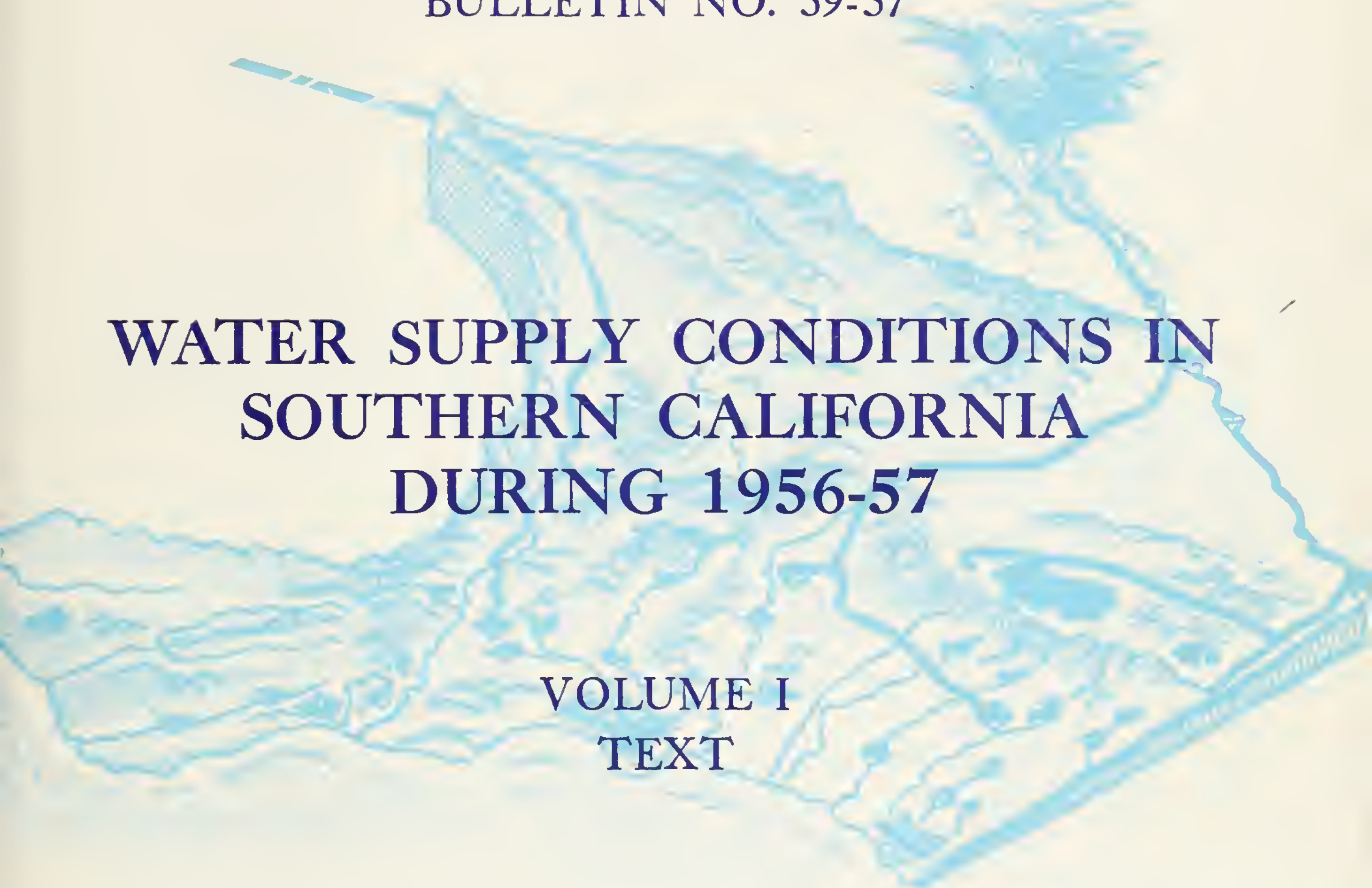
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

BULLETIN NO. 39-57



WATER SUPPLY CONDITIONS IN SOUTHERN CALIFORNIA DURING 1956-57

VOLUME I
TEXT

GOODWIN J. KNIGHT
Governor

HARVEY O. BANKS
Director of Water Resources

JUNE, 1958

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VOLUMES OF BULLETIN No. 39-57

Volume I—Text.

Volume II—Precipitation and Water Level Data, Central Coastal, and Los Angeles Regions.

Volume III—Precipitation and Water Level Data, Lahontan, Colorado River Basin, Santa Ana, and San Diego Regions.

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(The following appendixes are bound in Volume III)

(The following appendixes are bound in Volume IV)

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STATE OF CALIFORNIA
Department of Water Resources
SACRAMENTO

June 16, 1958

Honorable Goodwin J. Knight, Governor, and
Members of the Legislature of the
State of California

Gentlemen:

I have the honor to transmit herewith Bulletin No. 39-57, entitled "Water Supply Conditions in Southern California During 1956-57". This annual report is one of a series of bulletins on a continuing investigation of water problems in southern California. This investigation is being conducted pursuant to Chapter 832, Statutes of 1929.

During the Water Year 1956-57 (October, 1956, through September, 1957), there was a continuation of the drought which has prevailed in southern California since 1944, and which has been interrupted only by the above normal year of 1951-52. Precipitation in coastal southern California was generally on the order of 70 per cent of the mean, and the runoff of streams in this area dropped off to even a lower percentage, about 25 per cent of the mean.

On October 1, 1957, surface storage reservoirs in coastal southern California dependent on natural runoff were practically empty, containing only about 8 per cent of their total capacity. On the other hand, storage in Lake Mead on the Colorado River increased from 47 to 79 per cent of usable capacity during the 1956-57 water year. As a result of the drought, ground water levels have continued to decline throughout the southern California area establishing new historic low elevations in many instances. In the coastal portion of Los Angeles County, water levels were depressed to more than 70 to 80 feet below sea level, and in this basin, as well as several other coastal basins, sea-water intrusion continued unabated.

To offset the deficiency of local water supplies in coastal southern California, appreciable increases were made in imported supplies through the Los Angeles and Colorado River Aqueducts. These imports to the coastal areas of southern California totaled about 932,000 acre-feet, which is 22 per cent greater than the previous year. The increase in available Colorado River water was being made possible by an expedited construction program of The Metropolitan Water District of Southern California to augment the capacity of their facilities. A considerable portion of the imported water was being used for the purpose of recharging ground water basins.

In other areas in southern California, where imported supplies are not available or are limited and where ground water basins are small and have limited carry-over storage, problems of water supply were becoming very critical by the summer and fall of 1957.

Very truly yours,

HARVEY O. BANKS
Director

ACKNOWLEDGMENT

Contributions and assistance were rendered by many public and private agencies and individuals in the preparation of this report. The sources of data presented in Volumes II and III are noted therein.

Special mention is made of the cooperation received from the following:

City of San Bernardino

City of San Diego

Los Angeles County Flood Control District

Los Angeles Department of Water and Power

Orange County Flood Control District

Orange County Air and Water Pollution Control District

Riverside County Flood Control and Water Conservation District

San Bernardino County Flood Control District

The Metropolitan Water District of Southern California

United States Geological Survey

United States Weather Bureau

United Water Conservation District

Ventura County Flood Control District

State of California, Office of Controller, Division of Disbursements

Eleventh Naval District, Public Works Office

Without the cooperation of these agencies, including that of the Office of State Controller which was instrumental in the preparation of the machine processes used in presenting the basic data, this report would not be possible. The Department of Water Resources wishes to acknowledge the assistance of these agencies with thanks.

ORGANIZATION

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CHAPTER I. INTRODUCTION

This report is the twenty-sixth of a series begun in 1932 in recognition of the need for collecting and publishing basic hydrologic data for use in the continuing study of water problems in southern California. The report for this year has been expanded over previous publications to include data for the entire Southern California District area, the location of which is shown on Plate 1. Included for the first time is information concerning weather modification project operations, runoff to the ocean, disposal of sewage to the ocean, artificial recharge, and sea-water intrusion.

The drought, which commenced in 1944-45, continued unabated through the seasonal year 1956-57 and the months of November and December were among the driest for these months in southern California history. This protracted drought has been interrupted only by the wet year 1951-52. Seasonal unimpaired runoff in southern California streams was considerably below the mean for the 53-year period 1894-1947. Runoff in Arroyo Seco near Pasadena, for example, was 15.4 per cent of the long-time mean.

The below normal rainfall and runoff coupled with industrial and population growth continued to have an adverse impact on water supply conditions. For the most part, reservoir storage was near an all time low. Draft on ground water aquifers continued to be in excess of recharge thereto with the result that ground water levels continued to drop, and in coastal areas, sea-water intrusion into fresh water aquifers continued. Supplemental water imported from the Owens Valley through the Los Angeles Aqueduct amounted to about 330,000 acre-feet, which is the present maximum practicable capacity of the facility. Delivery of water from the Colorado River through facilities of The Metropolitan Water District into southern California, as measured at Hayfield Pumping Station, increased approximately 172,000 acre-feet during 1956-57 season to a seasonal total of about 602,000 acre-feet.

In some cases, the availability of water supply was becoming critical by the summer and fall of 1957. This was particularly true in areas where no supplemental supply exists or where such supply is limited, as in the northern portion of San Diego County. In these areas, existing surface storage of natural runoff was nearly exhausted, the existing ground water basins are small, and the limited carry-over storage was nearly depleted. In the City of San Diego, an extensive and effective water conservation campaign was conducted during the dry months.

Authorization

The Legislature, by Chapter 832, Statutes of 1929, directed that exploration and investigation be conducted for the furtherance of a coordinated plan for the conservation, development, and utilization of the water resources of California. As a result of this legislation, the Division of Water Resources undertook a continuing hydrologic investigation of the southern California area. Initially, this included some investigation of the quality of irrigation waters; however, pursuant to Chapter 1552, Statutes of 1949, this work was expanded to include the study of pollution and degradation of waters of the State. Effective July 5, 1956, the responsibilities of the Division of Water Resources, Department of Public Works, except water rights, were assigned to the Department of Water Resources pursuant to Chapter 52, Statutes of 1956.

Prior Reports

Bulletin No. 39, entitled "Records of Ground Water Levels at Wells", was published in 1932 as a part of the investigation under Chapter 832. Since 1932, water levels at selected wells have been published annually in Bulletins 39-A through 39-W, the last of the lettered series reports, and Bulletin 39-56. Bulletin No. 39-56, the first of the numbered series followed Bulletin No. 39-W with no interruption in the continuity of data. Seasonal precipitation data from United States Weather Bureau records, as well as from records at stations not included in official publications of that agency, were first published in Bulletin No. 39-A and have been incorporated in all subsequent publications of the series.

Since 1930 many bulletins covering various aspects of the hydrology of the South Coastal Basin have been published by the Department of Water Resources and its predecessor, the Division of Water Resources. These bulletins include data on water use, ground water levels, quality of water, value and cost of water for irrigation, water losses and evaporation data, underground geology, and evaluation of overdraft on ground water basins in southern California. These bulletins include:

California State Department of Public Works, Division of Water Resources. "Santa Ana River Basin". Bulletin No. 31. 1930.

California State Department of Public Works, Division of Water Resources. "South Coastal Basin, A Symposium". Bulletin No. 32. 1930.

California State Department of Public Works, Division of Water Resources. "Rainfall Penetration and Consumptive Use of Water in Santa Ana River Valley and Coastal Plain". Bulletin No. 33. 1930.

California State Department of Public Works, Division of Water Resources. "South Coastal Basin Investigation, Quality of Irrigation Waters". Bulletin No. 40. 1933.

California State Department of Public Works, Division of Water Resources. "South Coastal Basin Investigation, Detailed Analyses Showing Quality of Irrigation Waters". Bulletin No. 40-A. 1933.

California State Department of Water Resources. "Quality of Surface and Ground Waters in Upper Santa Ana Valley". Bulletin No. 40-57. June, 1957.

California State Department of Public Works, Division of Water Resources. "South Coastal Basin Investigation, Value and Cost of Water for Irrigation in Coastal Plain of Southern California". Bulletin No. 43. 1933.

California State Department of Public Works, Division of Water Resources. "South Coastal Basin Investigation, Water Losses Under Natural Conditions from Wet Areas in Southern California". Bulletin No. 44. 1933.

California State Department of Public Works, Division of Water Resources. "South Coastal Basin Investigation, Geology and Ground Water Storage Capacity of Valley Fill". Bulletin No. 45. 1934.

California State Department of Public Works, Division of Water Resources. "South Coastal Basin Investigation, Overdraft on Ground Water Basins". Bulletin No. 53. 1947.

California State Department of Public Works, Division of Water Resources. "Report to the Assembly of the State Legislature on Water Supply of Antelope Valley in Los Angeles and Kern Counties". May, 1947.

California State Department of Public Works, Division of Water Resources. "Southern California Area Investigation, Memorandum Report on Water Conditions in Antelope Valley in Kern, Los Angeles and San Bernardino Counties". February, 1955.

California State Department of Water Resources, Division of Resources Planning. "Sea-Water Intrusion in California". Bulletin No. 63. August, 1958.

Scope of Report

The early reports of the Bulletin No. 39 series were limited to publication of records of ground water levels in the Santa Ana, San Gabriel, and Los Angeles River Valleys, and the West and South Coastal Plains. Subsequently, precipitation records were added and the area covered by the report was extended to include the San Jacinto and Antelope Valleys. A general water supply summary for the southern portion of the State was added in 1948. The summary contained information on precipitation, runoff, surface reservoir storage, importations, water quality, and changes in ground water levels.

To enable more rapid dissemination of data, the period encompassed in the reports was changed from the calendar year to the water year in 1956. Beginning with this bulletin the area encompassed by the report has been expanded to include the entire Southern California District as delineated on Plate 1. In addition, discussions of sea-water intrusion, weather modification operations, outflow to the ocean, and sewage discharge to the ocean have been included to provide a more complete description of water supply conditions.

