of plans.

21. Pending further study of the water supply situation, the Authority should proceed with the preparation of preliminary plans for a second aqueduct and related facilities along the proposed route with a capacity of 200 c.f.s.

The Board of Engineers is appreciative of the opportunity to review the water supply problems in the San Diego County Water Authority and will be glad to discuss its conclusions at any time.

Respectfully submitted,

BOARD OF ENGINEERS

Raymond A. Hill
John S. Longwell
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San Diego County Water Authority

San Diego, California

REPORT ON

THE PROBABLE EXTENT OF AUTHORITY AREA, THE AMOUNT AND SOURCE OF ADDITIONAL WATER SUPPLY REQUIRED, AND THE SYSTEM REQUIRED TO EFFICIENTLY DELIVER AUTHORITY WATER TO THE AGENCIES COMPRISING THAT AREA

RICHARD S. HOLMGREN
General Manager and Chief Engineer

JUNE 1955

LETTER OF TRANSMITTAL

June 16, 1955

Board of Directors
San Diego County Water Authority
Offices

SUBJECT: REPORT ON THE PROBABLE EXTENT OF AUTHORITY AREA, THE AMOUNT AND SOURCE OF ADDITIONAL WATER SUPPLY REQUIRED, AND THE SYSTEM REQUIRED TO EFFICIENTLY DELIVER AUTHORITY WATER TO THE AGENCIES COMPRISING THAT AREA.

Gentlemen:

There is transmitted herewith a report on the engineering study made by the Authority staff in compliance with the Board's instruction of October 14, 1954 to determine the probable ultimate extent of the Authority area, the water requirements of such an enlarged area, and the available sources of additional water to meet the growing needs of the Authority, together with the development of a general plan of a system including aqueducts, branch lines and reservoirs to economically deliver water to each of the present and potential Authority member agencies.

The study was initiated as the result of requests by some member agencies that the Board reconsider its policy pertaining to Autohrity participation in the construction of branch lines. Final action was deferred until the information from the study was available and the Board could better consider the problem of branch lines in the light of the probable extent and timing of future Authority commitments necessary to provide ample water to the Authority area. A brief statement of the conclusion reached in the study is as follows:

(1) The Authority will probably ultimately include an area of about 820,000 acres extending from the coast inland for about a distance of 30 miles to about elevation 1600, and extending from Riverside County on the north to the Mexican Border on the south.

(2) The water required to be delivered from the Authority system to meet the demand of its member agencies is estimated at 152,000 acre feet in 1960, 329,000 acre feet in 1970, and 682,000 acre feet in the year 2000.

(3) It is estimated that the Colorado River supply of the Metropolitan Water District, totaling 1,212,000 acre feet per year, is sufficient to meet all of the water needs of the District, including the Water Authority until the year 1975, at which time it is estimated that the Authority will require slightly in excess of 400,000 acre feet annually to supply the needs of its member agencies. After 1975 the quantity of Colorado River water available to the Authority will gradually decrease, and the most probable source of water to make up the decrease and provide for further increased demand appears to be the Feather River Project of the State Water Plan.

(4) If the demand for Authority water continues to increase as estimated, the present aqueduct will not be able to supply the necessary water after about 1960. By that time a second aqueduct must be in operation if the needs of the area are to be met and growth of the area is to continue. A second aqueduct, in general lying westerly of the present aqueduct, with a capacity of 500 c.f.s. at the county line, has been adopted in this report. This aqueduct, together with the present aqueduct will deliver, if running continuously at full capacity, a total quantity of water slightly in excess of 500,000 acre feet annually, estimated as sufficient to meet the need of the Authority in the year 1985. For the purpose of this study, the cost of the second aqueduct, south of the Metropolitan Water District's delivery point at San Luis Rey, is estimated at $30,700,000 and has been based on a single pipeline. However, the construction program of Metropolitan Water District, and a more detailed financial and engineering study of the aqueduct, might indicate a two-barrel construction of the aqueduct with pipes of one-half capacity. If such a program were found to be economically preferable, it would result in a somewhat higher overall cost, but payment would extend over a longer period with smaller annual requirements.

(5) The study shows four urgently needed branch lines, each of which could serve more than

one agency, and, therefore, could be operated as joint lines. These are: (a) San Marcos-Carlsbad Branch, which could deliver water to Bueno Colorado District, Carlsbad, San Dieguito, and Santa Fe Districts, and the City of Oceanside, assumed as having an ultimate capacity of 129 c.f.s., and estimated to cost $1,820,000; (b) El Monte Branch, which could serve the La Mesa and the proposed Rio and El Cajon Valley Districts, assumed as having an ultimate capacity of 112 c.f.s., and estimated to cost $1,960,000; (c) Rainbow-Valley Center Branch, which could serve the southerly Rainbow and Valley Center Districts, assumed as having an ultimate capacity of 42 c.f.s., at an estimated cost of $590,000; and (d) Fallbrook-Rainbow Branch, serving Fallbrook and Rainbow Districts, assumed as having an ultimate capacity of 73 c.f.s., and estimated to cost $680,000.

(6) Studies and preliminary estimates of costs were made of 45 reservoir sites, from which seven were chosen as sites which appeared to be economically feasible for the storing of aqueduct water, sufficient to ultimately meet the seasonal fluctuations of demand within the Authority. The so-called San Marcos Reservoir, located on San Marcos Creek, containing 16,000 acres of usable storage and costing about $1,475,000, appears the most urgent, but construction of the second aqueduct, with its surplus capacity in the near future and a continued use of storage capacity in San Vicente Reservoir would permit delay in the construction of this reservoir until after 1970.

(7) Consideration was given to pumping plants required to elevate the water to serve some of the areas. Six stations were selected as needed to provide for delivery of water to agencies of the Authority located above the aqueduct hydraulic gradient. The estimated cost of these six stations is $2,400,000.

The construction of the second aqueduct, branch lines, pumping stations, and the San Marcos Reservoir, as outlined, would represent a total expenditure of $42,905,000, which would require about $1,895,000 annually to meet bond interest and retirement of bonds, assuming a 40-year issue at 3% interest. This annual requirement would be equivalent to a 24c/$100 tax rate on the $800,000,000 assessed valuation of taxable property estimated within the Authority for the fiscal year 1955-56. The construction of the aqueduct alone, if made in one step, would require a $30,700,000 bond issue with a yearly bond service charge of about $1,330,000, equivalent to a 17c/$100 tax rate on the estimated 1955-56 assessed valuation of the Authority. It has been assumed that revenues from water sales would be sufficient to at least carry the operation and maintenance charges of the present Authority system as well as any future additions.

No recommendation is made to the Board as to the extent to which the Authority should participate in any of the work enumerated above. It is hoped that the information made available by this study will be sufficient for the Board to review its policy on branch lines and come to a final decision. When a policy is fixed by the Board, the conclusions reached in this report will be reviewed in the light of such policy.

Credit is acknowledged to all persons and agencies which have furnished information used as a basis for this study. Special credit is due Mr. W. G. Sloan, Consulting Engineer, for his painstaking work in analyzing this mass of data and in personally directing the detailed studies which have brought forth the program outlined in this report. Excellent cooperation has been received from Messrs. Raymond A. Hill, John S. Longwell, and Carl R. Rankin, comprising the Engineering Board of Review, engaged by the Board of Directors to review the results given in this report. They will within the near future submit an independent report to you, commenting on the results obtained from our study.

Respectfully submitted,

Richard S. Holmgren

General Manager and Chief Engineer

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REPORT ON ENGINEERING STUDY TO DEVELOP PROBABLE EXTENT OF AUTHORITY AREA, THE AMOUNT AND SOURCE OF ADDITIONAL WATER SUPPLY REQUIRED, AND THE SYSTEM REQUIRED TO EFFICIENTLY DELIVER AUTHORITY WATER TO THE AGENCIES COMPRISING THAT AREA.

SCOPE OF REPORT

The following are excerpts from minutes of meeting of Board of Directors of the San Diego County Water Authority of October 14, 1954, outlining the work to be covered in the Study:

"The Chairman requested the Secretary pro tem to read the report of the Engineering and Operations Committee dated October 14, 1954, before considering the next item on the agenda presented by the General Manager, since his recommendations in this connection were based on said report. The report covers a meeting of the Committee held on September 22, 1954, attended by all members of the Committee with the exception of Director Brooks, and resulted in the adoption by the Committee of the following recommmendations to the Board:

'1) That the General Manager and Chief Engineer be instructed to proceed with an engineering study for the purpose of developing the probable ultimate extent of the Authority area, and a general plan of an Authority system, including aqueducts, branch lines, and reservoirs needed to efficiently supply supplemental water to that area, including a time table of probable construction requirements; also that funds be appropriated sufficient to permit employment of additional staff and the retaining of a consulting engineer to assist in the study as it develops.' "

* * *

"Then read was letter addressed to the Board by Richard S. Holmgren, General Manager and Chief Engineer, dated October 14, 1954, subject, proposed study to determine future Authority area and system.

With reference to the recommendation of the Engineering and Operations Committee set forth in paragraph numbered (1) above, the General Manager's letter presents a brief outline of the recommended scope of the proposed study and report, as follows:

'1) Determine the probable ultimate extent of area to be included within the Authority, and estimate the probable requirement of this area for water.

2) Investigate briefly the probable sources available to the Authority for obtaining additional water supply when needed.

3) Prepare a preliminary layout and design of a basic water system consisting of (a) additional aqueduct or aqueducts needed to bring additional water to the Authority, and (b) branch lines which would economically deliver Authority water to each of the present and potential member agencies of the Authority.

4) Study the need for storage reservoir capacity required to balance the seasonal variation in demand for Authority water, with the ultimate requirement for maximum delivery to the Authority when the Aqueduct must be operated continuously at full capacity. All present and proposed storage reservoirs within the County are to be considered and studied as to their capabilities of providing the necessary storage capacity.

5) Prepare preliminary estimates of costs of the recommended aqueducts, branch lines and reservoirs.

6) Prepare economic studies of the benefits accruing to each agency from the recommended branch lines and reservoirs.' "

SUMMARY AND CONCLUSIONS

(1) **Estimated Increase in Area Within Authority:** The Authority area, as of June 1, 1955, includes 16 member agencies, having a total area of 349,060 acres. There are 5 additional areas organized or seriously considering organization with a total area of 129,040 acres which may be annexed within the near future.

Upon the annexation of these units, practically all developed areas within the county coastal plain area lying generally below elevation 1600 will be included within the Authority. It is doubtful whether any land lying generally easterly thereof at the higher elevations will find it profitable to annex to the Authority. The intervening areas now existing between member agencies within the coastal plain area will, probably within the near future, be annexed to existing agencies. When such annexations are completed, it is estimated that the probable area of the Authority will be about 820,000 acres, including U. S. Government installations at Linda Vista and Camp Pendleton. The area included is shown on Plate 1, appended hereto.

(2) **Probable Water Requirement of Area:** It is estimated that about 630,000 acres of the 820,000 acres expected to be within the Authority will be served with water by the year 2000. The quantity of water probably required to serve this area has been determined on a per capita basis within the Cities of San Diego, Oceanside, and Escondido, and on an average per acre basis for the remainder of the area. The most conservative of forecasts of future population within the City of San Diego predict that the City will have an ultimate population of 1,000,000 by the year 2000, with a total water requirement of 200,000 acre feet per year. The estimated safe yield of developed local supplies of the City is 46,000 acre feet, leaving 154,000 acre feet required to be ob-

tained from Authority sources. To provide room for this increased population, the area of the City would probably be expanded in the course of future years to about double its present 79,100 acres or to 160,000 acres in the year 2000. It is estimated that the Cities of Oceanside and Escondido with a combined area of 15,000 acres will require 22,000 acre feet of Colorado River water in that year.

The water requirement of the remaining 455,000 acres, probably served with water by the year 2000, has been estimated on the basis of an average need of the several areas using from 1.2 to 1.4 acre feet per acre of gross area served—(See Table 1). On this basis, the areas outside the Cities of San Diego, Oceanside, and Escondido will require a total of about 584,000 acre feet of water, with local sources estimated to safely yield about 56,800 acre feet. The total estimated water supply of the Authority, required to meet the demands of its agencies for supplemental water in the year 2000, is estimated at 682,000 acre feet—(See Plate 2). The annual near future requirements are estimated at 152,000 acre feet in 1960 and 329,000 acre feet in 1970.

(3) **Sources of Water Available to Authority:** The Authority's basic preferential right in the Metropolitan Water District water supply from the Colorado River, if and when the time comes that each member agency of the District is demanding its basic right, is estimated at about 120,000 acre feet annually. It is estimated that upon completion, by the District, of the Colorado River Aqueduct, and assuming no reduction in the District's present right in Colorado River water of 1,212,000 acre feet annually, that all water needs of the District member agencies, including the Authority, will be met until the year 1975, at which time the Authority's needs are estimated at 420,000 acre feet annually. However, in order for the Authority area to make use of this water, a second San Diego Aqueduct must be constructed to bring the water from the Colorado River Aqueduct to the Authority area. The estimated water needs during the years in the immediate future show that the full capacity of the present San Diego Aqueduct will be utilized continuously in 1959 and that additional capacity must be available at that time if growth is to continue.

The second most hopeful source of additional water is the Feather River Project, outlined by the State Engineer in a report submitted to the Legislature in February, 1955. Under this Project, it is proposed to deliver 1,800,000 acre feet of water annually from the Feather River and the Sacramento-San Joaquin Delta to Southern California, south of Tehachapi Mountains, of which 600,000 acre feet annually is expected to be used in the Antelope and Mohave Valleys and the remaining 1,200,000 acre feet in the area south of the San Bernardino Range. The amount proposed to be delivered to San Diego County areas through a pipeline at about elevation 2750 lying east of Lake Henshaw, Sutherland, El Capitan and Loveland Reservoirs and terminating in Barrett Reservoir, is 270,800 acre feet annually. The report also includes a possible alternate route in which the water could be dropped through a power recovery hydro-station after passing by a tunnel through the San Bernardino Mountains and delivered to the Colorado River Aqueduct of the Metropolitan Water District at the west portal of San Jacinto Tunnel. If this alternate route were adopted the water for San Diego County could then be carried through the proposed Second Aqueduct, which until that time would be used for bringing surplus water in the Colorado River Aqueduct to San Diego.

Another alternate route is suggested, in which Feather River Project water for Southern California would be delivered to the Metropolitan Water District near San Fernando Valley and be distributed by the District. This would increase the overall water supply of the District to 2,400,000 acre feet annually, sufficient to meet the probable District's needs, including the Authority, until about the year 2000. In this case, the lowest priced water to the agencies of the District, not considering relative water qualities of Feather River and Colorado River, would probably result from using Feather River water in the westerly and northerly part of the District and Colorado River water in the easterly and southerly part of the District, including the Authority area. However, in this case, additional pipelines should be built to make Feather River water available in San Diego County by a pipeline extending southerly into San Diego County along the coast or easterly to the head of the San Diego Aqueducts to maintain suitable quality of water to the Authority.

The presently scheduled construction program of the Feather River Project would make the first project water available to Southern California in 1975.

Additional sources of water to San Diego County which might be developed, after full utilization of the Colorado River and Feather River Projects, include additional development of local water resources; reclamation of sewage water; reclamation and importation of water from Imperial Valley; and possible conversion of sea water.

(4) **System Expansion—Aqueduct:** The studies indicate that an additional quantity of water above the 140,000 acre feet, which can be brought in annually through the present San Diego Aqueduct, will be needed by 1960. The only major source of additional water available at that time appears to be excess water in the Colorado River Aqueduct, available to the Authority from the Metropolitan Water District as a constituent member of the District.

A second San Diego Aqueduct is proposed, closely approximating the location of the present Aqueduct, north of the San Luis Rey River and located somewhat westerly of the present line south of the river. This aqueduct would pass just westerly of the present Hodges Reservoir Dam and terminate at Otay Reservoir, if found agreeable to the City of San Diego. It is assumed that the Metropolitan Water District will construct and operate the northerly portion of the Aqueduct to the point of present District water deliveries to the Authority—just north of San Luis Rey River, and that the Authority will

construct the portion of the Aqueduct southerly from that point. The capacity of the Aqueduct at the County line is designed for 500 c.f.s., and reduced at intervals as service outlets are provided for delivering water to agencies. The Aqueduct will be capable of delivering about 350,000 acre feet annually to the Authority area, and will meet the estimated peak loads of the Authority to 1970, deferring construction of any storage reservoirs to that date. The Authority's portion of the Aqueduct is estimated to cost $30,700,000. A schematic diagram, showing the general layout of the Aqueduct and the design capacity and pipe sizes, is included as Plate 7.

(5) **System—Expansion Branch Lines:** To supply certain areas recently annexed to the Authority and lying some distance from the Aqueduct, will require the construction of branch lines. In many cases such branch lines should be combined into joint lines to serve several agencies, resulting in minimum distribution costs.

The branch lines falling within this category and most urgently needed are listed below: (See Plate 4)

(a) **San Marcos Branch Line with the Carlsbad-Oceanside Sub-Branch, and the San Dieguito-Santa Fe Sub-Branch:** This branch would have a capacity of 129 c.f.s., and would extend westerly from the Aqueduct to the Carlsbad area and would deliver water by gravity directly into the existing and proposed systems in the area lying in the coastal plain extending from Santa Fe Irrigation Distrirct to the City of Oceanside. The estimated cost of this branch is $4,950,000.

(b) **El Monte Branch Line:** Would have a capacity of 112 c.f.s. and extend from the Aqueduct at Slaughterhouse Canyon to a point westerly of the present La Mesa District's El Monte Pumping Station. It is proposed to meet the increased demands of the La Mesa District, and to supply the proposed Rio San Diego and Rancho El Cajon Districts when annexed. The estimated cost of this branch line is $1,960,000.

(c) **Rainbow-Valley Center Branch:** Would extend westerly from the Aqueduct near Lilac to the boundary of the Rainbow District and deliver water by gravity to the proposed system of the Valley Center and Rainbow Municipal Water Districts. The design capacity of the branch where it leaves the Aqueduct is 42 c.f.s., and its estimated cost is $590,000.

(d) **Fallbrook-Rainbow Branch:** Would parallel the present Fallbrook-Oceanside Branch to the vicinity of the Red Mountain Ranger Station at the boundary of the Fallbrook District, with a design capacity where it leaves the Aqueduct of 73 c.f.s. The estimated cost of the branch is $680,000.

(6) **System Expansion—Reservoirs:** Reservoirs for storing water during the low-demand period will be needed whenever the peak demand on the Authority system exceeds the capacity of the system to deliver. At present the Authority has an agreement with the City of San Diego to store up to 20,000 acre feet of water in the San Vicente Reservoir. In order to determine the availability of sites for additional storage reservoirs, topographic maps of the County were carefully studied and 45 possible reservoir sites were investigated.