The expansion of this report has been made possible by the use of machine data handling procedures developed with the assistance of the Disbursing Division of the State Controller's office. In connection with this procedure, the well numbering system has been modified to the use of the State Well Number for all water level data. To assist agencies utilizing other numbering systems in the use of these data, cross indexes have been prepared and are presented in Volume IV.

This first part of Bulletin No. 39-57, Volume I, contains a summary of water supply conditions in southern California during 1956-57. In addition to this introductory chapter, Chapter II, entitled "Surface Water Supply", contains a discussion of precipitation and weather modification operations in each of the regions in the Southern California District, together with information concerning runoff, discharge to the ocean, storage in surface reservoirs, imported supplies, and sewage discharged to saline waters. Chapter III, entitled "Ground Water Supply Conditions", contains a discussion of artificial recharge activities, and information concerning ground water elevations including average changes during the 1956-57 season. Chapter IV presents a brief discussion of the quality of surface and ground waters and the latest information concerning sea-water intrusion into aquifers of coastal southern California, while Chapter V presents a brief discussion of construction activities during the period encompassed by this report.

In Volume II, there are presented Appendixes A through C, including precipitation records for that portion of the Central Coastal Region in the Southern California District and for the Los Angeles Region, in addition to all available records of ground water levels in these regions. In Volume III, there are presented Appendixes D through H, including similar data for the Lahontan Region within the Southern California District, the Colorado River Basin, Santa Ana and San Diego Regions. In Volume IV, there are presented Appendixes I through Q, which include cross indexes between the State well numbering system and the various local numbering systems in common use in southern California, together with a cross index between the location designation of precipitation stations and the numbering system formerly used in the Bulletin 39 series.

Numbering System Designations

In the paragraphs which follow, there are presented descriptions of the various numbering and coding systems utilized in this report. These systems were required in order to facilitate utilization of machine data processing.

Region and Basin Designation

The region and basin numbering system used in this report generally follows that presented in Water Quality Report No. 3, entitled "Ground Water Basins in California", by the Department of Public Works, Division of Water Resources, dated November, 1952. The region areas used herein are geographic areas and are defined in Section 13040 of the Water Code. Of the nine regions defined, portions of Central Coastal Region No. 3 and Lahontan Region No. 6, and all of Los Angeles Region No. 4, Colorado River Basin Region No. 7, Santa Ana Region No. 8, and San Diego Region No. 9 are in the Southern California District. The location of these regions within the District are delineated on Plates 6 through 11.

With respect to the basin numbering code, a decimal numbering system of the form X-XX.XX has been used. The number to the left of the dash refers to the geographic region described above. The digits to the left of the decimal refer to a hydrologic unit which is generally designated a valley or group in this report. The digits to the right of the decimal refer to the individual basin within the valley or group. The locations of the various valleys or groups, and the individual basins are delineated on Plates 6 through 11.

Precipitation Station Designation

The precipitation station designation used herein is based on the longitude and latitude of the station to the nearest second. This designation gives the actual location of the station to about the nearest 100 feet.

Well Numbering System

The well numbering system employed herein is that originated by the United States Geological Survey and is referenced to the township, range, and section subdivision of the Federal Land Survey. It conforms to that used in all ground water investigations made by the U. S. Geological Survey in California and has been adopted by the Department of Water Resources.

Under the system each section is divided into 40-acre plots called lots, which are lettered as follows:

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

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Wells are numbered within each of these lots according to the sequence in which they have been assigned State Well Numbers. For example, a well which has the number 10N/18E-26A1,S would be in Township 10 North, Range 18 East, Section 26, S. B. B. & M., and would be further located as the first well assigned a State Well Number in Lot A. In this report, well numbers are referenced either to the San Bernardino Base and Meridian (S) or the Mount Diablo Base and Meridian (M).

For some wells, the letter following the section number is designated "X". This indicates that the well has been field located and accurately plotted with respect to its position on the map, but that the map control for the Public Land Survey at present is too poor to warrant assignment of more accurate location number.

CHAPTER II. SURFACE WATER SUPPLY

Precipitation

Precipitation in southern California during the seasonal year 1956-57 was generally subnormal for the twelfth year since 1943-44. The protracted drought has been interrupted only by the wet year 1951-52. The precipitation varied from about 30 per cent of the mean for the 50-year period 1897-1947 in the eastern Colorado Desert to about 95 per cent of the mean in Owens Valley. Precipitation in coastal southern California was generally on the order of 70 per cent of the mean. The general distribution of precipitation in per cent of the mean for the season may be seen from an inspection of Plate 2. Seasonal and mean precipitation for selected stations in southern California during 1956-57 are shown in Table 1. To indicate the historic trend in the water supply from this source, the seasonal precipitation and accumulated deviation from the mean in per cent for four stations are delineated on Plate 3.

TABLE 1

SEASONAL AND MEAN PRECIPITATION AT SELECTED STATIONS IN SOUTHERN CALIFORNIA

Station	County	50-year mean, 1897-1947, in inches	1956-57 season: In inches	1956-57 season: In per cent of mean
San Luis Obispo	San Luis Obispo	21.68	15.98	74
Paso Robles	San Luis Obispo	15.82	10.92	69
Santa Maria	Santa Barbara	14.35	8.97	63
Santa Barbara	Santa Barbara	18.56	13.86	75
Ventura	Ventura	15.59	9.13	59
Los Angeles	Los Angeles	14.81	9.54	64
Pomona	Los Angeles	18.21	11.56	63
Santa Ana	Orange	14.16	8.38	59
San Bernardino	San Bernardino	14.11	12.39	88
Barstow	San Bernardino	4.17	3.90	94
Blythe	Riverside	4.03	1.36	34
Brawley	Imperial	2.40	0.65	27
San Diego	San Diego	10.36	8.89	86

Prior to January 1, 1957, southern California had received only about 14 per cent of its normal rainfall and had experienced one of the driest November-December periods of record. An indication of this condition may be seen from an inspection of Table 2, which presents cumulative monthly rainfall for the 1956-57 season at Los Angeles and San Diego in relation to the cumulative mean. This dry period, coupled with severe "Santa Ana Conditions", created a serious potential fire hazard. A major fire in the Cleveland National Forest north of Descanso in San Diego County burned 44,000 acres, and a five-day fire in the coastal portion of the Santa Monica Mountains of Los Angeles and Ventura Counties burned over 40,000 acres and destroyed 67 homes. Large burns also occurred in San Bernardino County.

TABLE 2

CUMULATIVE MONTHLY PRECIPITATION
AT LOS ANGELES AND SAN DIEGO
1956-57

Month	Cumulative monthly precipitation at Los Angeles			Cumulative monthly precipitation at San Diego		
	50-year mean, 1897-1947, in inches	1956-57 season		50-year mean, 1897-1947, in inches	1956-57 season	
		In inches	In per cent of mean		In inches	In per cent of mean
July	0.01	0	0	0.03	T	0
August	0.03	T	0	0.09	T	0
September	0.31	T	0	0.23	T	0
October	0.90	0.12	13	0.79	0.68	86
November	1.96	0.12	6	1.61	0.68	42
December	4.46	0.46	10	3.59	0.86	24
January	7.41	4.87	66	5.51	5.66	103
February	10.78	6.34	59	7.67	6.16	80
March	13.45	7.36	55	9.32	6.91	74
April	14.40	8.83	61	10.05	7.75	77
May	14.74	9.46	64	10.32	8.63	84
June	14.81	9.54	64	10.36	8.89	86

In the paragraphs which follow there is presented somewhat more detailed information concerning precipitation in each of the regions in the Southern California District, together with a discussion of weather modification operations.

Central Coastal Region No. 3
Santa Barbara and San Luis Obispo Counties

Precipitation in the Central Coastal Region varied from a minimum average of about 64 per cent of the mean for the 50-year period 1897-1947 in the San Antonio Creek Valley to a maximum average of about 83 per cent of the mean in the San Luis Obispo area. A summary of the average indexes of precipitation in the major valleys and basin groups of San Luis Obispo and Santa Barbara Counties is presented in Table 3. Measured seasonal precipitation at San Luis Obispo was 15.98 inches, which is about 74 per cent of the long-time mean, while precipitation at Santa Barbara was about 13.86 inches, or 75 per cent of the mean.

TABLE 3

AVERAGE INDEX OF PRECIPITATION FOR 1956-57 SEASON
FOR VALLEYS IN CENTRAL COASTAL REGION NO. 3

Valley	Number of stations	Average index
Salinas Valley (3-4.00)	8	71
San Luis Obispo Group (3-8.00)	2	83
Arroyo Grande Group (3-11.00)	2	76
Santa Maria River Valley (3-12.00)	5	68
Cuyama River Valley (3-13.00)	2	80
San Antonio Creek Valley (3-14.00)	2	64
Santa Ynez River Valley (3-15.00)	6	70
South Coast Basins, Santa Barbara County (3-16.00)	3	70
Carrizo Plain (3-19.00)	4	70

Weather modification operations were conducted, using silver iodide, throughout the County of Santa Barbara during the period January 1 through April 30, 1957. Generation time amounted to about 1,160 hours. Seeding for the South Coast Basins of Santa Barbara was done as a part of a controlled experiment to determine the effectiveness of artificial nucleation. During the four-month period, there were approximately 25 seeding opportunities, of which 13 opportunities were seeded. Comparison between seeded and nonseeded storms suggest some increase in precipitation through the seeding program. However, additional study will be required before results can be considered conclusive.

Los Angeles Region No. 4

Average precipitation indexes as indicated by the data presented in Table 4 show that the total seasonal precipitation for this region was generally below the mean for the 50-year period 1897-1947. Precipitation in the Coastal Plain of Los Angeles County was about 68 per cent of mean, while in the Santa Clara River Valley in Ventura County it was about 77 per cent of mean. Total measured seasonal precipitation at the United States Weather Bureau Station in Los Angeles was 9.54 inches, or about 64 per cent of the mean. Snowfall in the San Gabriel Mountains was of little significance in the over-all water supply picture.

TABLE 4

AVERAGE INDEX OF PRECIPITATION FOR 1956-57 SEASON
FOR VALLEYS IN LOS ANGELES REGION NO. 4

Valley	Number of stations	Average index
Upper Ojai Valley (4-1.00)	3	70
Ojai Valley (4-2.00)	1	67
Ventura River Valley (4-3.00)	7	67
Santa Clara River Valley (4-4.00)	24	77
Acton Valley (4-5.00)	4	69
Pleasant Valley (4-6.00)	4	73
Arroyo Santa Rosa Valley (4-7.00)	1	86
Las Posas Valley (4-8.00)	6	82
Simi Valley (4-9.00)	2	76
Conejo Valley (4-10.00)	1	71
Coastal Plain, Los Angeles County (4-11.00)	63	68
San Fernando Valley (4-12.00)	32	74
San Gabriel Valley (4-13.00)	72	72
Upper Santa Ana Valley, Los Angeles County (4-14.00)	7	73
Malibu Coastal Group (4-16.00)	3	73

There was no program of weather modification designed primarily for areas in Region No. 4 during the 1956-57 season. However, silver iodide generators were installed and operated in portions of coastal Los Angeles County as a part of a program conducted for the Santa Ana watershed.

Lahontan Region No. 6

Average precipitation indexes as presented in Table 5 indicate the precipitation during the 1956-57 season was about 78 per cent of the mean for the 50-year period 1897-1947 in Antelope Valley, 57 per cent of the mean in the Mono Valley, and 95 per cent of the mean in the Owens Valley. Seasonal precipitation in the remaining portions of the Lahontan Region south of the Mono divide appears to have been below normal, but in many portions of the area data are very meager. Weather modification operations were conducted for the California Electric Power Company in the vicinity of the Bishop Creek watershed. Total operations amounted to about 38 generator hours, and occurred during the months of October through April.

TABLE 5

AVERAGE INDEX OF PRECIPITATION FOR 1956-57 SEASON
FOR VALLEYS IN LAHONTAN REGION NO. 6

Valley	Number of stations	Average index
Mono Valley (6-9.00)	2	57
Long Valley (6-11.00)	1	84
Owens Valley (6-12.00)	10	95
Deep Springs Valley (6-15.00)	1	80
Death Valley (6-18.00)	1	96
Riggs Valley (6-23.00)	1	92
Ivanpah Valley (6-30.00)	1	70
Lower Mojave River Valley (6-40.00)	1	60
Middle Mojave River Valley (6-41.00)	1	94
Upper Mojave River Valley (6-42.00)	2	61
Antelope Valley (6-44.00)	18	78
Fremont Valley (6-46.00)	1	78
Searles Valley (6-52.00)	1	46
Rose Valley (6-56.00)	1	77

Colorado River Basin Region No. 7

Precipitation indexes shown in Table 6 indicate the seasonal precipitation in the Colorado Desert area generally averaged less than 50 per cent of the mean for the 50-year period 1897-1947. It varied from a minimum average of about 27 per cent in the vicinity of the Salton Sea to a maximum of about 89 per cent in the San Felipe Valley. However, there is a paucity of data throughout much of the area. Measured precipitation was 1.36 inches at Blythe and 0.65 inch at Brawley, representing 34 per cent and 27 per cent of the mean, respectively. Weather modification operations totaling 963 generator hours using the iodine inpregnated rope method were conducted in Lanfair Valley from July 1, 1956, through April 19, 1957.

TABLE 6

AVERAGE INDEX OF PRECIPITATION FOR 1956-57 SEASON FOR VALLEYS IN COLORADO RIVER BASIN REGION NO. 7

Valley	Number of stations	Average index
Ward Valley (7-3.00)	1	31
Chuckawalla Valley (7-5.00)	1	28
Twentynine Palms Valley (7-10.00)	1	30
Lucerne Valley (7-19.00)	1	72
Morongo Valley (7-20.00)	3	69
Coachella Valley (7-21.00)	5	61
Borrego Valley (7-24.00)	1	49
Terwilliger Valley (7-26.00)	1	52
San Felipe Valley (7-27.00)	1	89
Vallecito-Carrizo Valley (7-28.00)	1	81
Coyote Wells Valley (7-29.00)	1	50
Imperial Valley (7-30.00)	4	27
Orcopia Valley (7-31.00)	1	40
East Salton Sea Valley (7-33.00)	1	30
Palo Verde Valley (7-38.00)	2	45
Calzona Valley (7-41.00)	1	30
Needles Valley (7-44.00)	1	39

Santa Ana Region No. 8

Precipitation indexes presented in Table 7 indicate the total seasonal precipitation in the Santa Ana Region during the 1956-57 season was below the mean for the 50-year period 1897-1947. In the Upper Santa Ana Valley precipitation averaged about 75 per cent of the mean, while on the Coastal Plain of Orange County the average was about 66 per cent of the mean. Measured seasonal precipitation at the United States Weather Bureau

Station in Santa Ana was 8.38 inches, or about 59 per cent of the mean. Very little water was stored in form of snowfall on the San Bernardino Mountains and runoff from this snow was of minor significance with respect to water supply.

TABLE 7

AVERAGE INDEX OF PRECIPITATION FOR 1956-57 SEASON
FOR VALLEYS IN SANTA ANA REGION NO. 8

Valley	Number of stations	Average index
Coastal Plain, Orange County (8-1.00)	35	66
Upper Santa Ana Valley (8-2.00)	44	75
Cajalco Valley (8-3.00)	1	88
Elsinore Valley (8-4.00)	1	64
San Jacinto Valley (8-5.00)	1	79
Bear Valley (8-9.00)	1	98

Weather modification operations were conducted in Upper Santa Ana Valley, Orange County, and parts of Los Angeles County during the period December 6, 1956, through May 15, 1957. Silver iodide generators were operated a total of 2,061 hours in this program.

San Diego Region No. 9

Precipitation indexes shown in Table 8 indicate that although below normal the precipitation for the 1956-57 season was generally closer to the 1897-1947 mean in this area than in the remainder of southern California. Indexes varied from an average of 66 per cent of the mean in the Warner Valley to 96 per cent of the mean in the Sweetwater Valley. At San Diego, measured seasonal precipitation totaled 8.89 inches, or about 86 per cent of the mean. Weather modification operations, using approximately 21 silver iodide generators, were scattered over the western portion of San Diego County. The period of seeding started January 1, 1957, and continued through April 22, 1957.

TABLE 8

AVERAGE INDEX OF PRECIPITATION FOR 1956-57 SEASON
FOR VALLEYS IN SAN DIEGO REGION NO. 9

Valley	Number of stations	Average index
San Juan Valley (9-1.00)	3	75
Santa Margarita Valley (9-4.00)	6	74
Coahuila Valley (9-6.00)	1	79
San Luis Rey Valley (9-7.00)	4	84
Warner Valley (9-8.00)	3	66
San Pasqual Valley (9-10.00)	2	82
Santa Maria Valley (9-11.00)	1	74
Poway Valley (9-13.00)	1	81
Mission Valley (9-14.00)	4	93
San Diego River Valley (9-15.00)	3	76
Sweetwater Valley (9-17.00)	4	96
Otay Valley (9-18.00)	1	92
Tia Juana Valley (9-19.00)	2	84
Jamul Valley (9-20.00)	1	87

Runoff

Mountain Runoff

Runoff in southern California streams during the 1956-57 water year was generally far below the mean for the 53-year period 1894-95 through 1946-47. For example, the estimated seasonal natural runoff at Arroyo Seco near Pasadena was only 16 per cent of the 53-year mean. Similar values for the Santa Ana River near Mentone, Sespe Creek near Fillmore, and Huasna River near Santa Maria were 37 per cent, 25 per cent, and 3 per cent of the mean, respectively. Estimated seasonal natural flows for selected stations in southern California are presented on Plate 4, together with the accumulated deviation from the mean runoff. This low runoff reflected not only the subnormal precipitation, which occurred during the past year, but also the combined effect of several years of drought. In contrast, runoff in the Colorado River as measured at Lees Ferry was considerably in excess of normal. This runoff was in response to generally above-normal precipitation in the watersheds of this river.

Estimated seasonal natural runoff for selected stations representative of conditions in southern California during the 1956-57 season is presented in Table 9, together with a comparison of estimated or measured mean, maximum and minimum runoff for each station for the 53-year period.

ESTIMATED 1956-57 SEASONAL NATURAL RUNOFF AT SELECTED STATIONS IN SOUTHERN CALIFORNIA

In Acre-Feet

Station	Period of record	1956-57	53-Year mean[a]	Maximum[b] Season	Maximum[b] Quantity	Minimum[b] Season	Minimum[b] Quantity
Central Coastal Region							
Arroyo Grande at Arroyo Grande	1939 to date	3,320[c]	23,900	1906-07	76,200	1930-31	800
Huasna River near Santa Maria	1929 to date	680	20,600	1906-07	74,400	1928-29	0[d]
Los Angeles Region							
Sespe Creek near Fillmore	1911 to 1913 1927 to date	23,540	93,900	1940-41	376,000	1950-51	3,520
Arroyo Seco near Pasadena	1910 to date	1,170	7,300	1921-22	25,400	1898-99	160
Santa Anita Creek near Sierra Madre	1916 to date	1,570	4,920	1921-22 1942-43	16,600	1898-99	210
San Gabriel River near Azusa	1894 to date	37,250	122,000	1921-22	410,000	1898-99	9,620
Lahontan Region							
Owens River near Round Valley	1903-23 1927-40 1941 to date	143,040	164,800	1906-07	279,000	1930-31	75,900
Rock Creek near Valyermo	1923-27 1938 to date	4,420	15,000	1921-22	39,000	1950-51	1,380
Deep Creek near Hesperia	1904-22 1929 to date	20,450	47,200[e]	1921-22	177,000[f]	1950-51	4,340[f]
Colorado River Basin Region							
Colorado River at Lees Ferry	1895 to date	17,330,000[c]	13,881,000[c]	1916-17	21,860,000[cf]	1933-34	4,377,000[cf]
Colorado River at Hoover Dam	1933 to date	8,050,600[c]	11,171,000[cg]	1941-42	17,880,000[cf]	1933-34	5,058,000[cf]
Colorado River at Yuma	1878 to date	1,380,000[ch]	5,592,000[cg]	1908-09	26,070,000[cf]	1955-56	894,000[cf]
Palm Canyon Creek near Palm Springs	1930-41 1947 to date	9	4,840[e]	1936-37	18,980[f]	1955-56	0.2[f]

ESTIMATED 1956-57 SEASONAL NATURAL RUNOFF AT
SELECTED STATIONS IN SOUTHERN CALIFORNIA
(continued)

In Acre-Feet

Station	Period of record	1956-57	53-Year mean[a]	Maximum[b]		Minimum[b]	
				Season	Quantity	Season	Quantity
Santa Ana Region							
Cucamonga Creek near Upland	1928 to date	1,840	6,190	1921-22	20,900	1898-99	930
Santa Ana River near Mentone	1896 to date	26,158	70,600	1915-16	280,000	1950-51	13,090
San Diego Region							
Murrieta Creek at Temecula	1930 to date	997	8,670	1915-16	60,300	1933-34	420
Santa Ysabel Creek at Sutherland Dam[i]	1912 to 1928 1936 to date	940	15,200	1915-16	95,200	1954-55	700
Cottonwood Creek at Morena Dam	1911 to date	265	12,400	1915-16	75,300	1955-56	130

a. Mean for period 1894-95 through 1946-47, except as noted.
b. Indicated maxima and minima are recorded or estimated values for period 1894-95 to date, except as noted.
c. Measured runoff, unadjusted for upstream developments.
d. Years of no flow also included 1895-96, 1897-1900, 1901-02, 1918-19, 1920-21, and 1922-25.
e. Average for period 1920-21 through 1949-50.
f. Indicated maxima and minima are recorded or estimated values for given period of record.
g. Average for period 1936-37 through 1955-56.
h. Includes discharges from Yuma Main Canal Wasteway and California Drainage Canal.
i. Replaces station located near Mesa Grande which period of record is 1912-13 through 1927-28.

Runoff to the Ocean

Runoff to the ocean from a number of the streams in southern California is shown in Table 10. During the 1956-57 season, an estimated total of about 102,700 acre-feet was discharged to the ocean from 18 streams. This quantity represents nearly all such loss, most of which is storm runoff from coastal urban areas, not economically susceptible to capture. For example, an estimated 48,710 acre-feet was discharged by the Los Angeles River and 27,440 acre-feet was discharged by Ballona Creek, both of which drain highly urbanized areas of coastal Los Angeles County.

TABLE 10

DISCHARGE TO THE OCEAN DURING 1956-57
FROM SELECTED STREAMS IN SOUTHERN CALIFORNIA

Stream	Discharge, in acre-feet
Central Coastal Region	
Santa Maria River	0
Santa Ynez River	110[a]
Los Angeles Region	
Ventura River	1,720[a]
Santa Clara River	5,620
Ballona Creek	27,440
Dominguez Channel	11,440
Los Angeles River	48,710
Los Cerritos Channel	2,920
San Gabriel River	900
Coyote Creek	1,200
Santa Ana Region	
Santa Ana River	370[a]
Santa Ana Delhi Drain	950
Peters Canyon Drain	230
San Diego Region	
Aliso Creek	1
Trabuco Creek	120
San Juan Creek	960[a]
Santa Margarita River	0
San Luis Rey River	0
TOTAL	102,691

a. Preliminary-subject to revision

Storage in Surface Reservoirs

In general, the quantity of water in storage in southern California reservoirs at the end of the 1956-57 season continued to be very small, reflecting the protracted period of subnormal runoff. On October 1, 1957, nearly all reservoirs of more than 10,000 acre-foot capacity, except those receiving imported supplies, were at less than 20 per cent of capacity. Exceptions are the Gibraltar Reservoir on the Santa Ynez River which was filled to 68 per cent of capacity, and Morris Reservoir on the San Gabriel River which was filled to 63 per cent of capacity, both reservoirs having stored a substantial portion of these waters in previous years. This may be seen from an inspection of Table 11, which shows capacity and storage on October 1, 1956, and 1957, and per cent of capacity for all major reservoirs in the Southern California District.

TABLE 11

WATER IN STORAGE IN SELECTED SURFACE RESERVOIRS
IN, OR SUPPLYING WATER TO, SOUTHERN CALIFORNIA
ON OCTOBER 1, 1956 AND OCTOBER 1, 1957

Watershed	Reservoir	Capacity, in acre-feet	Water in storage, in acre-feet		Storage, in per cent of capacity	
			October 1, 1956	October 1, 1957	October 1, 1956	October 1, 1957
Central Coastal Region						
Santa Ynez River	Gibraltar	15,600	12,300	10,600	79	68
Santa Ynez River	Cachuma	206,500	36,630	30,150	18	15
Los Angeles Region						
Piru Creek	Lake Piru	100,000	2,000	800	2	1
Bouquet Creek	Bouquet Canyon	36,500	33,070[a]	32,460[a]	90	89
San Gabriel River	Morris	35,170	24,300	22,150	69	63
Lahontan Region						
Rush Creek	Grant Lake	47,530	47,090[a]	45,680[a]	99	96
Owens River	Long Valley (Lake Crowley)	183,470	183,470[a]	162,670[a]	100	89
	Pleasant Valley	3,820	720[a]	2,960[a]	19	77
	Tinemaha	16,410	6,700[a]	8,830[a]	41	54
Rose Valley	Haiwee (South)	58,530	38,200[a]	25,950[a]	65	44
Antelope Valley	Fairmont	7,500	6,880[a]	6,720[a]	92	90
Colorado River Basin Region						
Colorado River	Lake Mead	27,207,000	12,791,000	21,522,000	47	79
	Lake Mohave	1,810,000	1,263,000	1,429,000	70	79
	Lake Havasu	688,000	625,000	617,000	91	90
Santa Ana Region						
Bear Creek	Bear Valley	72,170	2,840	1,950	4	3
San Jacinto River	Lake Hemet	13,400	280	320	2	2
	Railroad Canyon	14,700	400[c]	1,480[c]	3	10
Cajalco Creek	Lake Mathews	100,000	59,840[b]	76,090[b]	60	76
Santiago Creek	Santiago	25,000	2,830[b]	3,780[b]	11	15

WATER IN STORAGE IN SELECTED SURFACE RESERVOIRS
IN, OR SUPPLYING WATER TO, SOUTHERN CALIFORNIA
ON OCTOBER 1, 1956 AND OCTOBER 1, 1957
(continued)

Watershed	Reservoir	Capacity, in acre-feet	Water in storage, in acre-feet		Storage, in per cent of capacity	
			October 1, 1956	October 1, 1957	October 1, 1956	October 1, 1957
San Diego Region						
Temecula Creek	Vail	49,500	790	550	2	1
San Luis Rey River	Lake Henshaw	194,320	1,140	1,120	0.6	0.6
Santa Isabella Creek	Sutherland	29,680	1,860	1,440	6	5
Escondido Creek	San Dieguito Lake	1,130	890[c]	920	79	81
San Dieguito River	Lake Hodges	33,550	2,640[c]	3,460[c]	8	10
San Vicente Creek	San Vicente Lake	90,230	36,840[c]	43,480[c]	41	48
Boulder Creek	Cuyamaca	11,600	0	0	0	0
San Diego River	El Capitan Lake	112,810	6,680	2,550	6	2
Chapparal Canyon	Murray Lake	5,740	3,850[c]	4,890[c]	67	85
Sweetwater River	Lake Loveland	25,390	1,550	1,660	6	7
Sweetwater River	Sweetwater	27,690	5,880[c]	4,440[c]	21	16
Cottonwood Creek	Morena Lake	50,210	530	480	1	1
	Barrett Lake	44,760	870	780	2	2
Proctor Valley Creek	Upper Otay Lake	2,790	320	270	11	10
Otay River	Lower Otay Lake	56,520	5,030	3,490	9	6

a. Storage in reservoirs in the Los Angeles Aqueduct System.
b. Includes imported Colorado River water via Colorado River Aqueduct.
c. Includes imported Colorado River water via Colorado River Aqueduct and San Diego Aqueduct.