Seven new reservoir sites were chosen, which, with the use of San Vicente Reservoir, Lower Otay, and Sweetwatetr Reservoir, would furnish sufficient capacity to permit ultimate full and continuous operation of the Aqueduct when required. The Second Aqueduct, if constructed to the 500 c.f.s. proposed, would provide ample capacity for fluctuation in demand in the immediate future, and would permit delay in the construction of reservoirs until after 1970; when the first reservoir, designated as San Marcos Reservoir, containing 16,000 acre feet usable storage and costing $1,475,000, would be required. All other reservoirs could be delayed until a later date.

(7) **System Expansion — Pumping Stations:** At present all Authority water is delivered by gravity to member agencies. With the expansion of the system, there will be areas which cannot be served by gravity—notably Valley Center and the proposed Ramona and Rancho El Cajon Districts. These areas will require the pumping of practically all of the water used by them. Later, when the San Marcos Reservoir is constructed, pumping will be required at this reservoir to lift stored water into the supply lines of the several agencies which will be served by this reservoir. The supplemental supplies obtained by the La Mesa District, through the proposed El Monte Branch, will require pumping.

The estimated cost of pumping stations and force main, required in conjunction with the proposed system of branch lines, is as follows:

Valley Center Pumping Station	$ 240,000
Ramona Pumping Station	630,000
Carlsbad-Oceanside Pumping Station	360,000
San Dieguito-Santa Fe Pumping Station	340,000
La Mesa Pumping Station	470,000
Rancho El Cajon Pumping Station	360,000
Total	$2,400,000

(8) **Tentative Construction Program:** The following schedule of construction will provide the facilities to meet the estimated demand of member agencies for water from the Authority up to the year 1970. Included is the estimated cost of work required for each project:

(a) **Capital Cost:**

Year	Facility	Estimated Capital Cost
1956	San Marcos Branch	$ 1,920,000
	El Monte Branch	1,960,000
	Rainbow-Valley Center Branch	590,000
	Valley Center Pumping Facilities	240,000
1957	Oceanside-Carlsbad Branch	1,430,000
	Santa Fe-San Dieguito Branch	1,600,000
1958	La Mesa Pumping Station and Pipe	470,000
	Rancho El Cajon Pumping Sta. and Pipe	360,000
	Fallbrook-Rainbow Branch	680,000
1959	Ramona Branch and Pumping Plant	780,000
1960	Construction of Second Aqueduct	30,700,000
1975	Construction of San Marcos Reservoir	1,475,000
	Construction of San Marcos-Santa Fe Pumps and Connections	340,000
	Construction of Carlsbad Pump and Force Main	360,000
	Total	$42,905,000

(b) **Annual Cost:** The annual cost of the construction program outlined above, assuming a 40-year bond issue with interest at 3%, would require about $1,895,000 to meet bond interest and retirement of bonds—plus operation, maintenance, and replacements, etc., of about $1,210,000.

(c) **Pumping Cost:** The actual cost of pumping will vary from year to year, depending on the need for water and the cost of power. Assuming an estimated power cost of nine mills per kilowatt hour, the annual cost of power will vary from about $40,000 on the early years to about $145,000 when pumping the 1970 requirement.

(9) **Authority Participation in Cost of Program:** At present the Authority system consists of the San Diego Aqueduct and two branch lines—the Fallbrook-Oceanside Branch and the La Mesa-Sweetwater Branch. The cost of these facilities is being met from taxes levied uniformly on all taxable property within the Authority. The two branches were built during the original construction period and at Authority expense, at a combined cost of about $2,500,000, to deliver water to each of the then member agencies at the most economical point of delivery for the Authority. In general, the capacity provided was about 1.5 times the agencies' preferential rights in the capacity of the completed Aqueduct.

In 1948 the Board adopted a policy that a single service outlet from the Aqueduct would be provided at Authority expense for each new member agency, but that the construction of additional outlets and any branch lines from such outlets to the agency's system would be the obligation of the agency. This policy was later expanded to permit agencies to build joint branch lines, which, if conforming with Authority standards, would be accepted by the Authority as part of the Authority system for operation and maintenance, without reimbursement from the Authority for the cost of such lines.

It would appear that the cost of the proposed Second Aqueduct should be paid for from taxes levied over the entire area and from revenues if available, since benefits from the construction of this additional facility would be Authority-wide. However, there appears to be some difference of opinion as to the extent to which the Authority should go in the construction of branch lines, reservoirs, and pumping stations. There are three possible policies which the Authority might adopt, briefly stated as follows:

(a) The Authority will construct, maintain and operate a new Second Aqueduct from Station North 1920 + 00 (junction of Metropolitan Water District and San Diego County Water Authority) to Otay Reservoir, and such cross connections between the Second and First Aqueducts as the Authority may find desirable.

(b) The Authority will construct, maintain and operate a system which will deliver water to each agency in the quantities required to meet the ultimate demand of the agency on a uniform flow basis, or as facilities and supplies will permit—such delivery to be made at a location as near the boundary of each agency as can be reached by gravity flow from an Authority Aqueduct.

(c) The Authority will construct, maintain and operate a system which will deliver water to each agency in the quantities required to meet the ultimate demand of the agency on a uniform flow basis, or as facilities and supplies will permit—such delivery to be made at a location at or near the boundary of each agency to which the water can be conveniently transported by the Authority and advantageously used by the agency, including pumping if necessary.

The estimated capital, expenditures, and yearly debt requirement for bond retirement and interest only under each of these plans are as follows:

	Total Cost	Annual Bond Service	Tax Rate on 1955-56 Assessed Valuation
Plan 1	$30,700,000	$1,330,000	17c/$100
Plan 2	40,355,000	1,790,000	23c/$100
Plan 3	42,905,000	1,895,000	24c/$100

(10) **Financing:** If Plan 1 is adopted, the general Authority-wide benefits would indicate that funds for the project should be obtained through a bond issue, which would be repaid through tax levies on the entire Authority area.

If Plan 2 or Plan 3 is adopted, funds could be raised by general obligation bonds for the entire project, same as Plan 1. In view of the special benefits to certain areas from the branch lines and pumping stations, the expenditures for these facilities could be partially or entirely repaid through some form of repayment contracts, entered into by the Authority and the areas benefited. The extent of Authority participation depends entirely on the policy which the Board adopts in respect to serving water to the areas remote from the aqueduct.

The combined annual cost to the Authority for service charges on outstanding indebtedness, and the annual cost for debt service if Plan 2 were adopted, is shown on Plate 10.

PROBABLE EXTENT OF SERVICE AREA IN SAN DIEGO COUNTY

San Diego County has a gross area of 2,727,100 acres. Much of it is mountainous and rugged, or desert area unfit for cultivation. The jurisdiction of the Water Authority is county-wide, but its service area is confined by statute to those cities and quasi-municipal organizations which have qualified for membership in the Authority. As a member of the Water Authority, each agency is automatically qualified for certain restricted rights to obtain water for domestic, municipal, and irrigation purposes. The Authority itself is a qualified member agency of the overriding Metropolitan Water District of Southern California, which furnishes water imported from the Colorado River for distribution to its agencies in Los

Angeles, Riverside, San Bernardino, Orange, and San Diego Counties in Southern California.

As of June 30, 1954, the Authority comprised 15 member agencies with a gross area of 284,190 acres. Six other divisions with a gross area of 218,341 acres have taken initial steps to qualify for membership, or to annex to existing agencies. All of these areas lie west of the central mountain range which divides the county from north to south, and most of the area in these agencies is below elevation 1600 feet above sea level.

Anticipating that most of the remaining area will eventually become member agencies of the Authority, the unorganized area west of the mountains and below elevation 1600 has been arbitrarily divided into 7 divisions which comprise a total of 147,770 acres. U. S. Government reservations, military and otherwise, comprise a total area of 170,720 acres. The overall gross area, considered for water requirements, is 821,021 acres—summarized as follows:

Organized or in process of organization	502,531 acres
Unorganized areas	147,770 acres
U. S. Government	170,720 acres
Total	821,021 acres

While there are several thousand acres of land lying above elevation 1600 on the west slope now partially irrigated and while there may be several possibilities for increasing this acreage if water could be made available, the present and foreseeable costs of furnishing water to such areas is far beyond their capacity to produce values in support of the costs. For that reason, such areas have not been considered in this study.

East of the mountains in the desert area, lying on the west side of Imperial Valley, there are probably several hundred thousand acres of land which could produce valuable agricultural crops with water. In Borrego Valley and its neighboring smaller valleys about 3,000 acres are now irrigated from groundwater wells. The supply is probably limited, and prospects for any large development are most certainly dependent upon imported water supplies. Most of the valley lies between elevations 500 and 1000 above sea level. The area has already enjoyed considerable development as a winter resort and would no doubt equal or exceed the Palm Springs area in popularity if sufficient water could be made available. Within the last four years the Division of Water Resources of California has made a reconnaissance land classification of that part of the county, and it has found that a gross area of 48,000 acres in scattered developments can be classed as irrigable. It would require at least 144,000 acre feet of water to supply these areas. This area and its required amount of water has not been included in the future requirements provided in the plans herein, for the reason that a definite plan cannot be foreseen at the present time.

PROBABLE UNIT WATER REQUIREMENTS

Having determined the probable service area in the western part of the county, the next step is to determine how much of the area will eventually require water service and in what quantities. Numerous reports on this subject have been made in the past, all of which are on file in this office. They have been studied and briefed as part of this study. The area naturally is divided into two classes—namely, urban and rural. The extent of rural development is to a major extent dependent upon soil capabilities. As time goes on and as the pressure of population increases, many of the rural areas will become so blended with urban development that they will become semi-urban and will finally be completely urbanized. Fortunately, past experience has amply demonstrated that the change-over from rural to urban communities involves only slight changes in the all-over water requirements of an area, except when population densities in the urban area become quite high. Beyond a certain point, urban requirements per acre become greater than in the rural areas, and in contrast during early stages of rural development the water requirements are greater per acre than in later stages when the population density per acre increases.

After studying the past water use and population statistics in all of the cities within the Metropolitan Water District area, it was concluded that there has been for sometime a trend toward increased annual use from 0.14 acre foot per capita to approximately 0.20 acre foot per capita. In this study, a figure of 0.20 acre foot per capita annually has been adopted for three of the incorporated cities of San Diego County—San Diego, Escondido, and Oceanside. In 1952 a report was prepared by a Board of Engineers for the county on sewage requirements, which presented forecasts of future population, based upon several different methods. The most conservative of these methods has been accepted for forecasting the population of the three cities mentioned above as follows:

Place	Population Yr. 2000	Water Requirements at 0.20 ac. ft. Per Capita Annually
		ac. ft./yr.
San Diego	1,000,000	200,000
Escondido	28,000	5,600
Oceanside	100,000	20,000

All other cities have been included in the water organization surrounding them, and the estimates of their water requirements are based upon the acreage to be served in each organization.

A study of past records of the La Mesa, Lemon Grove and Spring Valley Irrigation District, the Vista Irrigation District, and the Fallbrook Public Utility District show average annual requirements of from 1.2 to 1.4 acre feet per gross acre served. These districts are representative of the north, central, and south portions of the county. Computations within the limits given above have been applied to each of the areas, as delineated on Plate 1.

ACTUAL ACREAGE TO BE SERVED AND AMOUNTS OF WATER REQUIRED

A scientific estimate, based on soil surveys of the actual acreage in each division which may ultimately require water, has appeared to be an impractical

undertaking within the limited time and resources available for making this report. Furthermore, such a study could not have a practical value, for the reason that development and settlement in the past have been made with disregard of the soil information then available. The prevailing rapid change-over from dry land to semi-urban settlement has been no respecter of soil capabilities. Location, topography, land values, and availability of water have been factors which have overriden proper consideration of the ability of the soil to produce. Available soil studies have failed to restrict growth in accordance with soil characteristics. Therefore, although frequent reference has been made to the soil studies in past reports, forecasts herein of future areas to be developed have been based upon judgment and the considered opinions of many local water officials.

In general, it has been recognized that settlement with its concomitant water needs will be more rapid and complete in the area within a few miles of the coast than further inland. In the higher areas east of the coastal areas, growth pressure has been so great that many attempts are now being made to develop small avocado groves in areas with pitifully deficient water supplies; thus pyramiding the demand for additional water supply. So many inadequate forecasts have been made in the past that there is now a tendency on the part of many developers to overestimate the rate of development. After consulting with many of the water officials intimately acquainted with conditions in their local areas, and in an attempt to be conservative in estimating the ultimate acreage to be developed, the estimates appearing in the third column of Table 1 have been made. A summation of these acreages gives a total of 527,222 acres which will ultimately require water. This represents about 65% of the gross area being considered.

In contrast to this total, Column 4 of Table 1 shows the areas actually served with water in 1954, which totals 164,135 acres or only 30% of the forecasted total area which will need to be served.

Applying figures given above, as to the unit requirements of water for both rural and urban areas, the individual ultimate requirements for each of the areas shown on Plate 1 have been computed and appear in Table 1 under Column 6. The total ultimate requirement is thus computed at 788,100 acre feet annually. Excluding estimates of the safe yield of local water sources now available to each of the individual divisions, totaling 106,600 acre feet, a total ultimate requirement for additional water of 681,500 acre feet per year is shown.

The safe annual production by each of the divisions has been determined after consulting numerous reports on local water supplies which have been written in the past by able engineers and from a study of the past records for each of the districts in which statistics are available. In this study of local water sources, much use has been made of the information in Bulletin No. 55 of the Division of Water Resources, Department of Public Works of California, which was published in 1949. Additions and revisions of those studies have been made from time to time since that publication, both by the Division of Water Resources and by the consulting engineers employed by the various districts. These studies have indicated that the maximum safe yield of local water resources when fully developed will be approximately 150,000 acre feet annually, of which, as listed in Column 5 of Table 1, 106,600 acre feet have already been developed. This leaves only about 42,000 acre feet of additional annual increase in local possible supplies when fully developed. The difference between the ultimate requirements, as shown in Column 6 of Table 1 and the present local safe yield of local resources, as shown in Column 5, represents the amount of additional water which eventually must be available for use in San Diego County. This ultimate amount, listed by individual areas, totals 681,500 acre feet, as shown in Column 16 of Table 1. The word "ultimate" is used advisedly but with hesitation, for it takes much temerity to forecast the ultimate needs of the county. Actually, the ultimate needs shown herein are the probable needs in about the year 2000.

In summary, the following forecast of imported water for San Diego County's needs is as follows:

Year	Amount in Acre Feet
1960	152,300
1970	329,600
1980	446,900
2000	681,500

AVAILABLE WATER SUPPLIES

As shown above, the safe yield of the combined local sources in the individual divisions amounts to 106,600 acre feet. With completion of the First San Diego Aqueduct, there is a capacity to import approximately 137,600 acre feet annually of Colorado River water from the Metropolitan Aqueduct. Actually, this 137,600 acre feet is about 20,000 acre feet in excess of the estimated probable basic preferential right of the Authority to water from the Metropolitan system so that the County Water Authority has already built capacity in excess of its minimum rights to Colorado River water. Any requirement over this minimum right is being delivered to the Authority by the Metropolitan system only because the full minimum rights of other members of the Metropolitan system have not been and are not likely to be used for sometime to come.

a) **Minimum Entitlement:** Sec. 5 (11) of the County Water Authority Act, (Chapter 545, Statutes of 1943, page 2090, as amended) defines the preferential rights of each member agency of the Authority; this section may be summarized as follows: "Each public agency, the areas of which shall be a part of the Authority shall have a preferential right to purchase from the Authority for distribution by such public agency . . . a portion of the water served by the Authority, which shall from time to time bear the same ratio to all of the water supply of the Authority as the total accumulation of amounts paid by such public agency to the Authority on tax assessments and otherwise, excepting purchase of water toward the capital cost and

TABLE 1

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
AREAS	Gross acres	Probable acres to be served	Acres served 1954	Local safe yield ac. ft.	Ultimate requirements ac. ft.	Ult. Colo.* River water c.f.s.	Colo. River water 1954 ac.ft.	ESTIMATED REQUIREMENT OF COLORADO* RIVER WATER IN ACRE FEET							
								1955	1956	1957	1958	1959	1960	1970	Ultimate
1. Bueno Colorado	47,000	35,000	17,467	10,000	45,500	49	0	2,500	3,500	4,500	5,000	6,000	6,500	15,000	35,500
2. Carlsbad	20,000	20,000	6,600	1,700	26,000	36	47	1,500	2,500	3,500	4,500	5,500	6,500	15,000	24,300
3. Escondido	1,932	1,932	1,680	800	5,600	7	740	1,000	1,200	1,500	1,700	1,900	2,200	2,800	4,800
4. Fallbrook	17,062	14,865	8,192	2,000	22,500	28	5,720	6,900	7,500	8,100	8,500	9,000	10,000	14,000	20,500
5. Rio San Diego	19,400	15,000	1,420	1,000	18,000	23	100	200	750	1,000	1,500	2,000	2,500	10,000	17,000
6. La Mesa Irr. District	30,000	30,000	14,100	4,550	38,000	46	5,320	7,500	9,000	11,000	12,000	13,000	14,000	25,000	33,450
7. South Bay & Nat'l City	17,024	17,000	9,960	8,500	24,000	21	4,900	7,500	8,000	10,000	10,500	11,000	11,500	15,000	15,500
8. Oceanside	8,019	8,019	7,636	3,000	20,000	23	1,470	1,500	1,700	1,900	2,500	3,200	4,600	11,000	17,000
9. Poway	10,800	7,000	0	500	9,000	12	0	1,000	2,000	3,000	3,500	4,000	4,500	7,500	8,500
10. Rainbow	36,500	25,000	7,100	2,400	33,000	42	137	2,000	4,000	6,000	7,000	8,000	9,000	15,000	30,600
11. Rincon	24,000	21,000	6,934	6,000	27,000	29	0	1,000	2,000	3,000	4,000	5,000	6,000	14,000	21,000
12. San Diego	76,288	77,000	50,200	46,000	200,000	210	33,710	50,000	52,000	55,000	56,000	57,000	58,000	85,000	154,000
13. San Dieguito	4,020	4,020	4,020	1,300	5,200	5	0	500	700	1,000	1,300	1,600	2,000	3,500	3,900
14. Santa Fe	10,106	10,106	10,106	1,750	13,000	16	0	300	500	800	1,000	1,500	2,000	3,500	11,250
15. Valley Center	58,100	30,000	3,700	3,700	39,000	49	0	0	0	500	1,500	2,500	3,000	6,000	35,300
16. Otay	60,000	50,000	0	500	65,000	88	0	0	0	0	1,000	2,000	3,000	10,000	64,500
17. Ramona	20,600	17,000	200	200	22,000	30	0	0	0	0	500	1,000	2,000	5,000	21,800
18. Rancho El Cajon	14,700	10,000	500	200	12,000	16	0	0	0	0	500	1,000	2,000	5,000	11,800
19. Pauma Valley	12,280	6,510	1,320	2,500	13,000	15	0	0	0	0	0	500	1,000	1,500	10,500
20. Imperial	14,700	14,000	3,000	2,000	17,000	21	0	0	0	0	1,000	1,500	2,000	5,000	15,000
SUB-TOTAL	502,531	413,452	154,135	98,600	654,800	766	52,144	83,400	95,350	110,800	123,500	137,200	152,300	268,800	556,200
Outside City of San Diego	426,243	336,452	103,935	52,600	454,800	556	18,434	33,400	43,350	55,800	67,500	80,200	94,300	183,800	402,200
UNORGANIZED AREAS															
24. North of Santa Fe	15,420	10,000	0	0	13,000	18	0	0	0	0	0	0	0	6,000	13,000
25. East of San Dieguito	9,060	9,000	0	0	11,700	16	0	0	0	0	0	0	0	6,000	11,700
26. Near Miramar	7,460	4,870	0	0	5,800	8	0	0	0	0	0	0	0	5,800	5,800
27. Near Oceanside	14,940	14,900	5,000	4,000	10,000	8	0	0	0	0	0	0	0	0	6,000
28. South of Lake Hodges	34,940	24,000	0	0	29,000	40	0	0	0	0	0	0	0	10,000	29,000
29. East of Del Mar	40,700	31,000	0	0	37,000	51	0	0	0	0	0	0	0	15,000	37,000
30. Lower Pauma Valley	25,250	10,000	5,000	4,000	13,800	13	0	0	0	0	0	0	0	5,000	9,800
SUB-TOTAL	147,770	103,770	10,000	8,000	120,300	154	0	0	0	0	0	0	0	47,800	112,300
U. S. Government	170,720	10,000			13,000	18								13,000	13,000
GRAND TOTAL	821,021	527,222	164,135	106,600	788,100	938	52,144	83,400	95,350	110,800	123,500	137,200	152,300	329,600	681,500

* Or Other Imported Water.

operating expense of the Authority's works shall bear to the total payments received by the Authority on account of tax assessments and otherwise, excepting purchase of water, toward such capital cost and operating expense."