In eleven City of San Diego reservoirs, storage on October 1, 1957, was about 14.5 per cent of capacity as compared to 14.0 per cent of capacity on October 1, 1956. However, a considerable portion of this storage was maintained by deliveries of Colorado River water to San Vicente and Hodges Reservoirs through the San Diego Aqueduct. Storage in Lake Hemet on October 1, 1957, was 2.4 per cent of capacity as compared to 2.1 per cent one year previous. Storage in Bear Valley Reservoir for the 1956-57 season was 2.7 per cent of capacity as compared to 3.9 per cent one year previous. Lake Elsinore continued to be dry.

Total storage in four major reservoirs of the Los Angeles Department of Water and Power in the Owens Valley area decreased from 90 per cent of capacity on October 1, 1956, to 79 per cent of capacity on October 1, 1957. These reservoirs are generally used for regulation of flow through the Los Angeles Aqueduct.

While storage in coastal southern California generally continued to be meager, storage in Lake Mead increased 8,731,000 acre-feet, or 32 per cent during the 1956-57 water year. Storage on October 1, 1957, was 132 per cent of the 10-year mean 1947-57. The water surface elevation of the Salton Sea was 234.75 feet below sea level on September 30, 1957, reflecting a decrease in elevation of 0.20 foot during the year.

Importations and Diversions

During the 1956-57 water year, the combination of continued drought, increased population, and depletion of ground water supplies resulted in a continued increase in the use of the imported water supply, particularly in coastal southern California. Imports to coastal southern

California through the combined facilities of The Metropolitan Water District and the City of Los Angeles aqueducts totaled about 932,000 acre-feet, of which 602,000 acre-feet were measured at the Hayfield Pumping Plant on the Colorado River Aqueduct. This total import represents an increase of about 167,000 acre-feet, or about 22 per cent over that imported the year previous. A graphic illustration of the historic increase in the importation of supplemental water into the coastal area of southern California by the Los Angeles Aqueduct and Colorado River Aqueduct is presented on Plate 5.

A total of 330,000 acre-feet of supplemental water, as estimated flow from Fairmont Reservoir, was imported from the Owens River-Mono Basin area into the Los Angeles area through the aqueduct of the Department of Water and Power. This import represented approximately 68 per cent of the total water used by the City during the year and except for short periods of shutdown for routine maintenance and inspection, the Los Angeles Aqueduct was operated at capacity.

Total diversion of water from the Colorado River by all entities of this State during the 1956-57 season was about two per cent greater than that diverted during the previous season. Diversions by The Metropolitan Water District of Southern California increased by over 36 per cent, while diversions by the Palo Verde and Imperial Irrigation Districts remained nearly constant, and imports to the Coachella Valley County Water District decreased by about nine per cent. The quantities of the principal diversions to California for the 1955-56 and 1956-57 water years are presented in Table 12.

TABLE 12

QUANTITY AND PER CENT CHANGE IN AMOUNT OF WATER DIVERTED FROM THE COLORADO RIVER FOR USE IN CALIFORNIA DURING 1955-56 AND 1956-57

Diverted by	Diversion, in acre-feet		Per cent
	1955-56	1956-57	change
The Metropolitan Water District of Southern California	440,460	600,880	+ 36.4
Palo Verde Irrigation District	376,160	374,920	- 0.3
Imperial Irrigation District	2,982,680	2,968,790	- 0.5
Coachella Valley County Water District	574,210	524,490	- 8.7
Yuma Project (Reservation Division)	15,920	21,780	+ 36.8
TOTALS	4,389,430	4,490,860	+ 2.3

Deliveries of water to member agencies by The Metropolitan Water District of Southern California increased about 31 per cent during the past water year. Deliveries to five southern California counties increased from 430,900 acre-feet during 1955-56 to 565,500 acre-feet during 1956-57. The difference between diversions shown in Table 12 and the deliveries is accounted for by increased storage in distribution reservoirs such as Lake Mathews and by unavoidable transmission losses. The import to San Diego County continued at the capacity of the existing San Diego Aqueduct. Deliveries to Orange County increased from 49,700 acre-feet during 1955-56 to 154,250 during 1956-57, or over 210 per cent. This increase was due primarily to completion of additional distribution facilities into the area.

Completion of a section of the Lower Feeder in the vicinity of Buena Park eased a serious water shortage condition which had existed in the area for several years. In addition, the completion of a section of the eastern portion of the Lower Feeder made available to the area sizable quantities of untreated water. As a result, 102,430 acre-feet of untreated water was purchased by Orange County Water District for ground water replenishment in the Santa Ana River spreading grounds. Deliveries of Colorado River water to the various coastal southern California counties are shown in Table 13.

TABLE 13

QUANTITY AND PER CENT CHANGE IN AMOUNT OF COLORADO RIVER WATER IMPORTED TO COUNTIES IN COASTAL SOUTHERN CALIFORNIA DURING 1955-56 AND 1956-57

Area	Seasonal import, in acre-feet: 1955-56	Seasonal import, in acre-feet: 1956-57	Per cent change
The Metropolitan Water District of Southern California:			
Los Angeles County	205,850	223,450	+ 8.5
San Diego County	142,050	144,400	+ 1.7
Orange County	49,700	154,250	+210.4
Riverside-San Bernardino Area	33,300	43,350	+ 30.2
TOTALS	430,900	565,450	+ 31.2

Sewage Discharge to Saline Waters

Approximately 621,500 acre-feet of sewage was discharged to the Pacific Ocean and tidal waters during fiscal year 1956-57 from seven outfalls. This represents an increase of about 7.8 per cent over total discharge in the year 1955-56. This may be seen from an inspection of Table 14, which shows the approximate sewage discharge through ocean outfalls for the period July through June for the years 1955-56 and 1956-57. This increase generally reflects increased water utilization in urban areas as a result of expanding population.

TABLE 14

SEWAGE DISCHARGED TO SALINE WATERS IN 1955-56 AND 1956-57
FROM MAJOR SEWERAGE SYSTEMS IN SOUTHERN CALIFORNIA

Station	Discharge, in acre-feet 1955-56	Discharge, in acre-feet 1956-57	Per cent change
City of Los Angeles	286,800	309,300	+ 7.8
County Sanitation Districts of Los Angeles County	202,800	214,600	+ 5.8
Orange County Sanitation Districts of Orange County	30,700	38,200	+24.4
City of San Diego	44,800	47,600	+ 6.3
City of Oxnard	3,690	4,040	+ 9.5
City of Ventura	2,580	2,580	0
City of Santa Barbara	5,000	5,210	+ 4.2
TOTALS	576,370	621,530	+ 7.8

CHAPTER III. GROUND WATER SUPPLY CONDITIONS

It has been indicated in Chapter II that the 1956-57 water year was one of subnormal water supply. There occurred a substantial increase in the quantity of Colorado River water imported into coastal southern California. Vigorous efforts have been made to conserve water by means of artificial recharge. In addition, "save water" campaigns have been initiated, particularly in San Diego County. Despite these efforts, ground water levels generally continued to decline, and in many areas, minimum elevations of record were established. Aspects of artificial recharge and ground water level changes during the 1956-57 season are discussed in this chapter.

Artificial Recharge

In an endeavor to provide additional conservation of local runoff and to augment dwindling ground water supplies, artificial replenishment of ground water basins is widely practiced in southern California. During the 1956-57 season, about 199,100 acre-feet of local and imported water was spread in 55 projects, of which 133,790 acre-feet, or 67 per cent, was imported water. In certain localized areas, this spread water had a marked effect in reducing the rate of ground water level decline.

The recorded and estimated amount of water spread at various artificial recharge projects in southern California during 1956-57 are presented in Table 15.

TABLE 15

SUMMARY OF PRINCIPAL ARTIFICIAL RECHARGE ACTIVITIES
IN SOUTHERN CALIFORNIA DURING 1956-57 WATER YEAR

Ground water valley or basin	Agency conducting spreading operation[a]	Number of projects operated	Reported or estimated amount spread, in acre-feet
Ojai Valley (4-2.00)	VCFCD	1	480
Santa Clara River Valley (4-4.00)			
Oxnard Plain Forebay Area (4-4.02)	UWCD	2	13,080
Piru Basin (4-4.06)	UWCD	1	3,650
Coastal Plain, Los Angeles County (4-11.00)			
West Coast Basin (4-11.02)	LACFCD	1	3,430[b]
Montebello Forebay Area (4-11.05)	LACFCD	3	35,510[c]
San Fernando Valley (4-12.00)			
San Fernando Basin (4-12.01)	LACFCD	3	530
	LADW&P	1	4,780
Tujunga Basin (4-12.05)	LACFCD	1	30
San Gabriel Valley (4-13.00)			
Main San Gabriel Basin (4-13.01)	LACFCD	4	1,010
	ESWC	1	3,460
Monk Hill Basin (4-13.02)	LACFCD	1	400
Pasadena Subarea (4-13.03)	LACFCD	1	0
Santa Anita Subarea (4-13.04)	LACFCD	1	2
	CSMWD	1	310
Upper Canyon Basin (4-13.05)	DMWC	1	6,440
	SGRSC	1	9,420
Glendora Basin (4-13.07)	GIC	1	10
	LACFCD	1	16
Upper Santa Ana Valley, Los Angeles County (4-14.00)			
Claremont Heights Basin (4-14.04)	PVPA	2	0
	CPWD	1	1,190
Coastal Plain, Orange County (8-1.00)			
Santa Ana Forebay Area (8-1.02)	OCWD	1	93,500[d]
	SAVIC	1	340
	AUWC	2	7,030[e]
	OCFCD	1	350
Yorba Linda Basin (8-1.05)	AUWC	1	1,350[f]
Santa Ana Narrows Basin (8-1.06)	AUWC	1	2,030[g]

SUMMARY OF PRINCIPAL ARTIFICIAL RECHARGE ACTIVITIES
IN SOUTHERN CALIFORNIA DURING 1956-57 WATER YEAR
(continued)

Ground water valley or basin	Agency conducting spreading operation[a]	Number of projects operated	Reported or estimated amount spread, in acre-feet
Upper Santa Ana Valley (8-2.00)			
Chino Basin (8-2.01)	SBCFCD	1	15
	EWC	2	310
Cucamonga Basin (8-2.03)	SAWC	1	1,500
	SBCFCD	1	7
Bunker Hill Basin (8-2.06)	SBVWCD	3	4,190
Lytle Basin (8-2.07)	FUWC	1	2,480
Devil Canyon Basin (8-2.10)	SBCFCD	1	1,760
Beaumont Basin (8-2.12)	RCFC&WCD	1	20
Bedford Basin (8-2.18)	TWC	3	260
Coldwater Basin (8-2.19)	TWC	1	40
Lee Lake Basin (8-2.20)	TWC	3	60
San Jacinto Valley (8-5.00)	RCFC&WCD	1	110
Total local and imported water reported spread			199,100
Total imported water reported spread			133,790
Total local water reported spread			65,310

a. Abbreviations of agencies conducting spreading operations are presented in alphabetical order: AUWC-Anaheim Union Water Company; CPWD-City of Pomona Water Department; CSMWD-City of Sierra Madre Water Department; DMWC-Duarte Mutual Water Company; ESWC-East Side Water Committee; EWC-Etiwanda Water Company; FUWC-Fontana Union Water Company; GIC-Glendora Irrigation Company; LACFCD-Los Angeles County Flood Control District; LADW&P-Los Angeles Department of Water and Power; OCFCD-Orange County Flood Control District; OCWD-Orange County Water District; PVPA-Pomona Valley Protective Association; RCFC&WCD-Riverside County Flood Control and Water Conservation District; SAWC-San Antonio Water Company; SBCFCD-San Bernardino County Flood Control District; SBVWCD-San Bernardino Valley Water Conservation District; SGRSC-San Gabriel River Spreading Corporation; SAVIC-Santa Ana Valley Irrigation Company; TWC-Temescal Water Company; UWCD-United Water Conservation District; VCFCD-Ventura County Flood Control District.

b. Total quantity is softened Colorado River water.

c. Includes about 27,930 acre-feet of unsoftened Colorado River water.

d. Total quantity is unsoftened Colorado River water.

e. Includes about 6,650 acre-feet of unsoftened Colorado River water.

f. Includes about 880 acre-feet of unsoftened Colorado River water.

g. Includes about 1,400 acre-feet of unsoftened Colorado River water.

Local Supplies

During water year 1956-57, about 65,310 acre-feet of local water was reported spread in southern California. Of this amount, about 16,730 acre-feet were spread in the Santa Clara River Valley by the United Water Conservation District, and 21,070 acre-feet were spread in the San Gabriel Valley, principally by the San Gabriel River Spreading Corporation and the Los Angeles County Flood Control District.

Imported Supplies

During the water year 1956-57, about 152,460 acre-feet of unsoftened and 3,430 acre-feet of softened Colorado River water were purchased for the purpose of spreading in southern California. Of this amount, about 102,430 acre-feet of unsoftened Colorado River water was bought by the Orange County Water District and spread in recharge projects in the Santa Ana Forebay Area. The Los Angeles County Flood Control District purchased with Zone I funds about 50,030 acre-feet of unsoftened Colorado River water, of which 27,930 acre-feet were reported spread in the Montebello Forebay Area. This water was released from Puddingstone Reservoir and conveyed through unlined Walnut Creek, a distance of about 13 miles to the San Gabriel River, thence to the spreading grounds in the Montebello Forebay. During the water year, approximately 3,430 acre-feet of softened Colorado River water was injected through recharge wells as part of the West Coast Basin Barrier Experiment.