This minimum entitlement or right varies from time to time, as payments are made to the Authority, and cannot be reduced or taken away except as the water supply of the Authority fails or is interrupted for some reason beyond the Authority's ability to prevent such an event.

b) **Maximum Entitlement:** If any of the member agencies of the Authority, at any time, do not need or do not call for their minimum entitlement, their uncalled for water can be redistributed by the Authority in accordance with the needs of other member agencies of the Authority. As the total available supply of such surplus becomes restricted, the amount of surplus over and above the minimum entitlement of each agency also becomes restricted, and such surplus will at such times be limited to each agency in the same proportion as their minimum entitlement bears to the whole.

Any member agency's full entitlement is then made up of two parts; viz., their minimum entitlement plus their proportionate share of any surplus in the aqueduct.

Likewise, the Authority's minimum entitlement in the Metropolitan Aqueduct is proportioned in the same manner as the minimum entitlements of the Authority's agencies, and their full or maximum entitlement is determined in the same manner.

On page 126 of the Fifteenth Annual Report of the Metropolitan Water District there appears the following statement of annexation policy:

"On December 18, 1953 the Board of Directors adopted the following annexation policy:

"The Metropolitan Water District of Southern California is prepared, with its existing governmental powers and its present and projected distribution facilities, to provide its service area with adequate supplies of water to meet expanding and increasing needs in the years ahead. The District now is providing its service area with a supplemental water supply from the Colorado River. When and as additional water resources are required to meet increasing needs for domestic, industrial, and municipal water, the Metropolitan Water District of Southern California will be prepared to deliver such supplies.

"Taxpayers and water users residing within the Metropolitan Water District of Southern California already have obligated themselves for the construction of an aqueduct supply and distribution system involving a cost in excess of $350,000,000. This system has been designed and constructed in a manner that permits orderly and economic extensions and enlargements to deliver the District's full share of Colorado River water, as well as water from other sources, as required in the years ahead. Establishment of overlapping and paralleling governmental authorities and water distribution facilities to service Southern California areas would place a wasteful and unnecessary financial burden upon all of the people of California, and particularly the residents of Southern California'."

Complete reliance on this "declared policy" of the Metropolitan Water District is the major basis which the San Diego County Water Authority has for using water or expecting water to be delivered to the county beyond its present minimum right of about 120,000 acre feet annually in the Metropolitan Water District supply. Any future expansion of water facilities in the county rests upon such a policy. For that reason and because of the large amount of water which will be required to fill San Diego County's needs in the future, a study has been made as to the probable future date when use of water in the remainder of the Metropolitan Water District will have reached the point where San Diego County can no longer expect to receive surplus water from the Metropolitan Aqueduct unless the District's present supply is augmented. From this study, it was concluded that total demands in the Metropolitan District will equal or exceed its ultimate total capacity in or about the year 1975.

Independent estimates of this forecast have been made, both by the Metropolitan Water District and by the Department of Water and Power for the City of Los Angeles. Metropolitan's figures check the date of 1975, while the Department of Water and Power of the City of Los Angeles has predicted that as early as 1966 the full capacity of the Metropolitan Aqueduct may be required to meet the combined needs of the District's area.

FORECASTS OF SAN DIEGO COUNTY ANNUAL WATER REQUIREMENTS

The Eighth Annual Report of the San Diego County Water Authority shows the amount of Colorado River water used by the Authority in each year since the construction of the First Barrel of the Aqueduct. In the fiscal year 1953-54 the total sales amounted to 69,650 acre feet. Within the last few months, the individual members of the Water Authority have presented to the General Manager their own estimates of their Colorado River water requirements for 1955, 1956, and 1957, assuming a continuation of drought conditions.

The figures given in Columns 9, 10 and 11 of Table 1 represent estimates made for this report, based upon the estimates given by the various agencies. In each case the agency estimates have been modified to some extent to conform with what judgment shows to be more realistic figures.

The estimated water requirements for the years 1958, 1959, 1960, and 1970, based upon judgment only as to the needs for those years and the trends as indicated by past performance, are shown in Columns 12, 13, 14, and 15 of Table 1. These forecasts indicate that by the year 1960 the demand in San Diego County alone will have reached a total of 152,300 acre feet; which is slightly in excess of the full capacity of the two barrels of the aqueduct now in operation. By that time, some means must

have been found to obtain additional water for the county. It must be emphasized that these estimates are based upon the assumption that there will be a continued use of the safe yield of each agency, as listed in Column 5 of Table 1. In years of exceptionally low runoff when safe yields do not become available the needs will exceed these estimates. It was amply illustrated in 1952 that with increased local runoff the demand for Colorado River water will materially decrease. In that year only 27,010 acre feet of Colorado River water was delivered by the Authority. It was a year of above normal rainfall, and a runoff considerably in excess of any in the last six years. Such a happy incident of rainfall and runoff may occur again; it is long overdue, but prudent engineering would dictate that little cognizance should be given to such occurrence in providing for ample supplies for the future. In the past, deliveries of Colorado River water to the City of San Diego have made up the largest proportion of deliveries from the aqueduct. In the future, by the inclusion of so many new areas with their large acreages, the deliveries to the City of San Diego will, although increasing in themselves, proportionately decrease in relation to the total water used; and since many of the new areas have exceedingly limited local supplies, their use of water will be almost entirely dependent upon imported water regardless of the extent of rainfall and local runoff.

In Plate 2, past deliveries of Colorado River water have been shown from completion of the First Barrel in 1947 up to February 1955, together with forecasts of annual estimated demands for imported water for each year from 1955 up to 1960, and for the year 1970. In the insert on the diagram the same information is shown on a smaller scale, with the ultimate demands for approximately the year 2000 added. For the purpose of illustrating the comments previously made about the proportion of total importations used by the City of San Diego, the monthly and annual use of that City have also been shown on the diagram. It should be noted that immediately upon completion of the First Barrel, almost full use was made of its capacity from January 1948 up to the time the Second Barrel was put into service with the exception of ten months in the year 1952, which has been commented upon previously. The conclusion that can be drawn from the diagram is that immediately upon making a new water supply available, it has become completely used and it appears from present indications that history will be repeated, for it is now quite evident that in the year 1955 full capacity of both barrels of the aqueduct will be required—at least for a portion of the year. However, the forecasts on the diagram clearly show that by 1960 the demand for increased importation of water will be in about the same position as it was in January 1948—when the First Barrel was put into operation.

FUTURE WATER SOURCES

The Authority's minimum right to Colorado River water has already been exceeded. The "ultimate" requirements for additional water, as forecast herein, exceed the county's right in Colorado River water by 574,500 acre feet. Consideration must, therefore, be given to the sources from which future importations can be obtained. These possible sources may be listed under the following general headings: (The listing is not necessarily in the order in which they may be developed.)

a) Feather River Project.

b) Development of additional local water resources—(surface and undeveloped).

c) Reclamation of sewage waters.

d) Reclamation and importation of water from the Imperial Valley.

e) Conversion of salt water to fresh water.

(a) **Feather River Project:** In the latest report of the State Engineer to the Legislature, it is proposed that 1,800,000 acre feet of water be imported into Southern California through the Feather River Project for use by the five southern counties of the state. Of this amount, it is proposed that 600,000 acre feet be used in the Antelope Valley, north of Los Angeles, and the remaining 1,200,000 acre feet be distributed in the remaining area. The report proposes delivery of 362,000 acre feet to San Diego County either by a high line to Barrett Reservoir (lying east of Lake Henshaw and El Capitan Reservoir), or at San Jacinto where the present San Diego Aqueduct begins.

The report estimates that this water can be delivered to San Diego County by the high line route for approximately $45 per acre foot, or at San Jacinto for $35 per acre foot. The Feather River Project is still in the planning stage and is not advanced to the point where an authoritative statement can be made as to when and how the water may be delivered to San Diego County. The amount suggested for delivery is far below the ultimate requirements for the county.

The Metropolitan Water District has made it known that it is their intention to accept delivery of this water on behalf of the five southern counties and to be responsible for its redistribution. As a member of the Metropolitan Water District, San Diego County Water Authority would legally be entitled to a minimum of 10% of the total amount made available to the Metropolitan District, or 120,000 acre feet—an amount just equivalent to its present minimum rights in the Colorado River and inadequate to supply the needs of the county. Again, the county would be placed in the position of depending upon its share in the unused water in the Metropolitan District system, and sooner or later would again face the possibility of having its deliveries cut down whenever the total needs of the agencies of the Metropolitan Water District reached the total amount imported from the Colorado and Feather Rivers. In anticipation of that time, it is imperative that other sources of water be considered for future development in addition to the Feather River. At this date it appears that the Feather River Project offers the most immediate and probably the least costly source of additional water (although inadequate) of any of

the sources that can now be considered. The Feather River water could not possibly be considered as being available before 1975 at the earliest, and then only if authorizations and appropriations are speedily forthcoming; and legal questions, negotiations, and other numerous problems are resolved with a minimum of delay.

Surely, it is incumbent upon the Authority to consider a future course in respect to the Feather River Project with full appreciation that the water provided by that Project offers the most obvious source of increasing our supplies. Energetic continuous contact with all responsible parties having anything to do with the Project is indicated.

(b) **Development of Local Resources:** Sec. 5. (11) of the County Water Authority Act specifically excludes the Water Authority from developing local resources. The act in enumerating the powers of the Authority is worded as follows: "To acquire water and water rights within or without the State **but not within the County** in which the Authority is organized and/or located; . . ." Nevertheless, in order to present a complete picture of future water resources the following comments on development of all local resources are presented:

In the past, practically all engineering studies of the water problem in San Diego County have been directed toward developing the total available water of the San Diego, San Dieguito, and the San Luis Rey Rivers, which are the principal streams draining the western slope. An extensive report has been made by the Bureau of Reclamation on the conservation of the water of the Santa Margarita River for the sole use of the Marine Corps Base at Camp Pendleton and the Fallbrook Public Utility District. To a minor extent the waters of the Tia Juana River, an international stream, have been studied. Further use of the Tia Juana River involves international agreements and complications which make difficult its consideration at this time or in the near future. The City of San Diego has been considering increasing the height of Barrett Reservoir, which is on a tributary of the Tia Juana River, but wholly within the United States. That project would increase the safe yield of the city reservoirs by approximately 5,000 acre feet per year. No estimates of cost are presently available.

The San Diego River watershed has been developed to the greatest extent of any of the watersheds of the county, and the City of San Diego has no immediate plan for any further development of the resources of that stream nor does any further development appear to be economically advisable at this time. On the San Dieguito River, the City of San Diego has for a long time considered the construction of what is called the Super Hodges Dam, as well as the construction of the Pamo Reservoir on a tributary of that stream. Extensive studies have been made of the possibilities of increasing the developed supply from that watershed, and the City of San Diego has even acquired rights of way for both of the above-mentioned reservoirs. In Bulletin 55 of the Department of Water Resources extensive studies are set forth, together with estimates of cost of various size reservoirs at Lake Hodges and at Pamo as of April 1947. In that bulletin it is estimated that the capital cost, as of 1947, for providing additional storage capacity at Lake Hodges would run from $707 to $922 per acre foot per year for additional yields of from 8,800 to 18,000 acre feet per year, and that the annual cost per acre foot of water would vary from $35 to $46.95 for the additional safe annual yield. On a 1955 price base, these figures would be at least 40% greatter than the 1947 prices; thus putting the cost of such water well above the cost of importing additional water from the Feather River or other sources. Furthermore, the amount of water that could be made available is so small it would have only a minor effect on a program to provide the total needs of the county.

Likewise, an additional reservoir at Pamo was found to involve a capital cost, based on 1947 prices, of from $826 to $933 per acre foot of annual safe yield, or an annual cost of from $35 to $39 per acre foot. On the San Luis Rey River frequent proposals have been made to construct a combination flood control and conservation reservoir at Bonsall. Many studies have been made of this possible development, which indicate an additional safe yield not to exceed 20,000 acre feet could be obtained by the largest reservoir proposed. Its annual cost would likewise be considerably in excess of the annual cost of any other water resources.

The proposal to develop the Santa Margarita River has not yet received congressional approval. If such a project were to be undertaken, it would be built by the Bureau of Reclamation and would be used primarily on a military reservation at Camp Pendleton. The Fallbrook Public Utility District, although designated as possible co-user in this project, is at present considering the construction of another dam located upstream for its sole benefit.

After reviewing all the possibilities for increasing local water sources, it is concluded that further attempts to increase the water supply from these sources should not be made until the Feather River resources have been exhausted. By that time water may have become so valuable as to justify further developments. The Authority Act would need an amendment to permit such development by the Authority.

(c) **Reclamation of Sewage Water:** Many suggestions have been made that the outflow from sewage systems in the county could be treated and purified to the extent that they would become usable, at least for irrigation and to some extent for recreation uses in the county. This possibility was given considerable attention in the 1952 report by a Board of Consulting Engineers to the County Supervisors on the "Treatment and Disposal of Sewage of San Diego County." An entire chapter of the report was devoted to this subject. Six areas were selected for a comprehensive analysis to determine the feasibility and cost of various plans for water reclamation. The areas are the Lower Tia Juana River Valley, Otay Mesa, Chula Vista, Spring Valley, El Cajon, and the San Diego metropolitan areas. In summarizing the results of these studies, it was found that in the

Lower Tia Juana River Valley some 6,900 acre feet of water could be reclaimed for use upon irrigation land within the lower valley adjacent to the international border for an average annual cost of $27.20 per acre foot. The plan was not recommended, as the major portion of flow in the sewage system comes from Mexico and the flow at anytime could be curtailed by use in that country. The same amount of water could be reclaimed and used for irrigating portions of Otay Mesa at an average unit cost of $31 per acre foot, but the same objections were made to that proposal.

In the vicinity of Chula Vista two proposals were made: (1) to reclaim 1,500 acre feet of water for 940 acres of agricultural land and 160 acres of golf course, at an average annual cost of $25.40 per acre foot; (2) to reclaim 3,000 acre feet of water for use on 2,200 acres of agricultural land and 160 acres of golf course, at an average annual cost of $20 per acre foot.

In the Spring Valley area it was proposed that some 2,800 acre feet a year be reclaimed for agricultural use, at a cost of $23.20 per acre foot.

In the El Cajon Valley it was suggested that possibly 1400 acre feet of water could be reclaimed for agricultural use, at an average annual cost of $33.50 per acre foot.

Certain portions of the sewage disposal from the San Diego metropolitan area, totaling some 3,550 acre feet per year, could be reclaimed for use in several localities as follows:

City of Coronado—800 acre feet at an average annual cost of $37.50 per acre foot.

Balboa Park—2,200 acre feet at an average annual cost of $55.40 per acre foot.

Mount Hope, Greenwood, and Holy Cross Cemeteries — 750 acre feet at an average annual cost of $46.70 per acre foot.

It was also proposed that some 3,500 acre feet of water could be reclaimed for use on the Mission Bay Park, at an average cost of $46.90 per acre foot, and in Mission Valley 3,500 acre feet could be reclaimed at $39.90 per acre foot. North of San Diego, on the Agua Hedionda, it was proposed to reclaim 3,500 acre feet at a cost of $26 per acre foot annually. In the San Elijo and Escondido Valleys a total of 2,400 acre feet could be made available at an average cost of about $45 per acre foot annually.

It should be noted that all of these proposals for the reclamation of sewage water involve small areas and separate systems of irrigation for each proposal. While the costs appear to be within economical limits, the water could not be used in a combination system which delivers both municipal and irrigation water. Therefore, the proposal to develop these sources and the administrative difficulties arising from such separate systems make it appear to be an impracticable undertaking for the County Water Authority. Such development is specifically prohibited by the present Authority Act. If and when the cost of Authority water exceeds the cost of reclamation, or an agency needs additional local supplies to augment its preferential right in Authority water, the individual agencies may well consider this source to increase their supply individually. The aggregate total thus made available from local sources is about 27,000 acre feet.

(d) **Reclamation and Importation of Water from Imperial Valley:** At the time consideration was being given to construction of the San Diego Aqueduct a contract was made with the Bureau of Reclamation to study the feasibility of transporting water from the Imperial Valley through the Laguna Mountains into the west coastal area of San Diego.

The City and/or County of San Diego had acquired a right to 112,000 acre feet of Colorado River water, and the city had arranged for carrying capacity in the All-American Canal for its transportation to San Diego County. After the decision was made to bring Colorado River water down from the Colorado River Aqueduct, through annexation to the Metropolitan Water District, the water rights of the City and/or County of San Diego were merged with those of the Metropolitan Water District, but the city retained its carrying right in the All-American Canal.

The report of the Bureau of Reclamation found that 60,000 acre feet of water could be transported to San Diego County through a series of pipe lines from a lateral of the Imperial Irrigation District and a seven-mile tunnel in the vicity of Julian to a point on the San Diego River above El Capitan Reservoir for a capital investment of $14,000,000 and an average annual cost per acre foot of $27.02.

The present study has found that it is quite unlikely that sufficient water can be obtained from the Colorado River or the Feather River to supply the ultimate water needs of San Diego County. Consequently, a re-examination of the Bureau study has been made to determine whether the Imperial Valley should be reconsidered as a source of water for future importations.

Conditions have changed materially since the original report of the Bureau of Reclamation. San Diego County has no further rights to Colorado River water, sufficient power is not in sight to pump the water over the Divide, and the needs have increased from an annual amount of 60,000 acre feet to approximately 350,000 acre feet.

It cannot be determined definitely at this time whether the seemingly insurmountable difficulties presented by the changes stated above can be resolved, but studies have indicated that there are possibilities into which further inquiry should be made and steps initiated to prove or disprove the practicability of obtaining water from the Imperial Valley.

In the past fifty years the irrigated area of the Imperial Irrigation District, which is served by the All-American Canal, has increased from a few thousand acres to well over 500,000 acres. In 1900 the Salton Sea, as we know it, was non-existent. In 1904 the Colorado River broke its confining levees just across the international border, and the entire flow of the river, for about a year, flowed into the Salton Sea. In so doing, it cut two wide erosion channels

from the border to the sea, which have since then been called the Alamo and New Rivers. For the past ten years, the average annual flow of these two streams into the Salton Sea has totaled more than 1,300,000 acre feet of water per year. This large runoff is composed of waste resulting from the operations of the Imperial Valley canals, surface waste from the individual farming areas, and drainage water from the thousand miles of drains which have been built in the valley. Over the past thirty years the average annual runoff to the Salton Sea has been about 32% of the water diverted by the Imperial Irrigation District for agricultural uses. This inflow into the Salton Sea has caused a rise in its water surface from a minimum in 1925 of 251 feet below sea level to an elevation of 235 feet below sea level in 1954. This rise has been caused principally by an inflow greater than the evaporation from the surfacce of the Salton Sea. A much more rapid increase in inflow to the sea has occurred within the last five years, possibly due to a sudden increase in the acreage of cotton under cultivation, which requires more water per acre than the crops which had heretofore been grown in the area.

Considerable concern has been experienced in this continued rise of the Salton Sea, but it is exceedingly unlikely that it will ever rise to a point which would create catastrophic conditions. Nevertheless, any proposal which would prevent any further rise, if reasonable, would meet with general approval of the residents of the Imperial Valley. It is, therefore, suggested that further studies may show that much of this water now wasting in the Salton Sea can be reclaimed and brought over to San Diego County in the necessary quantities and of a necessary quality at a cost approximating the cost of importing Feather River water.

Several conditions must be fulfilled before such a statement can be made with confidence. First, quality of water: All water now being diverted into the Imperial Valley carries approximately 550 to 600 parts per million of total salts. In order to maintain what is known as a salt balance in the soil of the valley as much salt must be removed by drainage channels as is placed on the land each year. Since the discharge into the Salton Sea is slightly less than 1/3 of the amount of water used in the area, it follows that the salt content of this water is at least three times the salt content of the water used for irrigation. Such is actually the case. Analyses of the waste waters by the Water Pollution Control Board of the State of California have shown that the salt content of the water flowing into the Salton Sea averages about 2,200 parts per million, or slightly over three times the amount of salt in the irrigation water. The water is too heavily charged with salt for the uses to which San Diego would wish to put that water. Therefore, its utilization depends upon ability to reduce the mineralization in the water about one-third to the equivalent or less of Colorado River water.

In the present studies two propositions have been considered: One is to demineralize the water and then transport it to San Diego, and the other is to demineralize it and use it on lower lands in the Imperial Valley and trade such water for water from the All-American Canal at its terminus; thus accomplishing the same purpose but in different ways. The latter would be more advantageous for San Diego, since the initial point of diversion of the water would be some 75 feet higher in elevation than the area where reclaimed water itself would need to be used.

For many years, the Imperial Irrigation District has contemplated the irrigation of some 150,000 acres of land of what is known as the West Mesa on the western side of the Imperial Valley. Detailed soil surveys of the area have indicated that the total irrigable area is about 100,000 acres. Any proposal to bring water across the range to San Diego County should include the development of this additional 100,000 acres as it is advantageous for San Diego to construct the first thirty miles of the conduit in conjunction with the irrigation of the West Mesa.

The problem of demineralizing the water flowing into the Salton Sea is as yet in experimental stages. For the last three years, the Department of Interior has had an annual appropriation for the purpose of contracting for research work on the subject of conversion of sea water to fresh water. In the course of these research studies, one method of demineralization has been found to have considerable merit and to produce fresh water within reasonable cost. Ionics, Inc., of Cambridge, Mass., has developed an ionic membrane process for reducing the salt content of water, and has prepared estimates of costs for large scale reduction of salt content of brackish waters containing 700 parts per million, 4,400 parts per million, and 9,700 parts per million to a final content of 350 parts per million. Estimated costs per acre foot for reducing a water to 350 parts per million on the scale of approximately 250,000 acre feet per year are as follows:

For reducing:

700 parts to 350 parts—$4.00/ac.ft./yr.
4,400 parts to 350 parts—$20.00/ac.ft./yr.
9,700 parts to 350 parts—$40.00/ac.ft./yr.

No estimate was made for reducing sea water of 34,000 parts per million to a desirable salt content. Its cost was entirely too high for use of this method. As pointed out above, the water entering the Salton Sea is about 2,200 parts per million while a water containing 500 parts per million may be acceptable for use in San Diego County. In the course of their research the Ionics, Inc., found that the cost of treatment varied in a straight line relation between a low salt content and a high salt content. Therefore, by interpolation, it would appear that the probable cost of reducing the waters of the Alamo and the New Rivers to a satisfactory quality would be about $11 per acre foot, which would bring this water within a usable range of cost, and indicates that serious consideration should be given to this plan as an additional source of future water for San Diego County. Again, it should be emphasized that the process is still in the experimental stage. It cannot be said with confidence at this time that

it is an answer to the problem, but with another year or two of research more authoritative answers may be reached. Water treated by this process must be a clear water. Therefore, it may be necessary to add to the above costs an additional cost for prefiltration.

It would, of course, be essential to initiate negotiations with the Imperial Irrigation District before proceeding much further with the investigation into this possibility.

Another one of the difficulties to be solved is the source of power required to pump the water over the mountain. It is probable that the combined needs for pumping and for demineralizing would require more than 200,000 kilowatts of electric power. This amount might be too large a quantity to obtain from any of the local power companies, and it is improbable that such an amount can be obtained from existing hydro-plants on the Colorado River. There is only a remote possibility that such a block of power can be obtained from proposed, but unauthorized power plants, above Hoover Dam on the Colorado River. There remains for consideration the construction of a power plant for the specific purpose of furnishing this power (possibly atomic fuel) for which the location and purposes of the plant seem to be ideally suited. This proposal to consider power from atomic fuel may not be as visionary as it may appear at first thought. Within recent weeks the Consolidated Edison Company of New York has made application to the Atomic Energy Commission for permission to build a 200,000 kilowatt plant in the immediate vicinity of New York City, using nuclear fuel. It has also been announced in the newspapers that England has proposed the construction of eight nuclear power plants, aggregating 2,000,000 kilowatts at an estimated cost of $440 per installed kilowatt.

The Imperial line to San Diego may not be needed until sometime after 1975. It is not at all improbable that by that time nuclear power will have been developed to the point where its cost will be comparable to hydro-electric power now being used. Elsewhere in this report is an estimate of cost for bringing 350,000 acre feet of water from an Imperial source and distributing it in San Diego. A summary of estimated cost for importation of Imperial Valley water follows:

Annual Cost per Acre Foot of Water With Power at—

2.5 mills per K.W.H.	$40.00
5.0 mills per K.W.H.	$51.00
9.0 mills per K.W.H.	$69.00

The plans which have been suggested for Imperial Valley importation and which are shown on Plate 6 would bring this water into the county at Elevation 2,650 above sea level, which is high enough to serve all of the areas in the county which now require pumping. This means that if this water were brought in a distribution system such as is shown on the map, it would provide all the water necessary for the two Pauma areas, all of Valley Center, all of the Rincon, Bueno Colorado, Escondido and Ramona areas, as well as the additional supplies needed for Rio San Diego, Rancho El Cajon, La Mesa, Imperial, and Otay Districts.

The plan provides for a branch line to be taken off the main aqueduct at a point about three miles below the outlet of the tunnel through the mountains, which would be built to what is called the Ballena Reservoir which has a capacity sufficient to serve the entire Ramona area without pumping; thence in the northeasterly direction to what is called the Guejito Reservoir, which will have a capacity of 30,000 acre feet sufficient to supply the storage needs of the two Pauma areas, Valley Center, Bueno Colorado, Rincon del Diablo, and the City of Escondido. One line will be taken out from the Guejito Reservoir then divided, with one branch leading to Lake Wohlford, which is now in existence, and the other leading to the highest point of the divide between Lake Wohlford and the Valley Center area. From that point every acre in the Valley Center and Palma areas can be served by gravity.

At the point on the main aqueduct where the north branch line begins, another line is planned southwesterly to the Upper Otay Reservoir. Enroute it would cross the San Diego River at El Capitan Dam where supplies would be dropped out for the City of San Diego. Immediately below, the line crosses the San Diego River, which crossing water would be taken out for the La Mesa District and the line carried through the Rancho El Cajon District at an approximate elevation of 1,600 feet.

On this line, four hydro-power plants are proposed. The first one at the upper end of San Vicente Valley with a power drop of 300 feet; the second one at El Capitan Reservoir with another power head of 500 feet; the third one in the same location with a power head of 1,250 feet; and the fourth one just above Upper Otay Lake with a power head of 350 feet. By means of these power plants a total of 25,000 kilowatts can be generated with an output sufficient to fill 15% of the requirements for pumping from Imperial Valley to the east portal of the Julian Tunnel, at the summit of the mountains, when the aqueduct is used to full capacity.

Beginning at the most westerly point of the west side lateral of the Imperial Irrigation District, the line to San Diego would be an open ditch for the first mile or so, where the water would be delivered into a pipeline and a lift to elevation 150 feet; thence the water will flow through an open concrete-lined canal for a distance of about thirty-five miles to the second pumping lift; thence through a system of four pumping lifts about evenly dispersed through about fifteen miles of either open concrete-lined canal or covered rectangular bench flume. The water will be conveyed to Grapevine Canyon, where it will be lifted through a short tunnel and pipeline to the last pumping lift just below Banner Grade on Highway 78. Thence the water will flow through a 6.8 mile tunnel to the upper reaches of the San Diego River. A total lift of 3,100 feet is involved and seven pumping plants required. Enroute from the west side canal, the

San Diego Aqueduct will traverse what is known as the West Mesa in the Imperial Valley, 100,000 acres of which have been proposed for irrigation by the Imperial Irrigation District. In the estimates hereafter given, no provision has been made for carrying this water for the West Mesa. If and when further studies are made of the route for that project, the water for the West Mesa can be combined with the San Diego water at less cost than was provided for in this estimate.

One of the chief advantages of such an importation of water is that it will give San Diego County a source of water which is independent of the present aqueduct; thus furnishing about one-half of the ultimate needs of the county from an independent source. It is prudent engineering to provide this extra source. In case of a national emergency or war if one source is cut off another source could serve the main needs of the county, but if all needs of San Diego County were imported from the north, any loss of that single aqueduct would be catastrophic.

(e) Conversion of Sea Water to Fresh Water:

For more than three years an annual appropriation for research work on this problem has been made by Congress to the Department of the Interior, and work under that program has been energetically undertaken through cooperation and consultation with most of the leading scientists, universities, and institutions—known as leaders in this particular field.

Summing up the results of all research to date, there are quoted below excerpts from a letter dated December 30, 1954, from Mr. David S. Jenkins who is the director of the saline water conversion program for the Department of the Interior.

"The cost of demineralizing sea water at the time this program was initiated was estimated at about $500 an acre foot, using compression distillation. Other processes were more expensive. At present, we have under development at Badger Manufacturing Company in Cambridge, Mass., a radical modification of the vapor compression system, which we believe may be able to produce water at about one-half that cost in the near future. It appears entirely possible that in three or four years the cost may be reduced again by one-half. Still further reductions may be possible over a period of years.

It should be emphasized that the process at present is not approaching the commercial stage, and that with adequate research and development we have every reason to believe that usable water may be produced at around $100 an acre foot, or somewhat less.

Another process under development at Nuclear Development Associates, making use of the phenomenon in which water reaches a supercritical state, gives promise of producing water at perhaps as low as $75 to $150 an acre foot. However, two serious problems must be solved. These are scale formation and corrosion at high temperatures and pressures. Within perhaps a year, we should know whether either or both of these problems can be solved. If so, we have a potentially excellent process, costwise. Summarizing, and with some speculation based on about five years of association with this subject, it is my considered guess that if given time, perhaps three to ten years, we will definitely have processes capable of producing fresh water from sea water at sea level at costs considered feasible for any municipal and industrial uses and limited irrigation of specialized crops. This means from $50 to $100 an acre foot."

The above comments summarize the status of proposals for conversion of sea water to fresh water in as concise wording and with as much authority as is justified at this time. Continued close contact with advances being made by this research program is indicated.

FUTURE PLANS

It has heretofore been shown that by 1960 the Authority Agencies will be putting to full use all imported water that can be brought in with the presently constructed aqueduct. This will necessitate the construction of a Second Aqueduct in the immediate future. Some of the agencies have not been able to use the available water to the desired extent because of the financial burden involved in constructing long supply lines, as much as thirteen to fifteen miles, to tap the present aqueduct. As a result, there is an urgent demand at present for branch lines to bring aqueduct water to these more remotely located agencies.

a) **A Second Aqueduct:** It is obvious that if an adequate water supply is to be furnished Authority agencies after 1960, a second aqueduct must be completed by that date. Having by that time already exceeded the Authority's minimum preferential right to Colorado River water, the additional needs must be supplied from surplus water available in the Metropolitan Water District system. The diagram in Plate 3 shows that there will be surplus water available, above the requirements of the District including the Authority, in decreasing amounts up until about the year 1975. By that time, Feather River water should be available for use in Southern California.

If the present policy of the Metropolitan Water District is not changed, that District assumes the responsibility of supplying all its member agencies, including the Authority, with water in quantities sufficient to meet their needs. The most practical method of supplying the increased needs of the Authority appears to be by the construction of a Second Aqueduct, entering the county in the vicinity of the First Aqueduct and delivering water to the Authority at or near the point of water delivery from the First Aqueduct. The Authority would then continue construction of the aqueduct southerly to the Otay Reservoir. It is advantageous to locate the line as far westward of the present line as appears practical, not only for the sake of safety but also to bring supplies closer to the areas located at a distance from the present line. Such a line has been laid out, using available U. S. G. S. topographical

maps, after detailed studies of several alternate lines. No field surveys were made, but proposed locations were inspected on the ground. The proposed line is shown on Plate 4.

It has been assumed that the Metropolitan Water District will finance and construct the aqueduct, as part of its system, to the vicinity of the San Luis Rey River—the point at which the District's line in the county now terminates, and that the Authority will construct the aqueduct from that point south. The line has been designed for a capacity of 500 second feet at the county line, which will be capable of delivering an annual amount of 360,000 acre feet. This closely approximates the quantity of water set forth in the Feather River report as the quanitity of water required from that project in San Diego County. Estimated cost of the second aqueduct is $30,645,000.

b) **Branch Lines & Pumping Plants:** In addition to a second aqueduct for bringing supplemental water into the area, there will be required certain branch lines which should be used jointly to deliver Authority water economically to present and potential member agencies of the Authority.

Any conception of what constitutes a basic branch line system to supply water to each agency requires certain assumptions as to capacity and location of points of delivery. In general, topography and centers of habitation dictate the proper points at which water will be delivered to an agency, and final determination of such delivery points cannot be made without some knowledge of the layout of the existing or proposed distribution system within an agency. Such layouts have not been made for the area within several of the agencies. Some are in the planning stage and others are substantially, or in part completed. The capacity of a branch line depends on the topography of the area and its need for water. Systems with capacity sufficient to supply the immediate needs, consisting of temporary or semi-permanent works, are often planned and built to the extent permissible within the limited financial ability of the partially developed areas.

The branch lines which have been planned herein are based on information received from the present operating agencies and from the limited information of the distribution plans of the member agencies. Consequently, these lines may required revision at a later time to fit the actual needs of such an area.

In general, the basic assumption adopted in this study in developing the branch line systems, was that water would be delivered to each agency in quanities required to meet the ultimate demands of each agency as facilities and supplies will permit; such delivery to be made at a location or locations at or near the boundary of each agency at which the water can be conveniently transported by the Authority and advantageously used by the agency—including pumping if necessary. The assumption implies that water would be delivered to each agency not only at points geographically desirable, but also at an elevation advantageous to the agency in supplying its area.

With these assumptions in mind, the following branch lines were studied and are proposed as those which would fall into a basic branch line system. They are shown on Plate No. 4.

1) **Fallbrook-Rainbow Branch:** Three lines now serve these two agencies: (1) the original Fallbrook-Oceanside line with a capacity of about 11 c.f.s., built by and at the expense of the Authority and at present serving Fallbrook, Oceanside, and Carlsbad; (2) a 24-inch line built and owned by the Fallbrook District at its own expense, with a capacity of 22 c.f.s., (3) a 10-inch line with a capacity of 6 c.f.s., built and owned by the Canonita Mutual Water Company, a unit within the Rainbow District.

The combined capacity of these lines is inadequate to meet the ultimate needs of the area. The proposed Fallbrook-Rainbow Branch line would extend from the aqueduct, paralleling the present Fallbrook-Oceanside Branch, to the Red Mountain Guard Station—a total distance of about 17,500 feet. This line would serve the Fallbrook District and the Rainbow District north of the San Luis Rey River by gravity from that point. The northern two-thirds of the Rainbow District will ultimately require a total of 20,400 acre feet. Combined with the needs of the Fallbrook area, the new branch line has been designed for a capacity of 73 c.f.s., which would result in a 39-inch diameter pipeline sufficient to supply the ultimate needs of the two areas when combined with present facilities. Estimated cost of the Falbrook-Rainbow branch is $678,100.

2) **Valley Center-Rainbow Branch:** The south one-third of the Rainbow District is separated from the northerly two-thirds by the San Luis Rey River and can be more economically served by a second branch line from the aqueduct. To reach the Rainbow District, the branch line must cross a portion of the Valley Center District, and should deliver water at some point along the line to that agency. In fact, it will serve the only large area in that district to which water can be delivered by gravity. All of the remainder of Valley Center is at an elevation above the hydraulic grade of the aqueduct, and its water supply must be pumped. The proposed branch line would consist of a pipe line varying from 33 inches to 21 inches in diameter. The capacity varies from 42 to 16 c.f.s., with a total length of 27,800 feet. Its estimated cost is $588,000. If and when the second aqueduct is completed, a new connection should be made to this branch where it crosses the second aqueduct, and thereafter most of the area will be served from the second aqueduct.