Ground Water Conditions

There was a general decline in water level elevations in ground water basins throughout southern California during 1956-57, and in many areas, minimum elevations of record were established. This decline generally reflected the subnormal water crop of the 1956-57 season. The manifestation of this and the several previous dry years on the ground water level elevations of selected wells in southern California is shown by the hydrographs presented on Plates 12 and 13.

In some areas, the increased use of supplemental water effected some reduction in ground water extractions and a consequent reduction in the rate of ground water level decline. Reductions in rates of ground water level decline have also been obtained in these and other areas by the effective use of artificial recharge projects utilizing local and/or imported water. In spite of these and other actions to conserve water, the water requirements in many areas far exceed the sum of the imported and mean local supplies with the result that overdraft conditions continue to prevail of these areas. In many of the coastal basins with aquifers abutting the ocean the overdraft, combined with the drought, has caused levels to be drawn or remain below sea level resulting in sea-water intrusion.

Central Coastal Region No. 3

Ground water levels generally increased in elevation between the summer of 1956 and the summer of 1957 in ground water basins in San Luis Obispo County, and in those basins in Santa Barbara County located northerly of the drainage divide between the Santa Ynez River Valley and San Antonio Creek. An exception to this general condition is the Santa Maria River

Valley. In basins south of this divide, ground water levels generally declined.

Observed ground water level elevations were generally above sea level in all areas except the South Coast Basins of Santa Barbara County. Available ground water level records for the Central Coastal Region are tabulated in Volume II, Appendix B, and the average change in ground water level elevations for selected valleys and basins in this region are given in Table 16. Fluctuation of water levels at key wells in Region No. 3 are shown on Plate 12 and the location of wells at which water level fluctuations are shown can be found on Plate 6.

TABLE 16

AVERAGE CHANGES IN GROUND WATER LEVEL ELEVATIONS IN
SELECTED VALLEYS AND BASINS IN CENTRAL COASTAL REGION NO. 3
DURING 1956-57

Ground water valley or basin: Name	Number	Number of wells considered in analysis	Average change in ground water level during the year, in feet	Location and observed extremes of depth to ground water during 1956-57, in feet: Maximum	Minimum
Salinas Valley	3- 4.00				
Paso Robles Basin	3- 4.06	24	+ 0.5	26S/12E-26D1,M 183.0	26S/14E-14R1,M Flowing
San Luis Obispo Group	3- 8.00				
San Luis Obispo Basin	3- 8.04	4	+ 1.9	31S/13E-19H1,M 19.0	31S/12E-28N1,M 8.9
Arroyo Grande Group	3-11.00				
Arroyo Grande Basin	3-11.01	9	+ 0.5	32S/13E-33K1,M 41.3	32S/14E-19A1,M 10.5
Santa Maria River Valley	3-12.00	48	- 1.2	11N/34W-19Q1,S 256.7	11N/35W-20E1,S 10.3
Cuyama River Valley	3-13.00	16	+ 0.5	9N/26W-4J1,S 312.7	10N/26W-22A1,S 16.7
San Antonio Creek Valley	3-14.00	9	+ 2.2	8N/32W-29R3,S 47.1	8N/32W-30K2,S 11.4
Santa Ynez River Valley	3-15.00				
Lompoc Subarea	3-15.01	103	- 2.9	7N/34W-12E1,S 307.0	7N/35W-28H2,S 3.0
Santa Rita Subarea	3-15.02	88	- 1.9	7N/33W-28E1,S 207.0	6N/33W-15G1,S 2.0
Buellton Subarea	3-15.03	60	- 2.2	6N/32W-2Q1,S 64.3	6N/31W-17M1,S 1.2
Santa Ynez Subarea	3-15.04	104	- 6.1	7N/30W-29N2,S 249.5	6N/30W-7M2,S 2.5
Headwater Subarea	3-15.05	11	- 5.0	6N/30W-24H1,S 25.4	6N/30W-14N1,S 1.2

AVERAGE CHANGES IN GROUND WATER LEVEL ELEVATIONS IN
SELECTED VALLEYS AND BASINS IN CENTRAL COASTAL REGION NO. 3
DURING 1956-57
(continued)

Ground water valley or basin: Name	Ground water valley or basin: Number	Number of wells considered in analysis	Average change in ground water level during the year, in feet	Location and observed extremes of depth to ground water during 1956-57, in feet: Maximum	Location and observed extremes of depth to ground water during 1956-57, in feet: Minimum
South Coast Basins, Santa Barbara County	3-16.00				
Goleta Basin	3-16.01	38	+ 0.5	4N/27W-6Q9,S 247.0	4N/28W-17R5,S 3.7
Santa Barbara Basin	3-16.02	4	- 2.6	4N/27W-7P1,S 122.3	4N/27W-18R2,S 37.8
Carpinteria Basin	3-16.04	18	- 5.9	4N/25W-26A1,S 332.5	4N/25W-25L1,S 7.3
Carrizo Plain	3-19.00	3	- 0.1	29S/18E-28K1,M 42.1	29S/18E-28L1,M 36.1

In the Paso Robles Basin of the Upper Salinas Valley, the observed ground water levels exhibited an average rise of about one-half foot between the summer of 1956 and the summer of 1957. Depth to water ranged from flowing, just west of Shandon, to 183 feet in the general vicinity of the City of Paso Robles. In the Cuyama River Valley, the average rise was about 0.5 foot and the maximum observed depth to ground water was about 310 feet at a well located about four miles southwest of the town of Cuyama.

In the Santa Maria River Valley water levels declined an average of about 1.2 feet between the summer of 1956 and the summer of 1957. Observed depths to ground water ranged from a minimum of about 10 feet to a maximum of over 250 feet in the vicinity of Nipomo.

A general decline in ground water level elevations occurred throughout all basins of the Santa Ynez River Valley during the period 1956 to 1957, with greater changes being noted in the upstream Headwater and Santa Ynez Subareas. Maximum observed depth to ground water in the Santa Ynez River Valley was over 300 feet at a well about five miles northeast of the City of Lompoc.

Ground water levels of the South Coast Basins of Santa Barbara County generally showed a decline during the period summer, 1956, to summer, 1957. The maximum decline was evidenced in the Carpinteria Basin where the average drop was nearly six feet. Static water levels in many of the wells in the Goleta and Carpinteria Basins were below sea level in the summer of 1957, and there was a continuation of conditions which permit sea-water intrusion. Minimum observed elevations in these basins were 95 feet below sea level in the Goleta Basin and 36 feet below sea level in the Carpinteria Basin.

Los Angeles Region No. 4

Measurements of depths to water indicate that ground water levels declined in nearly every basin in this region during the period summer, 1956, to summer, 1957. In nearly all of the coastal ground water basins, levels continued to be or declined below sea level. The declines occurred despite widespread conservation practices, including the spreading of both local and imported water. However, basin-wide averages indicated increases in water levels in a few small basins situated adjacent to the mountains in Los Angeles County. The average changes in ground water level elevations for selected valleys and basins in the Los Angeles Region are presented in Table 17, and a complete tabulation of water levels for this region for the period July, 1956, through June, 1957, is presented in Volume II, Appendix C. Fluctuations of water levels at key wells are delineated on Plate 12, and the locations of wells at which water level fluctuations are shown are delineated on Plate 7.

AVERAGE CHANGES IN GROUND WATER LEVEL ELEVATIONS IN
SELECTED VALLEYS AND BASINS IN LOS ANGELES REGION NO. 4
DURING 1956-57

Ground water valley or basin: Name	Number	Number of wells considered in analysis	Average change in ground water level during the year, in feet	Location and observed extremes of depth to ground water during 1956-57, in feet: Maximum	Minimum
Upper Ojai Valley	4- 1.00	4	- 4.0	4N/22W-12F1,S 173.2	4N/22W-10K2,S 19.1
Ojai Valley	4- 2.00	81	-19.8	4N/22W-4L1,S 292.0	4N/23W-14B1,S 10.6
Ventura River Valley	4- 3.00				
Upper Ventura River Basin	4- 3.02	101	- 7.7	4N/23W-21C5,S 172.5	4N/23W-32B1,S 1.7
Santa Clara River Valley	4- 4.00				
Oxnard Plain Pressure Area	4- 4.01	124	- 7.5	1N/21W-4P1,S 113.2	1N/22W-20E2,S 9.4
Oxnard Plain Forebay Area	4- 4.02	36	- 8.0	2N/22W-13A1,S 115.5	2N/22W-11B1,S 59.8
Mound Pressure Area	4- 4.03	42	- 8.4	2N/22W-9K4,S 232.2	2N/23W-23H2,S 5.6
Santa Paula Basin	4- 4.04	64	- 3.2	2N/22W-3M2,S 207.3	2N/22W-1E2,S 1.4
Fillmore Basin	4- 4.05	91	- 8.1	4N/20W-31H1,S 338.7	3N/20W-8F2,S 5.2
Piru Basin	4- 4.06	52	-13.9	4N/18W-27B1,S 226.0	3N/20W-8G1,S 8.8
Eastern Basin	4- 4.07	170	- 4.7	4N/15W-11F3,S 215.3	4N/17W-15N1,S Flowing

AVERAGE CHANGES IN GROUND WATER LEVEL ELEVATIONS IN SELECTED VALLEYS AND BASINS IN LOS ANGELES REGION NO. 4 DURING 1956-57 (continued)

Ground water valley or basin: Name	Number	Number of wells considered in analysis	Average change in ground water level during the year, in feet	Location and observed extremes of depth to ground water during 1956-57, in feet: Maximum	Minimum
Acton Valley	4- 5.00	16	- 5.5	5N/13W-25L2,S 180.2	6N/13W-23E1,S 24.9
Pleasant Valley	4- 6.00	67	- 8.2	2N/21W-24F1,S 340.4	1N/21W-22H1,S 36.6
Arroyo Santa Rosa Valley	4- 7.00	27	- 6.2	2N/19W-21H1,S 254.0	2N/19W-21E2,S 24.5
Las Posas Valley	4- 8.00				
West Las Posas Basin	4- 8.01	19	- 7.2	3N/21W-36P1,S 335.0	3N/21W-21B2,S 19.2
East Las Posas Basin	4- 8.02	79	- 4.7	3N/20W-31L1,S 520.0	2N/19W-1E2,S 17.8
Simi Valley	4- 9.00	92	- 3.9	2N/18W-1F12,S 289.0	2N/18W-7R2,S 5.4
Conejo Valley	4-10.00	130	- 2.1	1N/19W-5L1,S 197.8	1N/19W-15E2,S 2.9
Coastal Plain, Los Angeles County	4-11.00				
West Coast Basin North	4-11.01	52	- 0.3	1S/15W-25C1,S 205.8	1S/16W-31H1,S Flowing
West Coast Basin	4-11.02	360	- 1.1	2S/14W-27P2,S 261.7	5S/13W-3P9,S Flowing
Central Coastal Plain Pressure Area	4-11.03	554	- 4.1	2S/13W-13R1,S 287.0	3S/12W-18Q2,S 5.1

AVERAGE CHANGES IN GROUND WATER LEVEL ELEVATIONS IN
SELECTED VALLEYS AND BASINS IN LOS ANGELES REGION NO. 4
DURING 1956-57
(continued)

Ground water valley or basin: Name	Number	Number of wells considered in analysis	Average change in ground water level during the year, in feet	Location and observed extremes of depth to ground water during 1956-57, in feet: Maximum	Minimum
Coastal Plain, Los Angeles County (cont'd.)					
Los Angeles Forebay Area	4-11.04	75	- 3.5	2S/13W-10P5,S 413.0	1S/13W-27Q2,S 53.6
Montebello Forebay Area	4-11.05	160	- 4.4	1S/12W-33P3,S 324.0	2S/11W-6K1,S 11.8
Los Angeles Narrows Basin	4-11.07	15	- 0.7	1S/13W-4P1,S 59.0	1S/13W-35F1,S 4.8
San Fernando Valley	4-12.00				
San Fernando Basin	4-12.01	206	- 5.4	2N/15W-9G1,S 293.1	2N/16W-34G1,S Flowing
Sylmar Basin	4-12.03	13	- 3.9	3N/15W-34A1,S 159.1	2N/15W-4B6,S 27.1
Tujunga Basin	4-12.05	26	- 6.4	2N/14W-6J1,S 190.6	2N/14W-12C2,S 3.7
Verdugo Basin	4-12.07	24	+10.6	2N/13W-27Q1,S 264.2	1N/13W-10Q1,S 30.4
San Gabriel Valley	4-13.00				
Main San Gabriel Basin	4-13.01	209	- 3.3	1S/10W-13H1,S 335.8	2S/11W-5P2,S Flowing
Monk Hill Basin	4-13.02	21	- 3.6	1N/12W-5P2,S 300.0	1N/12W-7J2,S 90.0
Pasadena Subarea	4-13.03	55	- 4.3	1N/12W-23G1,S 333.8	1N/11W-29K1,S Flowing
Santa Anita Subarea	4-13.04	12	-14.3	1N/11W-21C2,S 227.0	1N/11W-22F1,S 13.7

AVERAGE CHANGES IN GROUND WATER LEVEL ELEVATIONS IN
SELECTED VALLEYS AND BASINS IN LOS ANGELES REGION NO. 4
DURING 1956-57
(continued)

Ground water valley or basin: Name	Number	Number of wells considered in analysis	Average change in ground water level during the year, in feet	Location and observed extremes of depth to ground water during 1956-57, in feet: Maximum	Minimum
San Gabriel Valley (continued)					
Upper Canyon Basin	4-13.05	13	+ 7.6	1N/10W-27J1,S 168.1	1N/10W-23A2,S 5.8
Lower Canyon Basin	4-13.06	8	+ 4.2	1N/10W-27P1,S 147.0	1N/10W-35B1,S 9.2
Glendora Basin	4-13.07	17	- 2.3	1N/9W-29C1,S 456.0	1N/9W-20H1,S 8.5
San Dimas Basin	4-13.09	34	- 4.4	1S/8W-6L2,S 285.0	1S/9W-11G1,S 32.4
Upper Santa Ana Valley, Los Angeles Co.	4-14.00				
Live Oak Basin	4-14.03	22	- 0.3	1S/8W-5D1,S 229.4	1N/8W-32P8,S 21.8
Claremont Heights Basin	4-14.04	22	- 1.3	1N/8W-23J1,S 484.0	1N/8W-26D1,S 24.3
Tierra Rejada Valley	4-15.00	12	- 7.3	2N/19W-15N2,S 212.7	2N/19W-14P1,S 45.0
Malibu Coastal Group	4-16.00				
Hidden Valley Basin	4-16.01	24	- 4.8	1N/20W-25C2,S 198.7	1N/19W-28M1,S 6.8

In Ventura County, averages of seasonal changes in water levels indicate decreases in water surface elevations occurred during the period summer of 1956 to summer of 1957 in all basins where data were available. Particularly, large drops are noted in Ojai Valley where the average decrease was on the order of 20 feet, and in Piru Basin where the average decrease was on the order of 14 feet. Maximum observed depths to water were generally on the order of 200 to 300 feet, with the exception of East Las Posas Basin where a maximum observed depth of 520 feet was recorded.

Water levels in a portion of the Oxnard Plain Forebay Area and piezometric levels throughout most of the Oxnard Plain Pressure Area were below sea level. The resulting landward hydraulic gradient provides conditions which have permitted the intrusion of sea water into the area. Ground water contours presented on Plate 14 indicate the lowest elevation of the trough in the Oxnard Plain Pressure Area to be located in the vicinity of U. S. Highway 101 and Hueneme Road. At this point piezometric levels as much as 69 feet below sea level were observed during the 1956-57 period.

Ground water levels declined throughout the major portion of the Coastal Plain of Los Angeles County between the summer of 1956 and the summer of 1957. This decline occurred despite the fact that over 31,000 acre-feet of Colorado River water was spread or injected into basins of this area during the period under consideration. The piezometric surface underlying the West Coast Basin remained below sea level throughout the entire period, and pressure levels exhibited an average decline of about one foot. However, no significant change was observed in the water level elevations of the trough. This trough is currently located about four miles inland from the coast and extends generally in a southeasterly direction from the southerly end of the Charnock fault through well 4S/13W-21H3,S. The piezometric level of the trough was generally more than 70 to 80 feet below sea level.

In the Central Coastal Plain Pressure Area piezometric levels declined an average of approximately 4.1 feet during the year, bringing water elevations to a record low in many portions of the basin. The pressure levels remained below sea level throughout most of the basin with observed levels of 100 feet below sea level in the area north of Culver City, and 123 feet below sea level north of Signal Hill.

The average decline in the Montebello Forebay Area, based upon wells measured in that area, was about 4.4 feet despite the fact that approximately 35,500 acre-feet of local and imported water was spread in artificial recharge projects adjacent to the Rio Hondo and the San Gabriel River. The effect of this spreading was to reduce the rate of decline of water levels in the forebay. This may be seen from inspection of the hydrograph for wells 2S/11W-18M2,S and 18K3,S on Plate 12. This hydrograph indicates the effect of the decrease in the rate of decline of water levels in recent years. In contrast, attention is directed to the hydrograph for well 2S/13W-10A1,S located in the Los Angeles Forebay Area which has received no artificial recharge water. Water level elevation in this well has shown a steady decline totaling about 125 feet from the spring of 1945 to the spring of 1957.

Ground water levels continued to decline in the San Fernando Valley with observed ground water levels in the San Fernando Basin declining an average of about five feet between the summer of 1956 and the summer of 1957. The decline occurred principally in the central and eastern portions of the basin, while the western portion exhibited little change. Depth to water varied from flowing in the western portion of the valley to a maximum of about 293 feet just south of San Fernando Reservoir.

In the San Gabriel Valley ground water levels in the more heavily pumped basins declined on the order of three to four and one-half feet. However, in certain of the smaller basins adjacent to the mountains such as Upper Canyon Basin and Lower Canyon Basin, increases in elevation were evidenced, while in others, such as the Santa Anita Subarea, rather large decreases were observed. This general decline occurred despite the fact some 21,000 acre-feet of local water was spread at projects in the valley, 15,800 acre-feet of which was spread in the Upper Canyon Basin. Depth to water in the San Gabriel Valley ranged from rising water at Whittier Narrows and near the Raymond fault to about 456 feet near the City of Glendora.

Lahontan Region No. 6

In general, ground water levels were relatively stable in most of the ground water basins in the Lahontan Region during the period summer of 1956 to summer of 1957. It should be noted, however, that in many of the basins the number of measurements is small and averages may not truly reflect conditions in the basins.

Water levels generally indicated decreases, mostly of minor magnitude, in areas where substantial development has occurred such as Harper, Fremont, Indian Wells, Antelope, and the Mojave River Valleys. For example, water levels in the Lancaster Basin of the Antelope Valley, which probably has the greatest development of the Lahontan area, indicated an approximate one-half foot decrease between the summer of 1956 and the summer of 1957. In the Mojave River Valley, water levels suggest a slight increase in the Upper Mojave River Valley and decreases in the Middle and Lower Mojave River Valleys. However, the fluctuations involved are generally less than a foot and one-half.

All available water level data for the period between the summer of 1956 and the summer of 1957 for the Lahontan Region are tabulated in Volume III, Appendix E, and the summary of these data is presented in Table 18. Historic changes in water level elevations at selected wells in basins in the Lahontan Region are given on Plate 13, and the locations of wells at which water level fluctuations are shown are presented on Plate 8.

TABLE 18

AVERAGE CHANGES IN GROUND WATER LEVEL ELEVATIONS IN SELECTED VALLEYS AND BASINS IN LAHONTAN REGION NO. 6 DURING 1956-57

Ground water valley or basin		Number of wells considered in analysis	Average change in ground water level during the year, in feet	Location and observed extremes of depth to ground water during 1956-57, in feet	
Name	Number			Maximum	Minimum
Adobe Lake Valley	6-10.00	3	- 0.3	1N/30E-7J1,M 32.0	1N/30E-6M1,M 7.0
Middle Amargosa Valley	6-20.00	4	-.03	22N/7E-13L1,S 25.0	21N/7E-6X1,S 3.0
Upper Kingston Valley	6-22.00	4	+ 0.5	16N/12E-33B1,S 79.7	14N/13E-13H1,S 14.6
Pahrump Valley	6-28.00	3	+ 0.4	21N/10E-11K1,S 225.4	21N/10E-34A2,S 117.7
Mesquite Valley	6-29.00	17	- 1.5	20N/12E-19F1,S 127.2	19N/12E-11B1,S 30.2
Ivanpah Valley	6-30.00	8	+ 0.4	15N/15E-13G1,S 370.1	16N/14E-31E1,S 14.2
Soda Lake Valley	6-33.00	9	- 2.7	14N/9E-30G2,S 77.6	12N/8E-35X1,S 7.8
Cronise Valley	6-35.00	4	- 0.3	12N/7E-30J1,S 45.5	12N/7E-18R2,S 14.0
Coyote Lake Valley	6-37.00	5	+ 1.0	12N/2E-31A1,S 55.9	11N/2E-8K1,S Flowing

AVERAGE CHANGES IN GROUND WATER LEVEL ELEVATIONS IN
SELECTED VALLEYS AND BASINS IN LAHONTAN REGION NO. 6
DURING 1956-57
(continued)

Ground water valley or basin		Number of wells considered in analysis	Average change in ground water level during the year, in feet	Location and observed extremes of depth to ground water during 1956-57, in feet	
Name	Number			Maximum	Minimum
Troy Valley	6-39.00	8	- 0.3	8N/3E-12J1,S 39.5	8N/3E-4B4,S Flowing
Lower Mojave River Valley	6-40.00	33	- 0.2	9N/1E-9D1,S 109.1	9N/3E-19E1,S 6.8
Antelope Valley	6-44.00				
Willow Springs Basin	6-44.02	5	- 1.8	11N/13W-29M1,S 337.0	9N/13W-7Q1,S 11.6
Lancaster Basin	6-44.05	109	- 0.4	6N/12W-13K1,S 306.8	7N/12W-4P2,S 1.0
Buttes Basin	6-44.06	11	+ 0.4	6N/10W-20N1,S 219.3	5N/12W-12A2,S 13.0
Rock Creek Basin	6-44.07	30	- 0.1	5N/9W-31R2,S 426.0	4N/9W-6Q1,S 5.5
North Muroc Basin	6-44.08	5	+ 0.6	11N/9W-17N1,S 130.2	10N/9W-24A2,S 72.3
Fremont Valley	6-46.00	9	- 3.6	32S/37E-24N1,M 275.7	30S/38E-32E1,M 36.4
Harper Valley	6-47.00	26	- 1.5	10N/6W-5E3,S 250.0	11N/3W-28R2,S Flowing
Superior Valley	6-49.00	7	- 0.6	31S/47E-5R1,M 252.0	31S/46E-12P1,M 84.7

Colorado River Basin Region No. 7

Available measurements of depth to water indicate that during the period summer 1956 to summer 1957, several basins experienced increases in elevation with decreases in others. In most basins the changes are indicated to be minor, although in many of the basins the number of wells measured is small and average values may not truly reflect the conditions in the basin. Maximum observed depths to ground water exceed 300 to 400 feet in many basins. However, in most cases, the greater depth to water measurements were observed at wells located relatively high on the alluvial fan, where large depths would be anticipated. Available ground water level measurements in the Colorado River Basin Region are presented in Volume III, Appendix F, and summarized by valley in Table 19. The historic change in water level for well 10S/6E-21A1,S, located in the Borrego Valley, is presented on Plate 13. The location of this well is shown on Plate 9.

TABLE 19

AVERAGE CHANGES IN GROUND WATER LEVEL ELEVATIONS IN SELECTED VALLEYS IN COLORADO RIVER BASIN REGION NO. 7 DURING 1956-57

Ground water valley or basin		Number of wells considered in analysis	Average change in ground water level during the year, in feet	Location and observed extremes of depth to ground water during 1956-57, in feet	
Name	Number			Maximum	Minimum
Fenner Valley	7- 2.00	4	- 0.1	8N/17E-2D1,S 387.0	6N/16E-6K1,S 258.5
Chuckawalla Valley	7- 5.00	6	- 1.1	5S/17E-30P1,S 150.0	4S/17E-6C1,S 21.4
Bristol Valley	7- 8.00	5	+ 3.9	5N/14E-15L1,S 220.5	5N/13E-22X1,S 56.0
Dale Valley	7- 9.00	7	- 0.1	1N/9E-14D1,S 255.2	1N/12E-22K1,S 10.1
Twentynine Palms Valley	7-10.00	35	- 0.1	1N/8E-9L1,S 320.8	2N/9E-30A2,S 0.4
Copper Mountain Valley	7-11.00	10	- 1.3	1N/6E-25M1,S 408.0	1N/6E-29L1,S 167.0
Warren Valley	7-12.00	9	- 1.2	1S/5E-3B1,S 213.9	1S/5E-4R2,S 51.9
Lucerne Valley	7-19.00	44	- 0.5	6N/1E-31Q1,S 223.0	4N/1W-14B1,S Flowing
Morongo Valley	7-20.00	17	- 2.7	3S/1E-8P1,S 381.2	2S/1E-3X1,S 2.5
Coachella Valley	7-21.00	31	- 1.2	3S/1E-17P1,S 370.0	6S/8E-19R1,S Flowing

Santa Ana Region No. 8

In general, the water levels in ground water basins in the Santa Ana Region declined during the period summer 1956 through summer 1957. An exception to this decline appears to have occurred in the Santa Ana Forebay of the Coastal Plain of Orange County where the importation and spreading of over 102,000 acre-feet of unsoftened Colorado River water during the water year was reflected in an increase in water level in the Forebay area. Available water level measurements for the Santa Ana Region for the period summer 1956 through summer 1957 have been tabulated in Volume III, Appendix G, and some pertinent statistics based on the data tabulated in Appendix H are presented in Table 20. Hydrographs of wells to indicate water level fluctuations in the Santa Ana Region are delineated on Plate 13, and the locations of these wells are presented on Plate 10.