3) **San Marcos Branch & Sub-Branch:** This system is designed to deliver water to the agencies serving the following areas: Oceanside, Carlsbad, San Dieguito, Santa Fe, and the unorganized areas designated Nos. 24 and 25 on Plate 1.

It now appears probable that the Bueno Colorado District may temporarily demand water from this line before the second aqueduct can be completed, in order to serve the San Marcos area lying adjacent to the proposed branch. Temporarily, the area can be served from this branch, but after the com-

pletion of the second aqueduct all deliveries to the Bueno Colorado District will be made from the main outlet on the second aqueduct, near where it crosses Deer Creek. Plans for a distribution system in the San Marcos area should be made so as to later receive its supply from the main Bueno Colorado service connection on the second aqueduct. The total ultimate area to be served by the San Marcos Branch System is large, comprising some 65,000 acres, and will require sub-branches to serve the individual areas—but each sub-branch, as planned, serves portions of more than one area.

The City of Oceanside is now being served by the existing Fallbrook-Oceanside Branch. The capacity of the branch is limited and the needs of the city will outgrow this capacity in a few years. When the San Marcos System is completed, Oceanside should then be taken off the Fallbrook-Oceanside Branch and transferred to the San Marcos System. Fortunately, the remaining capacity in the Fallbrook-Oceanside Branch will then be sufficient to serve the ultimate needs of Area No. 27, as shown on Plate 1, which is now unorganized and no additional branches will be needed to serve that area. The estimated cost of the proposed pipelines in the San Marcos System, exclusive of the reservoir and its accessory pumping plants and force mains, is $4,668,200.

The capacities and sizes on the system and its sub-branches are shown on Plate 5. The system has been designed to serve the needs of the entire area by gravity only until approximately 1970. Shortly after that date, the San Marcos Reservoir would be needed, together with pumping plants and force mains from the reservoir into the sub-branches serving Carlsbad and Oceanside and the southerly branch serving the San Dieguito and Santa Fe areas.

4) **Valley Center:** Most of that portion of the Valley Center area which can be served by gravity has been included in the Valley Center-Rainbow Branch, previously described. The much larger remaining area of the Valley Center area lies at elevations of from 1,300 to 1,500 feet above sea level. The hydraulic gradient of both the First and Second Aqueducts approximates elevation 1,150 throughout the area even though both lines traverse the area. It will, therefore, require pump lifts of some 300 to 600 feet to deliver water at points from which it can be distributed to the area. A study of the topography of the area indicates that it would be advantageous and most economical to tap the First Aqueduct at three or four locations; also the Second Aqueduct in at least one point.

No one plan of distribution for the whole area has yet been worked out, nor has any attempt been made in this study to definitely locate the probable points of diversion. However, in order to cover the cost of such diversions, there has been included as a branch line an estimate of $243,000 which would be the cost of pumping plants of sufficient capacity to lift the required amount of water to adequate elevations for service to the area.

5) **Ramona Branch:** All of the Ramona area lies at or just below elevation 1,600, while the hydraulic gradient of the First Aqueduct nearest to the area is at elevation 915. It will, therefore, require a pump lift of approximately 600 feet to serve the area and to reach a strategic location near the boundary of the area will require a branch line 15,000 feet long. The first 3,700 feet has been designed with a capacity of 72 c.f.s. in anticipation that such a capacity will be required to serve a proposed Woodson Reservoir along the route which may eventually be required to furnish storage capacity for the Poway District and unorganized areas, designated as Areas 28 and 29 on Plate 1. From the reservoir site to the Poway District is a distance of 15,100 feet. The line would have a 14 c.f.s. capacity and a 24-inch diameter. Including two pump plants, each with lifts of 375 feet, the total cost of the Ramona Branch Line is estimated at $780,000, of which $372,000 is the cost of the pumping plants.

6) **El Monte Branch Line:** The existing La Mesa-Sweetwater Branch Line is now of inadequate capacity for the ultimate needs of the area which it was designed to serve. In addition, two proposed districts, the Rio San Diego and the Rancho El Cajon, are actively considering becoming member agencies of the Authority. A branch line will, therefore, be needed from the First Aqueduct near the diversion point for the present La Mesa-Sweetwater Branch and follow up the San Diego River to a point near El Monte Park, which is the nearest and most advantageous point to lift the water to the high elevation of the Rancho El Cajon area, some portions of which are as high as 1,800 feet in elevation. Three pumping lines have been provided on this branch line: one near the El Monte Pumping Station of the La Mesa District, which will serve that district; two at the terminus of the line, one of which will lift water to elevation 1,000 feet in the proposed Rancho El Cajon area; and the other 1,600 feet elevation in that area. The total length of the El Monte Branch is 57,400 feet and will require a capacity ranging from 112 c.f.s. to 14 c.f.s., and pipe sizes from 54 to 24 inches in diameter. The estimated cost of the El Monte Branch is $1,955,000. The three pumping plants and force mains required to complete this system will cost an additional $830,000.

The total cost of the branch line, outlined herein, together with the cost of pumping plants and force mains, is summarized on page 40.

c) **Reservoirs:** The past operation of the First Barrel of the aqueduct has emphasized the need for storage capacity to provide for fluctuating monthly demands for water throughout the year. The proportional variations in demand for water from month to month are not uniform in all agencies. They are much higher in an area where agriculture predominates than they are in the populated urban areas. Past experience of the irrigation districts in the county has demonstrated that the monthly peak demand in the middle of the summer is about twice the average annual demand, whereas in a city like San Diego the peak average monthly demand is about 1.25 times the yearly average.

If the assumption is made that aqueducts and branch lines are to carry flows equal to the average flow throughout the year, it is obvious that, with the fluctuating demand, storage would be needed to equalize these flows. For the purpose of determining the extent of storage required (with this assumption), Plate No. 6 has been prepared, on which the average monthly demands in percentage of the average yearly demand have been plotted for the La Mesa, Lemon Grove and Spring Valley Irrigation District, the Vista Irrigation District, the Fallbrook Public Utility District, and the City of San Diego.

These particular areas were selected as being representative areas within the Authority, and the diagram demonstrates that if water is delivered to the agencies at a uniform flow throughout the year, approximately 25% of the total water must be placed in reservoirs during low-use periods to meet the high summer peaks. In actual practice, however, if adequate capacity is provided in the aqueduct and branch lines, there will be only short periods of time when such storage is needed.

Whenever capacity in the aqueduct is inadequate to take care of the fluctuations in monthly demand, storage becomes essential, but as soon as new and enlarged capacities have been constructed to meet future needs well beyond the immediate need, there will be available in this larger capacity sufficient room to provide for monthly variations in demands. Whenever peak monthly demands approach the capacity of the aqueduct, storage is needed; but in view of the rapid increase in demand for water, additional facilities should also be made available at about that time—thus eliminating the need for storage reservoirs.

The First Barrel has been inadequate to meet the peak monthly demands since it was completed in 1947 with the exception of ten months in 1952, when abundant rainfall provided local sources sufficient to meet most demands. However, by using reservoir capacity in San Vicente Reservoir, through an agreement with the City of San Diego, surplus water available during low-use periods has been stored to meet summer demands, and all water needs of the area have been met.

When the Second Barrel was completed in October, 1954, it was anticipated that there would be ample capacity to meet the peak monthly demands on the Authority for several years to come. Low rainfall during the past winter months and very little runoff into local reservoirs have resulted in all local water supplies being practically depleted. This depletion, accompanied by a large increase in the area of the Authority requiring water service has already created peak demands beyond the capacity of both barrels of the present aqueduct, and has indicated the apparent necessity for immediate construction of a second aqueduct. Use of storage in San Vicente Reservoir will be required to meet peak demands until the second aqueduct is provided.

With the second aqueduct completed sometime in 1960, having a capacity two and one-half times as great as the First Aqueduct, there will again ensue a period of years, probably until 1970, before any large quantities of storage capacity will be needed. The Metropolitan Water District is in the process of increasing the capacity of the Colorado River

SUMMARY OF ALL BRANCH LINES & PUMPING PLANTS

BRANCH LINES:		ESTIMATED COST
1. Fallbrook-Rainbow		$ 678,100
2. Valley Center-Rainbow		588,000
3. San Marcos System		4,668,000
Main Branch	$1,822,000	
Carlsbad-Oceanside	1,356,000	
San Dieguito-Santa Fe	1,490,000	
4. Valley Center Pumps		243,000
5. Ramona		777,400
Sub-Branch Line	405,600	
Pumping Plants	371,800	
6. El Monte		2,783,100
Main Branch	1,955,000	
La Mesa Sub-Branch and Pumping Plant	470,600	
Rancho El Cajon Sub-Branch and Pumping Plants	357,500	
Sub-Total		$ 9,737,600
7. Contingent and Unforeseen Lines		1,000,000
Over-all Total		$10,737,600

OPERATING TABLE - 1970

(ACRE FEET)

	JAN.	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT.	OCT.	NOV	DEC	TOTAL	STORAGE REQUIREMENTS IN	STORAGE REQUIREMENTS OUT
FIRST AQUEDUCT															
Flow in 1st Aqueduct	11467	11467	11467	11467	11467	11467	11467	11467	11467	11467	11467	11467	137600		
To East Valley Center	117	135	180	171	284	554	616	616	711	576	414	126	4500	1860	732
Balance	11350	11332	11287	11296	11183	10913	10851	10851	10756	10891	11053	11341	133100	7071	3032
To Ramona	130	150	200	190	315	615	685	685	790	640	460	140	5000	8931	4114
Balance	11220	11182	11087	11106	10868	10298	10166	10166	9966	10251	10593	11201	128100		1049
To Poway	225	218	345	472	690	930	975	1035	885	870	487	368	7500		8927 Ac-Ft
Balance	10995	10964	10742	10634	10178	9368	9191	9131	9081	9381	10106	10833	120600		
To Areas 26, 28 & 29	925	894	1418	1940	2835	3820	4000	4248	3635	3575	2000	1510	30800		
Balance	10070	10070	9324	8694	7343	5548	5191	4883	5446	5806	8106	9323	89800		
To El Monte Branch	1200	1160	1840	2520	3680	4960	5200	5520	4720	4640	2600	1960	40000		
Balance	8870	8910	7484	6174	3663	588	− 9	− 637	726	1166	5506	7363	49800		
To So. Bay & National City	450	455	690	945	1380	1320	1500	1740	1140	1080	975	735	12390		
Balance	8420	8475	6794	5229	2283	− 732	−1509	− 2377	− 414	86	4531	6628	37410		
To City of San Diego	6560	1404	6794	5229	2283	0	1532	1737	635	86	4531	6628	37410		
Balance	1860	7071	0	0	0	− 732	−3032	− 4114	−1049	0	0	0	0		
Accumulated Balance	1860	8931	8931	8931	8931	8199	5167	1053	4	4	4	4	4		
SECOND AQUEDUCT															
Flow in 2nd Aqueduct	21125	21125	21125	21125	21125	28525	28525	28525	28525	28525	21125	21125	290500		
To Fallbrook & No. Rainbow	623	720	960	911	1511	2950	3290	3290	3793	3071	2201	671	24000		
Balance	20502	20405	20165	20214	19614	25575	25235	25235	24732	25454	18915	20454	266500		
To Pala	169	195	260	247	410	800	890	890	1027	832	598	182	6500		No Storage Needed
Balance	20333	20201	19905	19967	19204	24775	24345	24345	23705	24622	18317	20272	260000		
To So. Rainbow & W. Valley Center	169	195	260	247	410	800	890	890	1027	832	598	182	6500		
Balance	20164	20015	19645	19720	18794	23975	23455	23455	22678	23790	17719	20090	253500		
To Bueno Colorado	285	180	180	375	1035	1935	2400	2460	2265	1935	1275	675	15000		
Balance	19879	19835	19465	19345	17759	22040	21055	20995	20413	21855	16444	19415	238500		
To Pincon & Escondido	319	202	202	420	1158	2168	2688	2752	2538	2169	1428	756	16800		
Balance	19560	19633	19263	18925	16601	19872	18367	18243	17875	19686	15016	18659	221700		
To San Marcos Branch	856	540	540	1126	3106	5800	7200	7380	6800	5800	3826	2026	45000		
Balance	18704	19093	18723	17799	13495	14072	11167	10863	11075	13886	11190	16633	176700		
To Imperial	150	145	250	315	460	620	650	690	590	580	325	245	5000		
Balance	18554	18948	18473	17484	13035	13452	10517	10173	10485	13306	10865	16388	171700		
To Otay	300	290	460	630	920	1240	1300	1380	1180	1106	650	490	10000		
Balance	18254	18658	18033	16854	12115	12212	9217	8793	9305	12146	10215	15898	161700		
To So. Bay (National City	0	0	0	0	0	540	450	330	630	660	0	0	2610		
Balance	18254	18658	18033	16854	12115	11672	8767	8463	8675	11486	10215	15898	159090		
To San Diego (Lake Murray)	0	4676	256	2421	6737	9410	8767	8463	8675	8534	2619	32	60590		
Balance	18254	13982	17777	14433	5378	2262	0	0	0	2952	7596	15866	98500		
Accumulated Balance	18254	32236	50013	64446	69,824	72086	72086	72086	72086	75,038	82634	98500	98500		
MONTHLY DELIVERIES															
First Aqueduct	9607	4396	11467	11467	11467	12199	14939	15581	12516	11467	11467	11467			
Second Aqueduct	2871	7143	3348	6692	15747	26763	28525	28525	28525	25573	13529	5259			
Total	12478	11539	14815	18159	27214	38962	43024	44106	41041	37040	24926	16726			

TABLE 3

RESERVOIR DATA

NAME - Areas Served	CAPACITY REQUIRED (Ac.Ft.)	DAM: ELEV. TOP OF DAM-Ft.	DAM: ELEV. OF STREAM BED (Feet)	DAM: MAX. HEIGHT (Feet)	DAM: CREST LENGTH (Feet)	DAM: EST. CU. YDS OF EMBANKMENT	DAM: ESTIMATED CONSTRUCTION COST	DAM: COST/ AC. FT. STG. CAP.	CONNECTING LINE: Q (cfs)	CONNECTING LINE: SIZE DIA. (Inches)	CONNECTING LINE: LENGTH (Feet)	CONNECTING LINE: COST/ LINEAL FOOT	CONNECTING LINE: ESTIMATED CONSTRUCTION COST	TOTAL COST	COST/ AC.FT. STORED	COST/ AC.FT. USED
OLYMPUS																
Fallbrook	5,100													Constr. * $2,831,000	$278	$ 70
2/3 Rainbow	5,100													Annual		
Total	10,200	1,597	1,500	97	2,080	670,000	$2,091,000	$205	56	39	6,900	$ 33.50	$ 231,000	206,000	20	5
PALA																
Pauma Valley	2,650													Constr. 2,406,000	472	118
Area 30	2,450													Annual		
Total	5,100	770	630	140	570	650,000	2,025,000	398	28	30	15,000	25.40	381,000	115,000	23	6
RED MOUNTAIN																
Bueno Colorado	8,900															
Rincon	5,300															
Escondido	1,300													Constr.		
Valley Center	8,900													8,649,000	320	80
1/3 Rainbow	2,600								148	84	10,100	124.00	1,252,000	Annual		
Total	27,000	1,095	925	170	1,290	2,235,000	6,975,000	258	148	63	6,100	69.20	422,000	415,000	15	4
SAN MARCOS																
Oceanside	4,350															
Carlsbad	9,400															
San Dieguito	1,000															
Santa Fe	2,900													Constr.		
Area 24	3,350													2,275,000	95	24
Area 25	3,000													Annual		
Total	24,000	452	295	157	487	730,000	2,275,000	95	-	-	-	-	-	101,000	4	1
WOODSON																
Ramona	5,400													Constr.		
Poway	2,100													2,229,000	235	59
Part Areas 28&29	2,000													Annual		
Total	9,500	795	655	140	535	676,000	2,113,000	222	53	39	3,700	31.40	116,000	101,000	11	3
LOS PENASQUITOS																
														Constr. 1,007,000	124	31
Part Areas 28 & 29	8,100	425	335	90	570	302,000	947,000	117	45	27	3,000	20.00	60,000	Annual 47,200	6	1
CARROLL																
														Constr. 1,915,000	300	75
Part Areas 26, 28 & 29	6,400	705	575	130	1,050	613,000	1,915,000	300	-	-	-	-	-	Annual 85,000	13	3
SAN VICENTE																
La Mesa	8,350													Constr.		
Rancho El Cajon	2,950													-0-		
Rio San Diego	4,300													Annual		
Total	15,600			Space Rental $3.00 per Ac. Ft. per Annum										46,800	3	1
LOWER OTAY																
														Constr. 1,250,000	78	19
Otay	16,100			Raise Present Dam 13 Ft.			1,250,000	78						Annual 56,400	4	1
SWEETWATER																
														Constr. -0-		
Imperial	3,750			Space Rental $3.00 per Ac. Ft. per Annum										Annual 11,250	3	1
														Constr. 22,562,000	179	45
TOTAL	125,750						$19,591,000	156					$2,462,000	Annual $1,184,650	$ 9	$ 2

* PUMPING PLANT

	Lift	KW Installed	Annual KWH	Est. Constr. Cost	Annual Pumping Cost (Power Only)	Annual Cost per Ac. Ft. Pumped
At Olympus Res.	321'	2180	4,800,000	$509,000	$47,300	$4.65

→ Total and annual costs included above under Olympus Reservoir.

Aqueduct to 1,000 c.f.s., which work should be completed by June of 1956. After that time, the Metropolitan will have capacity to take care of the Authority's fluctuating demands for several years just as the second aqueduct will have capacity to take care of the fluctuating demands of the Authority member agencies. The District is also contemplating completion of the aqueduct to its full capacity of 1,650 c.f.s., and increasing storage capacity in Lake Mathews by 1960, which should make possible ample capacity to meet the needs of the Authority without the construction of additional reservoirs until after 1970.

A study of demands within the Metropolitan District shows that the Colorado River Aqueduct, when completed, will have ample capacity for all needs of all agencies until about the year 1975. In the period from 1970 to 1980, storage facilities will be needed within the Authority system if no new aqueduct capacity becomes available.

The present arrangement with the City of San Diego permits the use of San Vicente Reservoir for storage of water by the Authority for its members, and this agreement will take care of storage needs of the Authority until the second aqueduct is built, providing ample water is available for storage. A critical situation may exist from about 1970 until Feather River water, or other water, is made available to Southern California. The earliest date now given for delivery of Feather River water is about 1976. Anticipating that the second aqueduct will be built and in use by the year 1960, Operating Table No. 2 has been prepared, based upon the monthly and annual demands in 1970, which have been forecast for each of the areas served by the Authority in order to demonstrate that practically no storage will be necessary. The table shows that in 1970, with the second aqueduct in operation, the maximum monthly demands of all of the agencies can be supplied by the First and Second Aqueducts, and within the capacity of the Metropolitan Aqueduct to serve the Authority, and that only 8,000 acre feet of storage water would be required for that year. From that time on the need for storage will increase unless additional aqueduct capacity is provided. The problem of when and where to build such storage facilities does not become pressing therefore until after 1970.

A thorough search was made throughout the county for reservoir sites which would be suitable and economical for incorporation into the aqueduct system. Some forty-five sites have been selected from topographical maps and have been inspected on the ground. Many of these were eliminated upon visual inspection. Area-capacity curves and preliminary estimates of costs of construction were made for more more than thirty of the sites. By a process of elimination, because of high costs or other limiting factors, the choice of sites was narrowed to seven locations which appear to be strategic sites and hold promise of furnishing economical storage capacity. Data concerning each of these sites are given on Table 3.

The desirability of utilizing existing or enlarged facilities, owned by the City of San Diego and the California Water and Telephone Company; namely, San Vicente, Lower Otay, and Sweetwater Reservoirs, was studied.

The City of San Diego already has ample storage capacity in San Vicente, El Capitan, and Otay Reservoirs to re-regulate its requirement for Authority water. Likewise, Sweetwater Reservoir has capacity which could be used without too much danger of spillage to re-regulate Authority water for the South Bay Irrigation District, and National City and Imperial areas. Following completion of the first construction on the present aqueduct, arrangements were made by the Authority with the City of San Diego to utilize up to 20,000 acre feet of unused storage in San Vicente Reservoir to provide storage facilities for its member agencies. During the past five years of operation of the First Barrel, the availability of San Vicente storage has permitted virtually uniform maximum flow in the First Barrel, excepting for ten months in 1952, and the supplying of the varying demands of the agencies for water. The maximum amount of water in storage at anytime during this period required to do this has been about 10,000 acre feet. The present agreement with the city for storage in San Vicente up to 20,000 acre feet, if renewed when present agreement expires in 1959, should be ample to supply all storage needs of the Authority outside of San Diego City, until about 1970.

As for the other reservoir sites, locations were sought which would require the shortest practicable distances from existing or proposed aqueducts, and at the same time would be at elevations such that the reservoir could be filled by gravity from the aqueducts and emptied at elevations sufficient to furnish the necessary pressure heads in each of the districts. The ideal conditions were exceedingly difficult to fulfill, but the selection of the reservoirs, shown on Table 3, was finally made after many trial studies.

All of these possible reservoir sites should be restudied as the time approaches when they will ultimately be ended. Aside from the continued use of the facilities available at San Vicente Reservoir, it is probable that the first reservoir that should be constructed is the San Marcos Reservoir on the San Marcos System.

d) **Future Plans Beyond 1970:** If the demands forecast for imported water in San Diego County prove correct, steps must be taken (at least by 1970) to provide a third aqueduct for the county. It has been pointed out that the Feather River Project probably offers the greatest possibility for obtaining the additional water required. Further study has, therefore, been given to this possibility for the purpose of determining how and where such water should be brought into the county. All of the coastal areas, from Oceanside to the Santa Fe District, will have been provided with capacity sufficient to serve their ultimate requirements, but areas lying east of and above the proposed aqueducts; such as the Pauma areas, Valley Center District, Ramona area, and large portions of the areas south and east of

the City of San Diego, will be in need of more capacity by 1970 to meet their requirements for water.

The latest report of the State Engineer on the Feather River Project indicates that if the High Line route is adopted, it would cross the Metropolitan Aqueduct above the San Jacinto Tunnel, about six miles south and one-half mile east of Beaumont, in Riverside County. The hydraulic gradient of the High Line at the crossing is at elevation 3,000, while the hydraulic gradient at the outlet of the San Jacinto Tunnel on the Metropolitan Aqueduct is at approximately elevation 1,490; thus being 1,510 feet below the High Line.

The Feather River Report suggests, but does not propose, that water could be delivered to the Metropolitan Aqueduct from the High Line by tapping the latter about one mile west of the aqueduct crossing. At this point, water would be released into Potrero Creek, which flows westward to the San Jacinto River. The report also suggests that a reservoir could be provided on Potrero Creek by building a 240-foot high dam to a water surface elevation of 2,000 feet, and with a capacity of 49,000 acre feet. From this reservoir, a pipeline 2.75 miles long would deliver water into the Metropolitan Aqueduct at its present elevation.

Should the High Line in San Diego County be built, the desirability of the above-described connection between the two aqueducts with the accompanying storage should be given further study. Its purpose would then be to serve as an emergency connection, and to afford insurance storage in a strategic location for the protection of both the Metropolitan District and the San Diego County Water Authority. Proceeding south from the intersection of the High Line and the Metropolitan Aqueduct, the High Line is carried to Henshaw Reservoir, on the San Luis Rey River, where the hydraulic gradient would be at elevation 2,750. The route then follows southerly across the San Diego River and into a tributary flowing into the Barrett Reservoir in the southern end of San Diego County. The route of this High Line as far as the San Diego River, appears to be in the proper location to best serve the needs of San Diego County. South of the San Diego River and for a few miles above it, the entire line is in tunnel and is very expensive construction. An alternate location for this southern portion is, therefore, suggested—terminating in Otay Reservoir rather than in Barrett Reservoir.

In connection with the studies herein reported upon for diversion of Imperial Valley water into San Diego County, a line has been estimated from the intersection of the proposed Feather River High Line route with the Imperial Valley line; thence to Otay Reservoir, which appears to be much more economical and so located as to serve the needs of the county in a much more satisfactory manner than the tunnel route to Barrett Reservoir. With this suggested change in the routing, the High Line route would have many advantages for the county.

A study has been made as to how the needs of the county could be best filled if such a High Line is built. Water could be released into Lake Henshaw as a re-regulating reservoir; thence down the San Luis Rey River to a diversion at about the present location of the Escondido Canal, now serving the Vista Irrigation District and areas around Escondido. Sufficient water can be released through Lake Henshaw and the river to serve by gravity all of the ultimate needs of the Upper and Lower Pauma Valleys, the entire Valley Center area and the remaining needs of the Bueno Colorado, Rincon and Escondido areas without additional pumping and without additional storage. The main delivery line to these areas would follow the general route of the Escondido Canal; thence through Lake Wohlford to a connection, not only with the First Aqueduct but to the San Marcos Branch, from the First and Second Aqueducts. No additional pumping will be required along the line to serve any of these areas.

In the vicinity of Witch Creek, about three miles north of the San Diego River intersection, the High Line could be tapped to put water in Sutherland Reservoir and to serve the entire Ramona area. No additional pumping would be required to serve the latter area. Enroute from the San Diego River intersection on the suggested new route for the High Line, outlets could be provided to feed San Vicente Reservoir, El Capitan Reservoir, and all of the ultimate needs for the Rio San Diego, Rancho El Cajon, and Otay areas. There are three possible locations for power plants which would have drops of from 500 to 1,000 feet, having power possibilities which should be fully considered at the time. The only required additional pumping of water delivered from this line would be to supply a small area in the vicinity of the Crest Public Utility District. The proposed High Line could well serve as a third aqueduct, but cannot be considered as a substitute for the proposed second aqueduct.

Further study has been given to the amounts of water which would be required periodically up to the year 2025. The total demands on the Metropolitan System were found by the year 2025 to be about 2,500,000 acre feet within the entire Metropolitan area, including the Authority. This forecast provides for annual increases in demand of from 47,000 acre feet in the year 1969, decreasing to annual increases of 25,000 acre feet per year in 1981, and maintaining that increase up until the year 2025. Assuming that the full rights of the Metropolitan to 1,200,000 acre feet of water will be unimpaired during this period, indications are that requirements from the Feather River Delta Project will increase to 1,300,000 acre feet by the year 2025. This is slightly more than the amount indicated in the report as being available to Southern California. If this forecast should prove to be valid, the project water will be exhausted at that time and additional supplies will be required.

At the present time, there appears to be some uncertainty as to the ability of California to maintain its full rights in the Colorado River water because of the pending California-Arizona water suit in the Supreme Court of the United States. The possible depletion of Colorado River water, due to

construction of Upper Colorado River reservoirs and trans-mountain diversions, may also operate to depreciate the full right.

In anticipation of a most unfavorable outcome of the California-Arizona suit and the effect of upstream development, another study has been made as to how long Feather River water can be expected to supply needs within the Metropolitan area in the event the Colorado River right is impaired by the amount of 500,000 acre feet by the year 1980. On such an assumption, the Feather River supply would need to be called upon as early as 1970, and would be completely exhausted by the year 2000.

Other routes for bringing in Feather River water have been considered in the State Engineer's Report. One such route would deliver water into the Metropolitan area at Devil's Canyon, a few miles above San Bernardino. Another would deliver it into Castaic Creek, above the San Fernando Valley, north of Los Angeles, and there was also proposed that it be delivered into the Metropolitan area via a coastal route, terminating in the same vicinity of Castaic Creek. None of these alternates contemplate any lines being built into San Diego County, probably on the assumption that the Metropolitan District would take over the Feather River water at the terminus of these alternate routes and redistribute it to the member agencies of the District.

The State Engineer's Report proposes to charge $45 per acre foot for water delivered from the High Line route in San Diego County, $35 per acre foot if delivered at Devil's Canyon, and $25 per acre foot at the terminus of the other alternate High Line routes. The cost of delivering this water into San Diego County in routes other than by the High Line has not been determined, but whatever it may be, the increase in cost to deliver the cheaper water to where it can be used in the county would considerably narrow the margin between the higher cost of water from the High Line as against the cheaper water delivered at an alternate terminus.

e) **Quality of Water:** Much concern has been expressed regarding the future quality of both Colorado River and Feather River waters. Records of the quality of Colorado River water, which have been kept since the Metropolitan Aqueduct was put into operation, have shown that as runoff in the Colorado River decreases and the storage level of Lake Mead is lowered, the quality of Colorado River water deteriorates to some extent. When high runoffs occur and Lake Mead approaches its full capacity, the quality of water somewhat improves again. Many California people fear that upstream development on the Colorado River will continue to deteriorate the quality of Colorado River water. It is probable that in the far future some steps would need to be taken to treat and filter the water to make it acceptable for safe use in the county.

On the other hand, Feather River water, at least at the beginning of its development, will be of far better quality than Colorado River water, but there is also a possibility that in time its quality will also deteriorate due to the greater development of irrigation in the San Joaquin and Sacramento River Valleys, and industrial pollution. On page 89 of the State Engineer's Report on the Feather River Project is the following statement:

> "Provisional findings indicate that the following range of quality characteristics is likely to prevail in the Delta under conditions of physical and economical development forecast for the year 2010, providing a salt-water barrier would be constructed:
>
> | | |
> |---|---|
> | Total Dissolved Solids, ppm | 100-500 |
> | Chlorides, ppm | 10-100 |
> | Total Hardiness, ppm | 50-240" |

The upper limits given in the above table approach the present quality of Colorado River water. Undoubtedly, Feather River water will have a higher quality for several years after its first use than that of the Colorado River water, and it would, therefore, be advantageous to provide for its use in San Diego County if economic considerations will permit.

Delay in obtaining Feather River water for only a few years beyond the proposed completion date of 1976 will create a critical condition in San Diego County, provided the estimated growth continues. Other possible water resources, which have been heretofore referred to in this report, should not be forgotten. The Authority should continue to investigate all of these other sources as insurance, should the Feather River supply become unavailable.

COST ESTIMATES

The estimates appended hereto are necessarily of a very preliminary nature. The entire study has been based upon existing topographic maps, which are adequate only for such a preliminary study. No field work of any kind has been carried on except visual inspection of portions of the various routes, the dam sites and the reservoir sites. The main transportation lines and branch lines have been first located on the map, and profiles have been plotted from the topography, grade lines established, and required classes of pipe have been determined by listing the lengths of pipe required for varying heads, as indicated by the grade lines and profiles of ground surface. Estimates of quantities required for earth-filled dams at the various dam sites are based upon enlarged portions of the topographic maps from which profiles of the dams were picked off. Dam embankment estimates are based upon overall side slopes of 7 to 1 and top widths of 25 feet. A freeboard of 10 feet has been allowed above the maximum required capacity of the reservoir. No test pits, drill holes, or excavations have been made of any of the dam sites. Much of the data for the San Marcos dam site was obtained from an engineering report prepared by Mr. Kenneth Volk, consulting engineer for the Santa Fe Irrigation District.

The cost of pipelines was based upon unit prices quoted by the American Pipe and Construction Company of Los Angeles, for sizes up to 66 inches in diameter. For larger sizes, unit prices were fixed after consulting recent bids received by the Metropolitan Water District. No attempt has been made to separate excavation costs from pipelines and to

estimate them individually. In all cases, quoted prices for furnishing and laying the various sizes of pipe have been doubled to provide for right-of-way costs, excavation, and backfill, and miscellaneous structure costs. Examination of the actual costs of the First and Second Aqueducts has shown that the final cost of the lines has amounted to approximately twice the unit cost of the pipe sizes. For the dams, a unit cost of $2.50 per cubic yard of embankment has been used for the overall cost of the dam. This overall price is a preliminary figure, based upon similar computations made on some 15 or 20 earth-filled dams which have been constructed in recent years. By using this factor, costs of rights of way, concrete, riprap, structures, and other miscellaneous costs have been provided for. In general, methods of preparing preliminary estimates have closely followed the manual of instructions now in use by the Bureau of Reclamation, with cost indices brought up to the first of January, 1955, in accordance with indices which are revised quarterly by the Bureau.

An overall 25% has been added to each feature cost to provide for engineering, administration, and contingencies. It is believed that the estimates herein are adequate to serve the purpose of aiding the Board of Directors in determining the financial implications of any policy which they might adopt. A great deal of field work and additional detailed study must be done before proceeding with the actual authorization of any of the projects listed. The estimates cover the components of a system which will distribute incoming water to each of the areas shown on Plate No. 4 at locations and elevations which will permit delivery of water at points advantageous to each agency.

ANNUAL COST

There has been prepared and included in this report (as Plate 10) a chart showing the annual requirements for meeting the existing outstanding indebtedness of the Authority, to which has been added the increased cost which would result were the Authority to adopt a plan whereby the Authority would construct and finance the second aqueduct and the branch lines outlined in this report. Due to the uncertainty as to the extent to which the Authority will participate in the construction of branch lines, no charts have been prepared at this time on other possible conditions.

APPENDIX A

PLATES

Areas to be Considered for Development.....Plate 1

Past and Forecast Needs of Imported Water—SDCWA.....Plate 2

Forecast of Metropolitan Water District Water Deliveries.....Plate 3

Existing and Proposed Facilities.....Plate 4

Diagram of San Marcos Branch System.....Plate 5

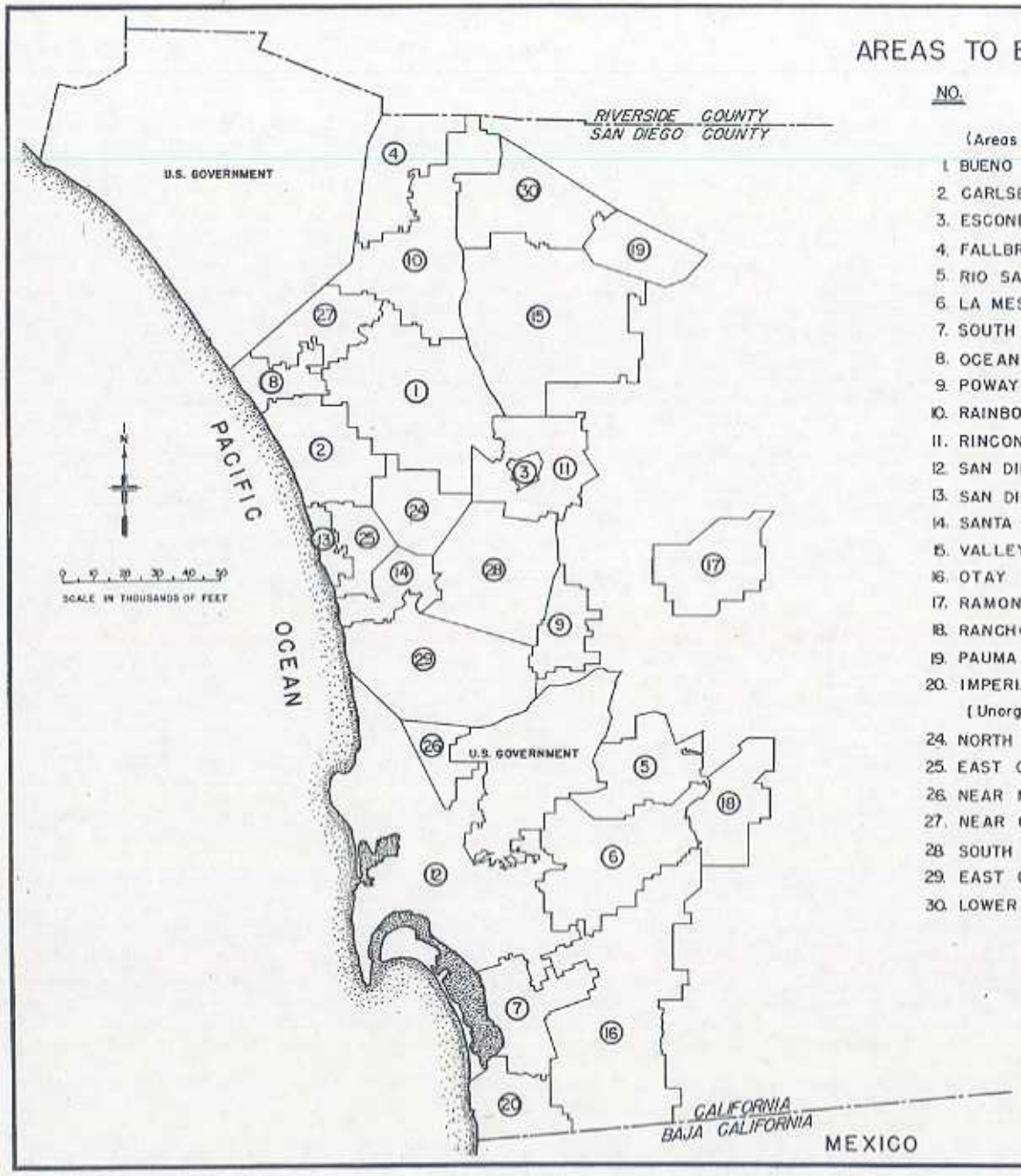
Average Monthly Demands for Water in Per Cent of Annual Requirement..Plate 6

Diagram of Main Pipeline and Branch Lines.....Plate 7

Imperial-San Diego Aqueduct.....Plate 8

Existing and Proposed Facilities for—SDCWA.....Plate 9

Annual Costs for Debt Service, Based on Plan to Include Second Aqueduct and Branch Lines.....Plate 10