TABLE 20

AVERAGE CHANGES IN GROUND WATER LEVEL ELEVATIONS IN SELECTED VALLEYS AND BASINS IN SANTA ANA REGION NO. 8 DURING 1956-57

Ground water valley or basin: Name	Ground water valley or basin: Number	Number of wells considered in analysis	Average change in ground water level during the year, in feet	Location and observed extremes of depth to ground water during 1956-57, in feet: Maximum	Location and observed extremes of depth to ground water during 1956-57, in feet: Minimum
Coastal Plain, Orange County	8-1.00				
East Coastal Plain Pressure Area	8-1.01	183	- 2.3	6S/8W-6P1,S 206.6	6S/10W-20M1,S 4.6
Santa Ana Forebay Area	8-1.02	22	+ 1.6	4S/9W-22R1,S 354.9	4S/10W-8C1,S 10.9
Irvine Basin	8-1.03	35	- 1.7	6S/8W-6A1,S 299.7	7S/9W-10P1,S 21.9
Yorba Linda Basin	8-1.05	8	+ 7.0	3S/9W-33E2,S 193.3	3S/9W-34H1,S 18.2
Santa Ana Narrows Basin	8-1.06	79	+ 1.1	3S/7W-29C1,S 20.7	3S/7W-20P2,S 0.1
Upper Santa Ana Valley	8-2.00				
Chino Basin	8-2.01	37	- 2.4	1S/8W-12H1,S 580.0	2S/8W-36R1,S Flowing
Bunker Hill Basin	8-2.06	20	- 3.4	1S/2W-19D1,S 352.5	1S/4W-22G11,S Flowing
Lytle Basin	8-2.07	15	- 4.4	1N/5W-15Q1,S 418.3	1N/4W-32N1,S 151.5
Beaumont Basin	8-2.12	29	- 1.5	3S/1W-3K1,S 423.0	2S/1W-2J1,S 65.0
San Timoteo Basin	8-2.13	18	- 4.2	1S/2W-29N1,S 383.5	2S/2W-20K1,S 35.0
Temescal Basin	8-2.17	79	- 0.2	3S/7W-35C1,S 191.5	3S/7W-21C1,S 2.5
Bedford Basin	8-2.18	5	- 4.8	4S/6W-35G2,S 72.4	4S/6W-35G2,S 37.7
Coldwater Basin	8-2.19	9	- 7.5	5S/6W-3Q1,S 219.4	5S/6W-2P1,S 107.0

SELECTED VALLEYS AND BASINS IN SANTA ANA REGION NO. 8
DURING 1956-57
(continued)

Ground water valley or basin		Number of wells considered in analysis	Average change in ground water level during the year, in feet	Location and observed extremes of depth to ground water during 1956-57, in feet	
Name	Number			Maximum	Minimum
Elsinore Valley	8-4.00	78	- 5.3	5S/5W-35N1,S 283.6	6S/4W-28P1,S 11.4
San Jacinto Valley	8-5.00	52	- 1.3	5S/1E-20G3,S 286.8	4S/1W-18L1,S 9.5

As stated, the spreading of over 102,000 acre-feet of imported Colorado River water during the water year was instrumental in creating a rise in water levels in the Santa Ana Forebay Area. Due to the complexity of the operation of the basin, selected water level data were analyzed on a weighted-area basis, indicating a rise of about two feet between the summer of 1956 and the summer of 1957. In the northerly third of the basin, general increases were observed and in the areas where spreading was concentrated, near the Santa Ana Narrows Basin, the observed rises were very substantial, as much as 25 to 50 feet. In the southerly two-thirds of the basin, general decreases were observed and in many instances levels were below sea level. The maximum observed depth to ground water was over 350 feet in the northern part of the basin.

Piezometric levels in the East Coastal Plain Pressure Area declined an average of about 2.3 feet between the summer of 1956 and the summer of 1957, and throughout most of the basin the levels were below sea level. Contours of ground water elevations indicate an elongated trough to be located parallel to and about five miles inland from the coast. This may be seen from an inspection of Plate 17, which shows contours of piezometric level for the East Coastal Plain Pressure Area. Minimum elevations appear near the intersection of Huntington Beach Boulevard and Wintersburg Avenue, and at a point approximately five miles south of Santa Ana. In these areas, elevations as much as 57 feet below sea level were observed. In the vicinity of Bolsa Chica gap, levels as much as 55 feet below sea level were observed. The occurrence of this trough provides conditions for the intrusion of sea water, which appears to be progressing rapidly in these areas. This subject will be discussed in Chapter IV.

In the Chino Basin of the Upper Santa Ana River Valley, water level data from selected wells were analyzed on a weighted-area basis, resulting in an average decline of nearly two and one-half feet. In many instances, minimum elevations of record were established and a depth to water of over 580 feet was observed in the area between Claremont and Upland in the northwestern part of the basin. On the other hand, substantial rises in water levels, 6 to 10 feet, were observed in the vicinities of Ontario and Prado Dam. Review of the data for this basin in Appendix G will show that the levels recorded for a large number of the wells extend only from October, 1956, through May, 1957. The machine computed averages of changes utilizing these wells indicated a general basin-wide rise. It is apparent that such a rise would be unduly influenced by the normal rise which occurs between the fall low and the spring high, and would, therefore, create a false impression. For this reason, averages based upon data from selected wells were used.

Average changes for selected wells in Bunker Hill Basin indicated a decrease in elevation of nearly eight feet between the summer of 1956 and the summer of 1957. However, for reasons cited in the foregoing paragraph, statistics used to indicate changes in the basin are also based upon selected wells. When the observed decreases are weighted with respect to area, it is indicated that the decrease is on the order of three and one-half feet. Substantial rises in levels on the order of 15 feet were observed in the general vicinity of the Santa Ana River; however, throughout the rest of the basin decreases were observed. Observed depths to ground water ranged from flowing near Colton to 350 feet near Highland. It is interesting to note that the last depth to ground water measurement for the famous Williams Well in Bunker Hill Basin was obtained on June 20, 1956, with a report that the well cannot be measured because the casing was broken about 75 feet below the reference point. This terminated a continuing water level record which had existed for nearly 64 years. Another well, 1S/3W-17C3,S, which is 100 feet south of the Williams Well, has been selected as a replacement for Williams Well.

In the San Jacinto Valley, ground water levels declined an average of about 1.3 feet between the summer of 1956 and the summer of 1957. The hydrograph of wells 4S/1W-25D1,S and 35Q1,S shown on Plate 13 indicates that in this valley there have been some 16 years of uninterrupted decline in water levels totaling 147 feet between the spring of 1941 and the spring of 1957, or an average annual drop of 9.2 feet. Maximum observed depth to ground water in this valley was on the order of 290 feet. In the Elsinore Valley ground water levels declined an average of over five feet between the summer of 1956 and the summer of 1957. Maximum observed depth to water in this area was 283 feet.

On April 29, 1957, Superior Court Judge Albert R. Ross filed a memorandum decision in favor of the Orange County Water District in a suit brought against the Cities of San Bernardino, Riverside, Redlands, and Colton. The decision, which concerns the water supply in both Orange County and the Upper Santa Ana Valley, states in part:

"The defendant cities have the prescriptive right to take the amount of water only that they had acquired at the time of filing the complaint in this action in October, 1951. The overlying landowners in the area of percolation of the plaintiff district have need for about 80,000 acre feet of water more from the underground supply of the basin, all of which can be and would be beneficially used. Their right to this water is paramount in this case. Defendant cities are now extracting about 30,000 feet per year more water than they have a right to and threaten to take still more if not restrained. The taking of this water does reduce the amount of water flowing, underground or on the surface, to the plaintiff district by approximately that amount. The consequent damage to the overlying landowners of the plaintiff district is serious and irreparable. Only the expensive buying of imported water has stayed off disaster for these landowners thus far. The defendants should be enjoined from taking more water than their respective prescriptive rights entitled them to."

The decision has been appealed to the State Supreme Court by the Cities of San Bernardino, Redlands, Colton, and Riverside.

San Diego Region No. 9

In general, ground water levels declined in most of the basins of the San Diego Region between the summer of 1956 and the summer of 1957. However, many of the basins in this region are small and have limited carry-over capacity, and because of the protracted drought, storage was substantially depleted. In these areas the available water supply was to a large extent limited to Colorado River water imported through the San Diego Aqueduct. Despite the fact that this aqueduct was operated at full capacity, water supply conditions became critical by the summer and fall of 1957.

Litigations were continued during 1956-57 over the water rights of the Santa Margarita River and the Tia Juana River.

In several of the basins, such as Tia Juana Valley and Mission Basin, observed water level elevations adjacent to the coast were below sea level, providing conditions which could allow sea-water intrusion. In addition, the protracted periods of low water level have permitted the movement of saline waters from older marine deposits flanking these basins, and in several of these basins water quality problems were becoming increasingly severe by summer of 1957. Available measurements of depth to water from Region 9 are tabulated in Volume III, Appendix H, and pertinent statistics are summarized in Table 21. Hydrographs of selected wells in Region No. 9 are presented on Plate 13, and locations of wells for which hydrographs are presented are delineated on Plate 11.

TABLE 21

AVERAGE CHANGES IN GROUND WATER LEVEL ELEVATIONS IN
SELECTED VALLEYS AND BASINS IN SAN DIEGO REGION NO. 9
DURING 1956-57

Ground water valley or basin		Number of wells considered in analysis	Average change in ground water level during the year, in feet	Location and observed extremes of depth to ground water during 1956-57, in feet	
Name	Number			Maximum	Minimum
San Juan Valley	9- 1.00				
Aliso Creek Basin	9- 1.01	22	- 1.7	6S/8W-26F4,S 70.5	6S/8W-26F5,S 1.5
San Juan Creek Basin	9- 1.02	56	- 0.7	7S/8W-25A1,S 56.8	8S/8W-13P1,S 3.8
Temecula Valley	9- 5.00				
Murrieta Basin	9- 5.01	17	- 4.1	6S/4W-27M1,S 132.7	8S/3W-13K1,S 14.1
Pauba Basin	9- 5.02	3	- 3.2	8S/2W-12H1,S 58.2	8S/2W-11L1,S 29.3
Wolf Basin (Pechanga)	9- 5.03	2	- 2.3	8S/2W-28C1,S 97.5	8S/2W-20E1,S 14.9
San Luis Rey Valley	9- 7.00				
Mission Basin	9- 7.01	6	- 0.3	11S/4W-18L3,S 78.0	11S/5W-13N2,S 29.7
Bonsall Basin	9- 7.02	18	- 4.5	10S/3W-15A1,S 57.0	10S/3W-20E1,S 17.8
San Pasqual Valley	9-10.00				
Lake Hodges Basin	9-10.01	6	- 0.7	13S/2W-2Q1,S 68.6	13S/2W-2D3,S 4.0
San Pasqual Basin	9-10.02	104	- 4.3	12S/1W-20Q1,S 74.6	12S/1W-33L2,S 3.6

AVERAGE CHANGES IN GROUND WATER LEVEL ELEVATIONS IN
SELECTED VALLEYS AND BASINS IN SAN DIEGO REGION NO. 9
DURING 1956-57
(continued)

Ground water valley or basin		Number of wells considered in analysis	Average change in ground water level during the year, in feet	Location and observed extremes of depth to ground water during 1956-57, in feet	
Name	Number			Maximum	Minimum
Santa Maria Valley	9-11.00				
Ramona Basin	9-11.01	7	- 1.8	13S/1E-24F1,S 114.7	13S/1E-15K2,S 8.3
Sweetwater Valley	9-17.00	7	+ 0.4	17S/1W-20E1,S 26.0	17S/2W-25P2,S 4.9
Tia Juana Valley	9-19.00	73	+ 0.2	18S/2W-27R2,S 87.0	18S/2W-32P2,S 5.7

CHAPTER IV. QUALITY OF WATER AND SEA-WATER INTRUSION

Although there were some instances of localized deterioration caused by disposal of sewage and industrial waste, the principal quality problems affecting fresh water supplies in the southern California area continued to be caused by sea-water intrusion and by intrusion of other saline waters.

Quality of Water

In some areas, the protracted period of depressed water levels has induced the movement of saline waters into producing aquifers from flanking and subjacent older marine formations. This problem of mineral quality degradation is especially noticeable in San Diego and Mission Basins and Tia Juana Valley of San Diego County. This degradation is also suspected in the southern part of Fillmore Basin of Ventura County and in the area adjacent to Newport Mesa in Orange County. Mineral analyses of samples from selected surface sampling stations and wells in southern California are presented in Tables 22 and 23.

TABLE 22

MINERAL ANALYSES OF SURFACE WATER AT
SELECTED STATIONS IN SOUTHERN CALIFORNIA

Station number	Station	Date sampled and estimated discharge	ECx10^6 at 25°C	Mineral constituents, in parts per million								Total hardness as $CaCO_3$, in ppm	Per cent Na
				Ca	Mg	Na+K	HCO_3	SO_4	Cl	NO_3	B		
37-121.7	Salinas River U.S.G.S. gage at old State Highway 41 bridge at Paso Robles	5- 7-57 15 cfs	863	87	37	53	323	137	45	0.6	0.20	369	23
318-35.5	Santa Ynez River at Mission Bridge 0.9 mile south of Solvang	5- 8-57 4.1 cfs	1,209	113	68	62	415	262	50	0.1	0.38	561	20
42-5.7	Ventura River N. of Ventura, in Foster Memorial Park, 300 feet downstream from highway bridge at U.S.G.S. gaging station	3- 4-57 10 cfs	892	94	34	50	286	169	44	2.0	0.40	375	22
43-17.0	Santa Clara River E. of Santa Paula, and about 1.5 miles upstream from Willard bridge	3- 4-57 125 cfs	1,493	156	58	114	284	507	53	4.2	0.74	628	27
47-23.9	Los Angeles River NE. of Los Angeles at Figueroa Street	5-24-57 3.6 cfs	1,562	67	36	221	115	326	240	0.5	1.20	315	59

MINERAL ANALYSES OF SURFACE WATER AT
SELECTED STATIONS IN SOUTHERN CALIFORNIA
(continued)

Station number	Station	Date sampled and estimated discharge	ECx10[6] at 25°C	Mineral constituents, in parts per million								Total hardness as $CaCO_3$, in ppm	Per cent Na
				Ca	Mg	Na+K	HCO_3	SO_4	Cl	NO_3	B		
47-12.2-9.6	Rio Hondo NE. of Montebello about 0.1 mile upstream from San Gabriel Blvd. bridge	5- 7-57 5.3 cfs	689	70	18	70	250	103	48	6.5	0.2	249	35
48-20.7	San Gabriel River SW. of El Monte, and 0.5 mile upstream from Whittier Narrows Dam	5- 7-57 .02 cfs	581	65	18	44	193	108	37	1.0	0.1	236	26
82-69.6-5.4	Mill Creek E. of Mentone, at Southern California Edison Company Plant No. 2	1-13-57 25 cfs	210	25	4	14	79	28	6	1.8	T	79	17
82-57.9-2.0	Warm Creek San Bernardino at "E" Street	2- 9-57 2 cfs	520	62	15	29	217	69	15	2.5	T	216	20
82-46.4	Santa Ana River W. of Riverside at Riverside Narrows	5- 7-57 24 cfs	995	103	24	76	326	88	93	20	0.1	355	30
93-20.0	Santa Margarita River N. of Fallbrook about 0.5 mile downstream from confluence with Sandia Creek	5- 6-57 1 cfs	1,226	90	29	151	375	116	16	0.5	0.3	343	48