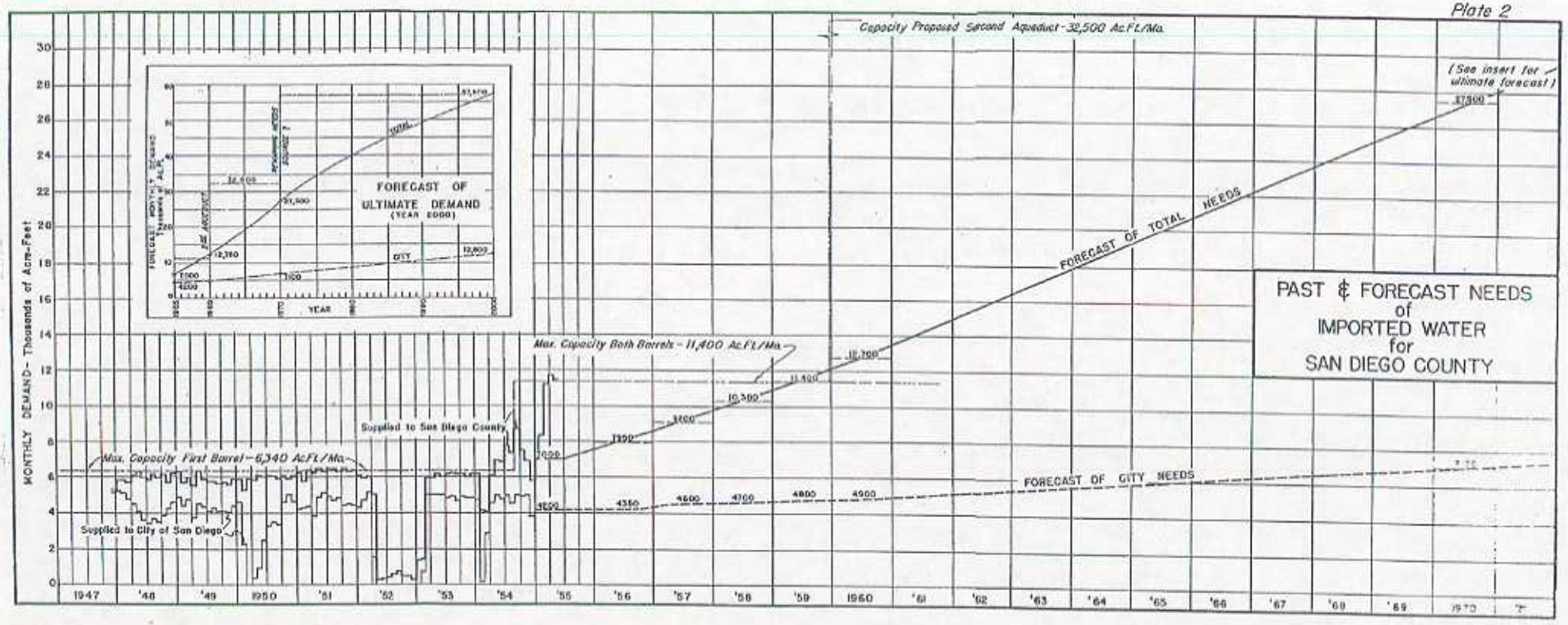
AREAS TO BE CONSIDERED FOR DEVELOPEMENT

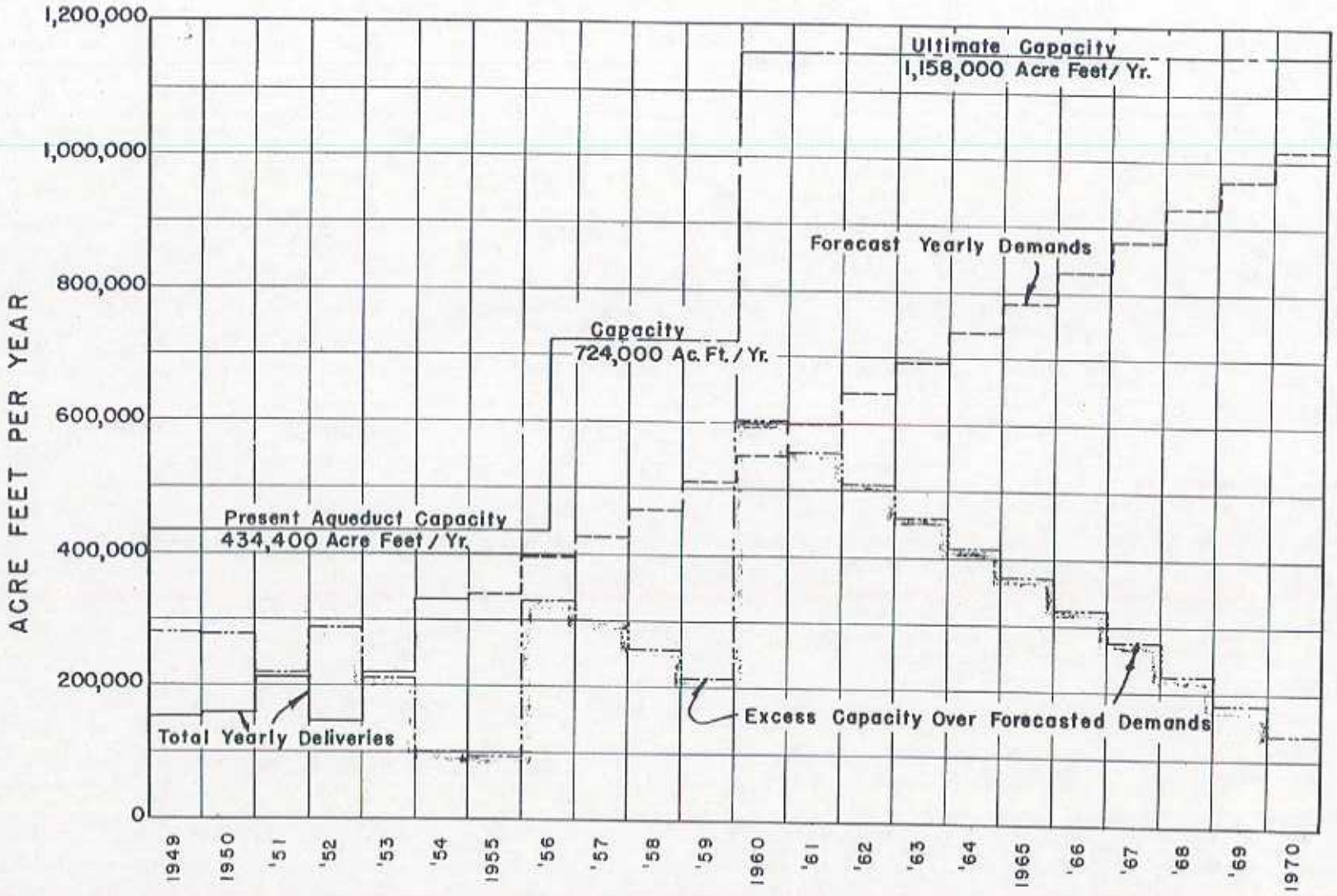
NO.	NAME
	(Areas Organized or In Process of Organization)
1.	BUENO COLORADO
2.	CARLSBAD
3.	ESCONDIDO
4.	FALLBROOK (Includes probable annexation)
5.	RIO SAN DIEGO
6.	LA MESA, LEMON GROVE & SPRING VALLEY
7.	SOUTH BAY & NATIONAL CITY
8.	OCEANSIDE
9.	POWAY
10.	RAINBOW
11.	RINCON DEL DIABLO
12.	SAN DIEGO
13.	SAN DIEGUITO
14.	SANTA FE
15.	VALLEY CENTER
16.	OTAY
17.	RAMONA
18.	RANCHO EL CAJON
19.	PAUMA VALLEY
20.	IMPERIAL
	(Unorganized Areas)
24.	NORTH OF SANTA FE
25.	EAST OF SAN DIEGUITO
26.	NEAR MIRAMAR
27.	NEAR OCEANSIDE
28.	SOUTH OF LAKE HODGES
29.	EAST OF DEL MAR
30.	LOWER PAUMA VALLEY

SAN DIEGO COUNTY

Plate 1

Plate 2

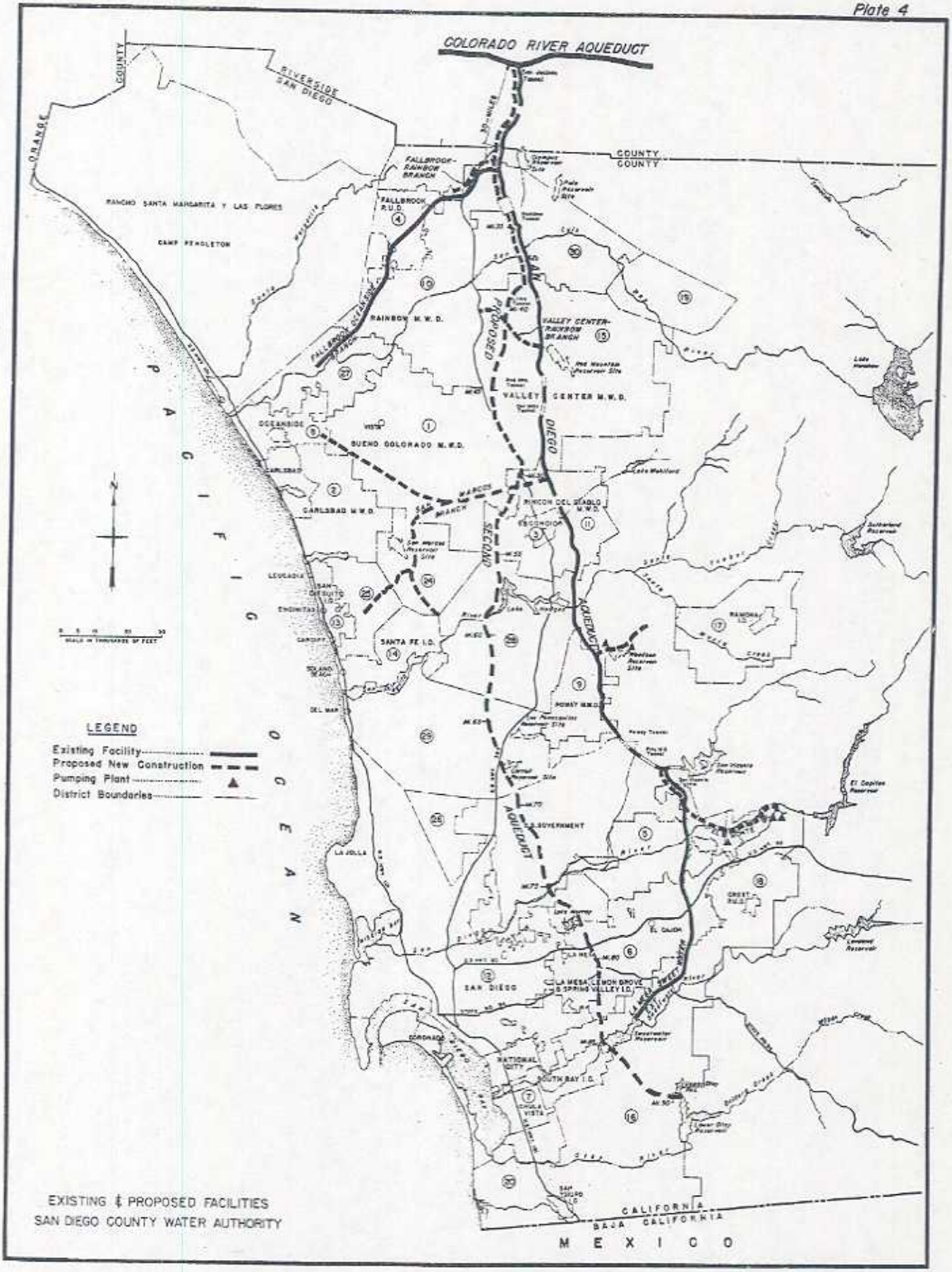

PAST & FORECAST NEEDS
of
IMPORTED WATER
for
SAN DIEGO COUNTY
MONTHLY DEMAND - Thousands of Acre-Feet
Capacity Proposed Second Aqueduct - 32,500 Ac.Ft./Mo.
(See insert for ultimate forecast)
FORECAST OF TOTAL NEEDS
FORECAST OF CITY NEEDS
Max. Capacity Both Barrels - 11,400 Ac.Ft./Mo.
Max. Capacity First Barrel - 6,340 Ac.Ft./Mo.
Supplied to San Diego County
Supplied to City of San Diego
FORECAST OF ULTIMATE DEMAND (YEAR 2000)
YEAR



FORECAST OF M.W.D. WATER DELIVERIES

Plate 3

Plate 4



EXISTING & PROPOSED FACILITIES
SAN DIEGO COUNTY WATER AUTHORITY

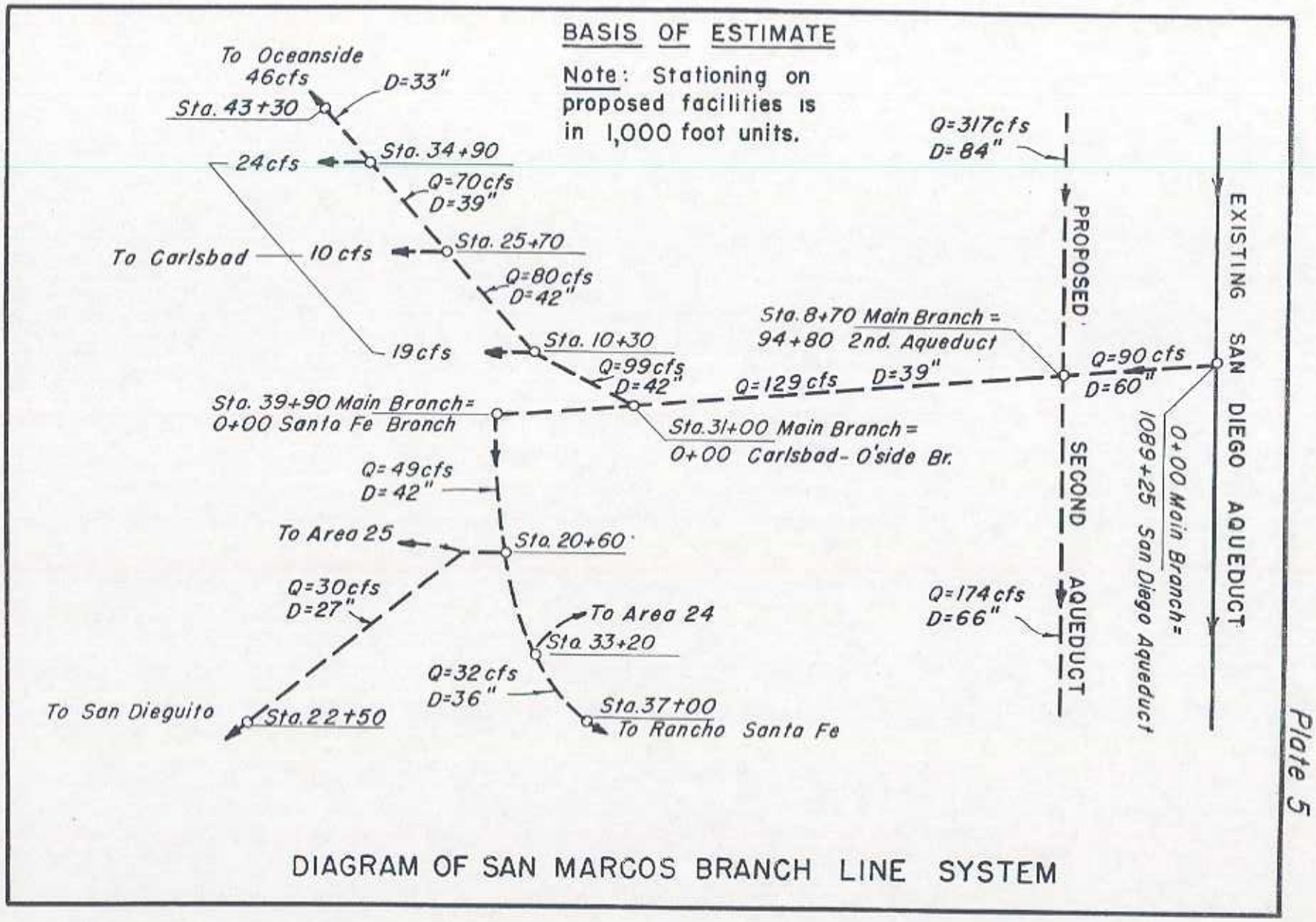
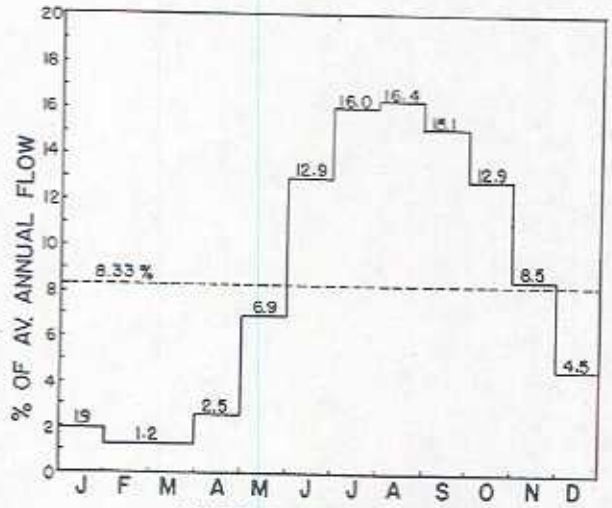


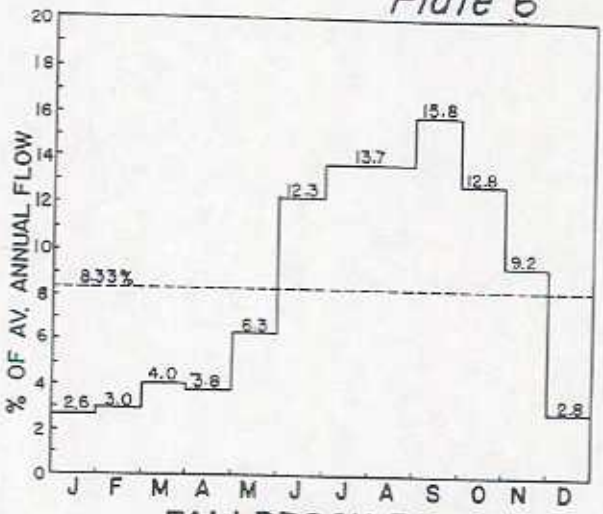
DIAGRAM OF SAN MARCOS BRANCH LINE SYSTEM

Plate 5

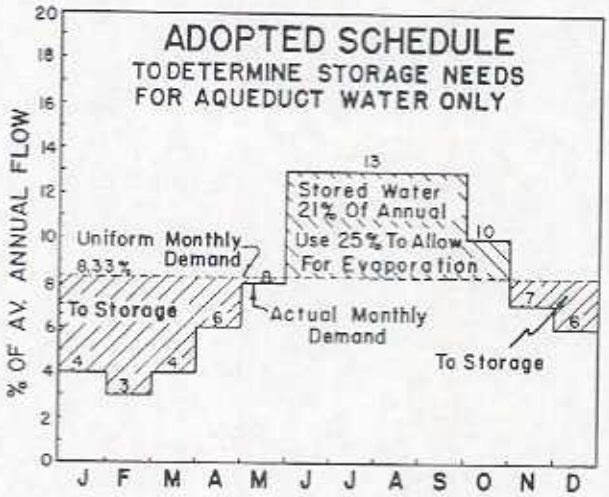
Plate 6

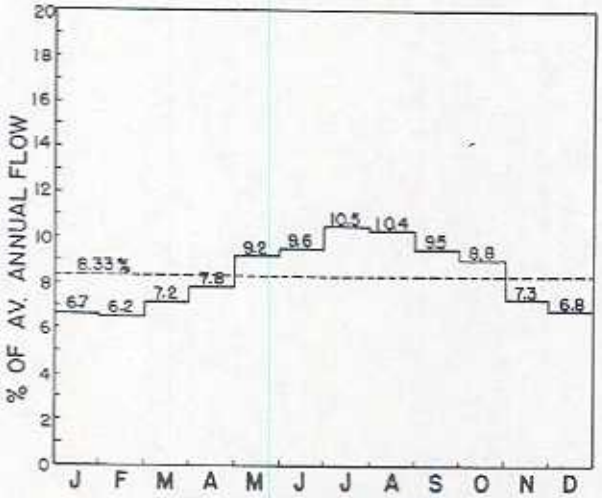


VISTA IRRIG. DIST.

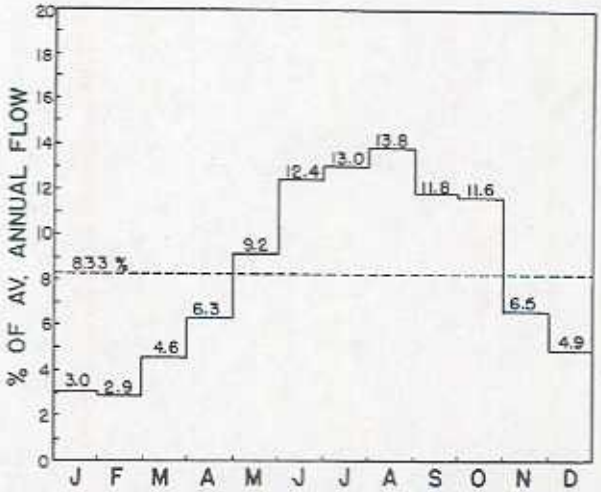


FALLBROOK P.U.D.





CITY OF SAN DIEGO



LA M., L.G. & SPR. V. IRRIG. DIST.

AVERAGE MONTHLY DEMANDS FOR WATER IN PERCENT OF ANNUAL REQUIREMENT

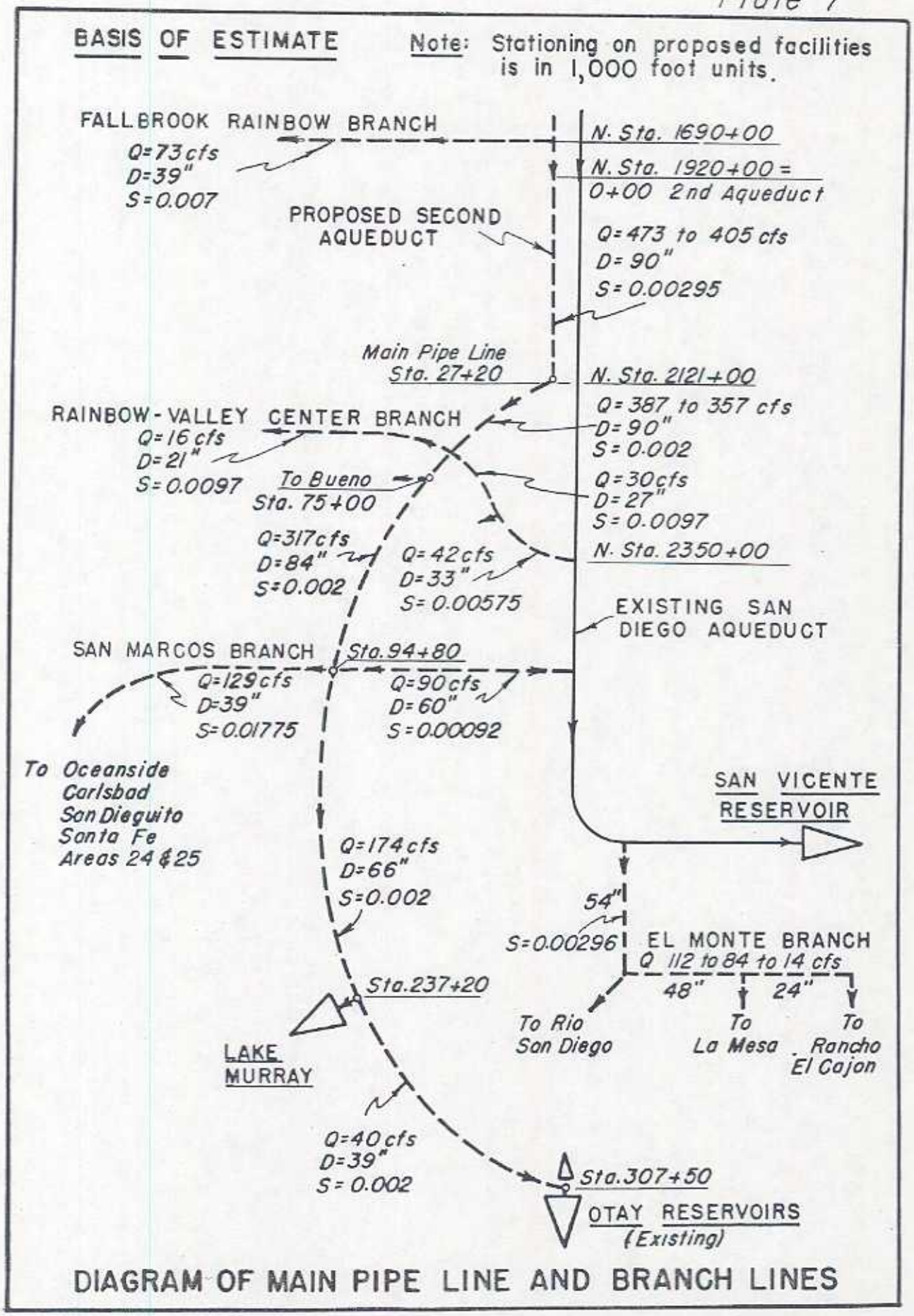
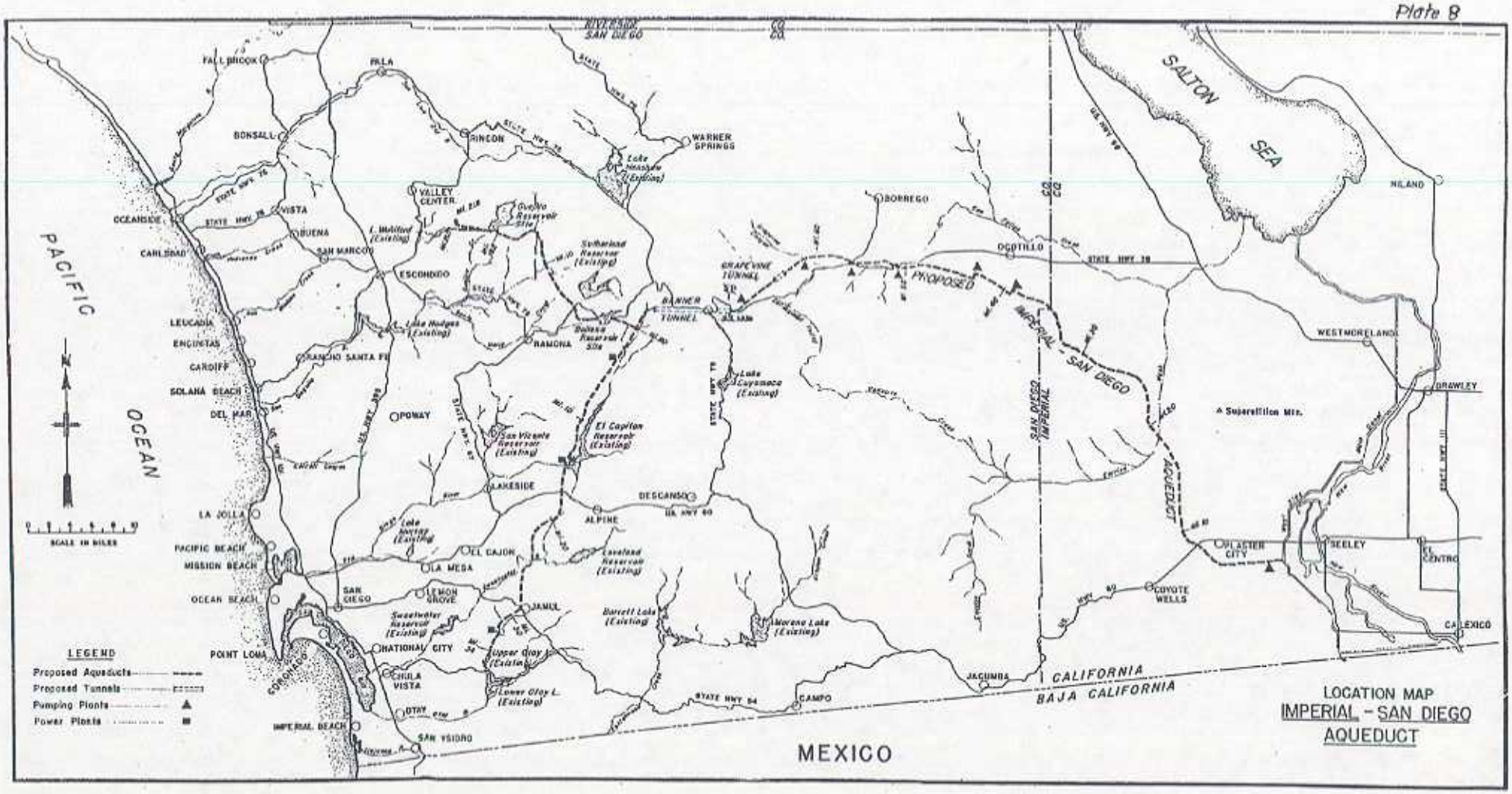
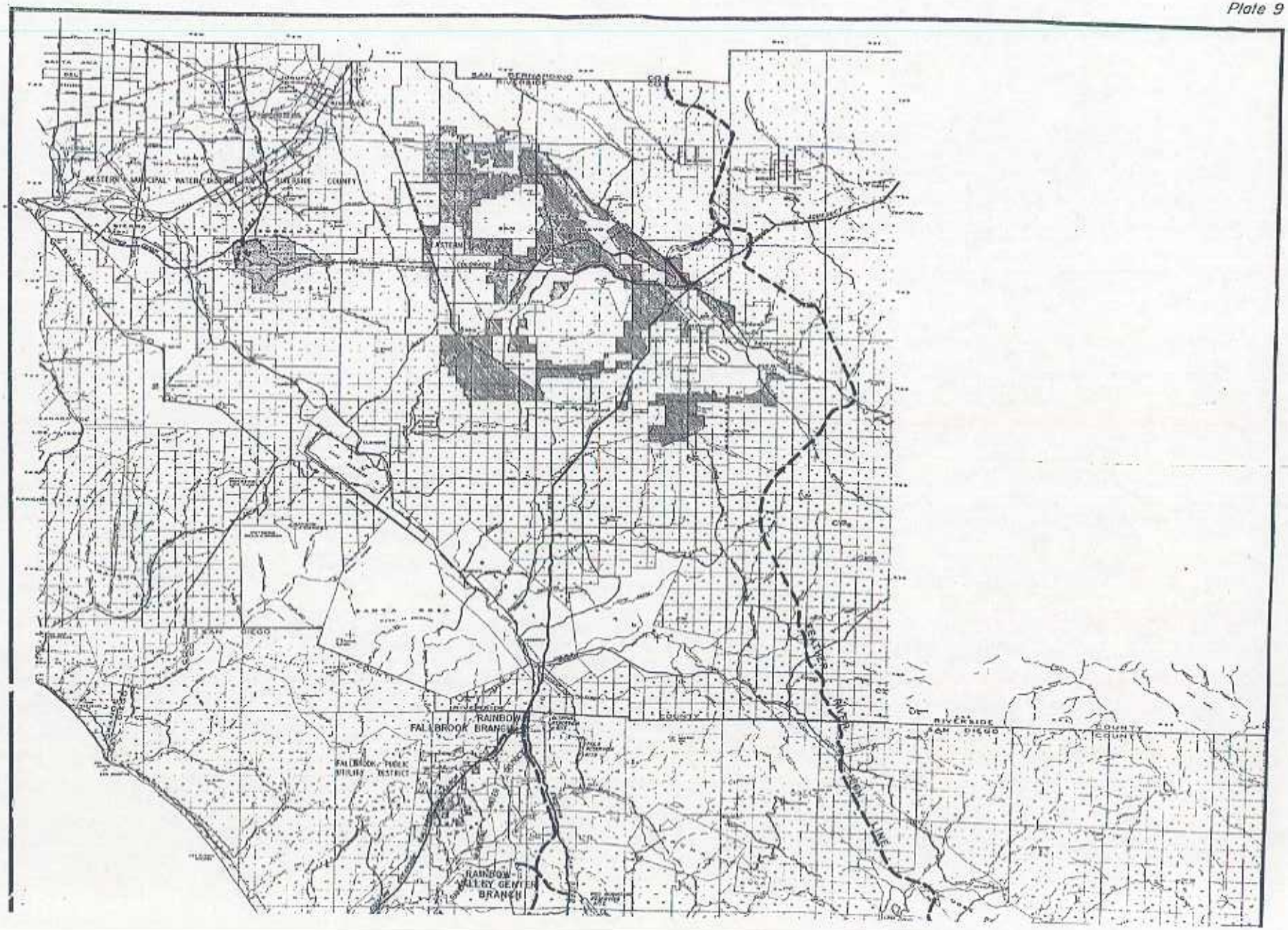


DIAGRAM OF MAIN PIPE LINE AND BRANCH LINES

Plate 8



LOCATION MAP
IMPERIAL - SAN DIEGO
AQUEDUCT


RAINBOW
FALLBROOK BRANCH
RAINBOW
VALLEY CENTER
BRANCH
RIVERSIDE
SAN DIEGO
COUNTY
COUNTY

EXISTING & PROPOSED FACILITIES
SAN DIEGO COUNTY WATER AUTHORITY

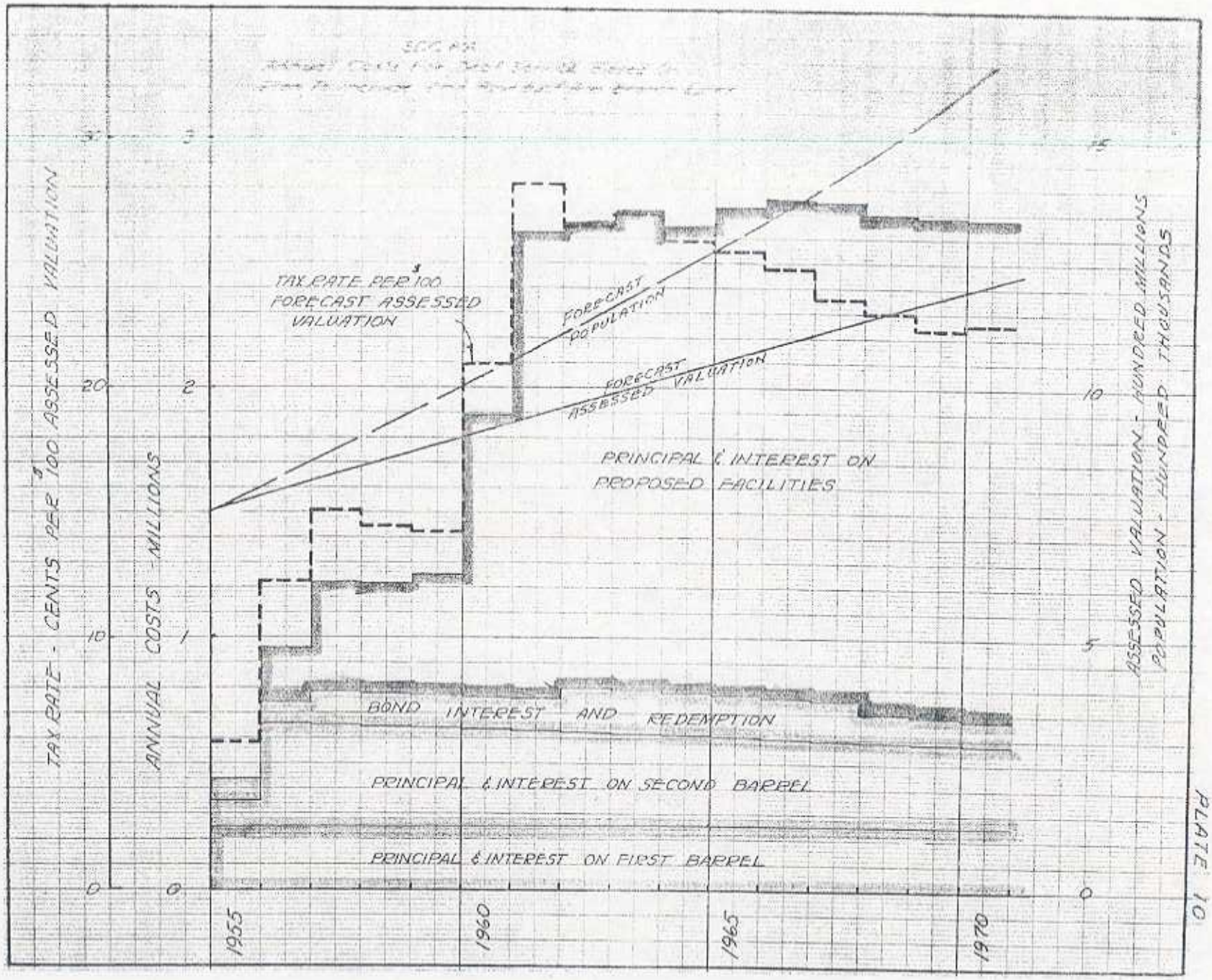

TAX RATE - CENTS PER $100 ASSESSED VALUATION
ANNUAL COSTS - MILLIONS
ASSESSED VALUATION - HUNDRED MILLIONS
POPULATION - HUNDRED THOUSANDS
TAX RATE PER $100
FORECAST ASSESSED VALUATION
FORECAST POPULATION
FORECAST ASSESSED VALUATION
PRINCIPAL & INTEREST ON PROPOSED FACILITIES
BOND INTEREST AND REDEMPTION
PRINCIPAL & INTEREST ON SECOND BARREL
PRINCIPAL & INTEREST ON FIRST BARREL
1955
1960
1965
1970

PLATE 10