MINERAL ANALYSES OF SURFACE WATER AT
SELECTED STATIONS IN SOUTHERN CALIFORNIA
(continued)

Station number	Station	Date sampled and estimated discharge	$ECx10^6$ at 25°C	Mineral constituents, in parts per million								Total hardness as $CaCO_3$, in ppm	Per cent Na
				Ca	Mg	Na+K	HCO_3	SO_4	Cl	NO_3	B		
94-28.0	San Luis Rey River SE. of Pala at Pala Diversion Dam	5- 6-57 1 cfs	666	64	21	51	166	141	45	0.5	T	246	28
620A-28.8	Big Rock Creek SE. of Pearblossom, and about 300 feet upstream from confluence with Pallett Creek	2- 6-57 2 cfs	555	62	24	24	231	95	4	6.7	0.11	253	14
619-95	Mojave River NW. of Victorville about 0.2 mile SE. of U.S. Highway No. 91 bridge	5- 9-57 25 cfs	483	38	15	43	184	52	33	0.2	0.15	157	36

MINERAL ANALYSES OF GROUND WATER AT
SELECTED WELLS IN SOUTHERN CALIFORNIA

State Well Number	Owner and location	Date sampled	$EC \times 10^6$ at 25°C	Mineral constituents, in parts per million								Total hardness as $CaCO_3$, in ppm	Per cent Na
				Ca	Mg	Na+K	HCO_3	SO_4	Cl	NO_3	B		
					Central Coastal Region								
Santa Maria River Valley													
10N/34W-19H1	1.0 mile N. of Betteravia Road on Black Road just W. of Black Road	9-26-56	1,242	--	--	71	--	--	51	--	0.2	534	--
Lompoc Subarea, San Ynez River Valley													
7N/35W-22L1	U.S. Army, Camp Cooke; 2,500 feet N. of Southern Pacific Rail-road and 25 feet W. of Renwish Avenue	9-57	2,260	122	123	185	156	372	505	18	0.2	806	32
					Los Angeles Region								
Oxnard Plain Pressure Area, Santa Clara River Valley													
1N/22W-3F4	City of Oxnard; 200 feet E. of Saviers Road, 100 feet N. of Third Street	4- 4-57	1,665	172	65	123	307	582	62	19.0	0.5	696	27

MINERAL ANALYSES OF GROUND WATER AT
SELECTED WELLS IN SOUTHERN CALIFORNIA
(continued)

State Well Number	Owner and location	Date sampled	$EC \times 10^6$ at 25°C	Mineral constituents, in parts per million								Total hardness as $CaCO_3$, in ppm	Per cent Na
				Ca	Mg	Na+K	HCO_3	SO_4	Cl	NO_3	B		
	Los Angeles Region (continued)												
	Oxnard Plain Forebay Area, Santa Clara River Valley												
2N/22W-12G1	United Concrete Pipe Corporation; One mile S.E. of Saticoy, 200 feet N.E. of Del Norte Avenue, 500 feet S.E. of Vineyard Avenue	12-19-56	1,886	226	74	174	367	776	93	0.5	0.8	868	29
	Central Coastal Plain Pressure Area, Coastal Plain (Los Angeles County)												
3S/12W-8F1	Los Angeles County Farm; Two miles S.W. of Downey, 1,600 feet S., 300 feet W. of intersection Imperial Hwy. and N. of County Farm Road	5- 2-57	530	--	--	--	232	--	18	--	--	188	--
	Montebello Forebay Area, Coastal Plain (Los Angeles County)												
2S/11W-19L1	La Habra Heights Water Company, Judson No. 3 well; Two miles W. of Whittier, 1,050 feet W. of Norwalk Blvd. 1,600 feet from Dunlap Crossing along road	8- 7-57	800	--	--	--	214	--	59	--	--	330	--

State Well Number	Owner and location	Date sampled	$EC \times 10^6$ at 25°C	Mineral constituents, in parts per million								Total hardness as $CaCO_3$, in ppm	Per cent Na
				Ca	Mg	Na+K	HCO_3	SO_4	Cl	NO_3	B		
	Los Angeles Region (continued)												
San Fernando Basin, San Fernando Valley													
1N/14W-17H1	Polar Water Company; Three miles W. of Burbank, 198 feet S. of Burbank Blvd., 154 feet E. of Denny Avenue	7-26-57	752	90	23	33	233	90	45	41	0.1	320	16
Main San Gabriel Basin, San Gabriel Valley													
1S/11W-2G1	City of Monrovia: Three miles S. of Monrovia, 400 feet E. of Peck Rd., 200 feet N. of Jeffries Avenue	12-26-57	583	68	21	17	256	22	13	41	0	255	11
Pasadena Subarea, San Gabriel Valley													
1N/12W-20B1	City of Pasadena, Copelin Well; Pasadena, 142 feet E. of Mentone Avenue, 118 feet N. of Manzanita Street	12- 3-56	---	50	16	31	215	35	19	11	--	190	26
		3- 3-57	---	52	18	26	211	38	19	11	--	205	22
		7-29-57	---	52	17	23	209	43	19	8	--	200	20

MINERAL ANALYSES OF GROUND WATER AT
SELECTED WELLS IN SOUTHERN CALIFORNIA
(continued)

State Well Number	Owner and location	Date sampled	$EC \times 10^6$ at 25°C	Mineral constituents, in parts per million								Total hardness as $CaCO_3$, in ppm	Per cent Na
				Ca	Mg	Na+K	HCO_3	SO_4	Cl	NO_3	B		
				Lahontan Region									
Lancaster Basin, Antelope Valley													
8N/13W-32N1	Pedro Lizzarraga; 100 feet E. of 90th Street, W. and 100 feet N. of Avenue "G"	12-18-56	990	113	27	74	315	97	128	22	0.3	393	28
		3-6-57	980	124	26	73	360	81	117	26	0.1	415	27
				Santa Ana Region									
East Coastal Plain Pressure Area, Coastal Plain (Orange County)													
4S/11W-36N1	Mountain Properties, Inc.; Three miles W. of Garden Grove, 125 feet S. of Stanford Avenue, 258 feet E. of Sycamore Street	5-28-57	505	53	13	34	207	44	28	1.9	T	186	26
Chino Basin, Upper Santa Ana Valley													
1S/7W-21D1	City of Ontario, No. 4 well; Two miles N.E. of Ontario, 90 feet S. of 4th St., 300 feet E. of Grove Avenue	7-18-57	372	49	10	16	184	20	8	15	0	165	16

State Well Number	Owner and location	Date sampled	$EC \times 10^6$ at 25°C	Mineral constituents, in parts per million								Total hardness as $CaCO_3$, in ppm	Per cent Na
				Ca	Mg	Na+K	HCO_3	SO_4	Cl	NO_3	B		
	Santa Ana Region (continued)												
Bunker Hill Basin, Upper Santa Ana Valley													
1S/4W-10F1	City of San Bernardino, Hanford No. 1 well; San Bernardino, 170 feet E. of "D" Street, 60 feet S. of Second Street	6-26-57	361	39	10	23	181	15	15	2.6	0.2	139	24
	San Diego Region												
Mission Basin, San Luis Rey River Valley													
11S/4W-18C1	2,900 feet N.E. along Hwy. 79, from ppg. plt., 1,760 feet N.W. along Private Road, 15 feet S.W. of Road	10-22-57	1,406	101	38	137	289	123	249	0	0.2	408	41
Tia Juana Valley													
19S/2W-4A5	California Water and Telephone Company, Well No. 5; South Basin Plant three miles W. of National Ave., 1,500 feet S. of Sunset Avenue	12-18-56	2,500	130	53	254	363	254	390	3.3	0.2	543	50

Sea-Water Intrusion

One of the major water problems in southern California is sea-water intrusion. In recent years this problem has grown in importance as ground water reserves have been depleted in meeting increased water demands. At this time, portions of valuable coastal ground water basins have been damaged by invading brines, and this problem threatens to increase in severity.

The serious effects of sea-water intrusion in Oxnard Plain Pressure Area, West Coast Basin, and East Coastal Plain Pressure Area can have such an economic impact that it is essential that the progress and current status of intrusion be known. Before discussing the current status, a brief history of sea-water intrusion is presented to provide a better understanding of the problem.

History

Prior to 1900, the water requirements for man and his activities were small and chiefly met by the development of surface water supplies. In southern California, however, the occurrence of surface water is sporadic and such supplies are inadequate during periods of drought. Rapid increases in population and the need for a firm water supply, coupled with the development of deep well turbine pumps, resulted in extensive utilization of ground water basins. This development and exploitation of ground water supplies helped to make possible the phenomenal growth in southern California during the last 50 years.

Prior to the advent of man's activities in southern California, the numerous coastal ground water basins were in a somewhat stabilized condition. Precipitation on the land had filled the ground water basins and established a seaward gradient in the water table. As used in this report, the term "seaward" means that the direction of ground water movement is toward the ocean, and the term "landward" means that the direction of ground water movement is landward and away from the ocean. During dry periods, the gradient would be less than during wet periods, but as there was very little extraction of water from these basins, the gradient remained toward the ocean.

Since the 1930's, increasing extractions of ground water for agricultural, municipal, and industrial purposes, coupled with a protracted period of subnormal precipitation starting in 1945, resulted in the lowering of ground water elevations below sea level along the seaward margins of many ground water basins. As a result, tremendous volumes of fresh water, stored in aquifers under the ocean, were depleted permitting ocean water to move into these ground water storage basins in place of the fresh water supplies. Substantial economic losses have resulted from this intrusion.

Oxnard Plain Pressure Area

The Oxnard Plain Pressure Area is located in the southern portion of Ventura County. The economy of this area is largely dependent on irrigated agriculture and related industries. The Cities of Oxnard and Port Hueneme and two naval bases are located within this basin.

Oxnard Plain Pressure Area contains three water-bearing zones, designated the Oxnard, Mugu, and Fox Canyon aquifers, in order of their depth below ground surface. Of these, the Oxnard aquifer is the most utilized. Under historic conditions of supply and demand, and prior to development by man, ground water moved westerly and southwesterly beneath the Oxnard Plain discharging to the ocean through seaward extensions of the aquifers. Increased extractions in recent years have resulted in reversal of the ground water gradients. Subsurface landward movement of the ground waters toward inland pumping troughs has resulted in sea-water intrusion.

Saline waters were first noticed in several wells along the coast south of Oxnard in the early 1930's. This advance was temporarily checked by the wet period extending from 1933-34 to 1943-44, which eliminated the landward hydraulic gradient. Deficient precipitation since 1945 and increased ground water extractions depleted ground water storage, and as a result, a landward gradient in the Oxnard aquifer has existed since 1948. Ground water levels in the summer of 1957 are shown on Plate 14. As shown, the water table was below sea level throughout virtually all of the basin, and at one point three and one-half miles inland from the coast, the water level was 40 feet below sea level.

Plate 14 shows lines of equal chloride concentration for 100 and 500 parts per million (ppm). Throughout most of the basin, the chloride content is less than 50 ppm, and available data indicate that similar water quality existed in the entire coastal segment of the basin prior to 1930. As shown, there are two major areas of intrusion, a northerly area in the vicinity of Port Hueneme and a southerly area near Mugu Lagoon.

In the vicinity of Port Hueneme, sea water has intruded a distance of approximately 1.5 miles inland into the highly productive Oxnard aquifer. It has been necessary to abandon wells within this area, and alternate water supplies have had to be developed. During the period 1955-57, there appears to have been an appreciable advance of saline water northward from Port Hueneme, although very little eastward advance was detectible. In this area, the maximum rate of advance during the 1955-1957 period is estimated to be about 1,500 feet per year. Plate 15 shows fluctuation of the chloride ion concentration in a well near Port Hueneme during the period of 1955 through 1957. This variation considered to be typical of well waters being degraded by the advance of a saline flow.

In the vicinity of Mugu Lagoon, the intrusion is not as accurately determined, due to the absence of water wells and necessary data. Analyses of water from wells in Point Mugu Naval Reservation, however, do show degradation from sea water. From limited data available, it is believed that within this area sea water is intruding the Mugu aquifer. Water levels indicate that a landward gradient in the water table in this area existed as early as 1947, and that a progressive increase in gradient has occurred since that date. This increasing slope indicates that an acceleration of sea-water intrusion may be occurring in this area.

Fox Canyon aquifer extends under the Oxnard Plain at a greater depth than either the Oxnard or Mugu aquifers. This aquifer underlies the Oxnard aquifer in the vicinity of Oxnard and Port Hueneme, and is virtually unexploited in this area. However, to the east in Pleasant Valley the Fox Canyon aquifer is extensively used and water levels have dropped to more than 40 feet below sea level in several areas. Lowered water levels in this aquifer represent a threat of sea-water intrusion through areas of interconnection with overlying aquifers and/or direct connection with the ocean.

The abandonment of wells in the area of sea-water intrusion has served to emphasize the fact that the ground water reservoirs are undergoing severe damage. The danger to the remainder of the basin is now recognized, and a concerted effort is being made to increase the use of imported waters so that water levels may be restored and maintained to resist the landward advance of sea-water. This effort includes the construction in 1955 of the El Rio spreading grounds for spreading diverted floodwaters from the Santa Clara River, and completion in April, 1956, of a pipe line to Oxnard for delivery of imported water. Ground water levels have continued to drop during the last 10 years, and sea-water intrusion will continue unless recovery of water levels can be accomplished by increasing replenishment and/or reducing ground water extractions.

West Coast Basin

West Coast Basin is located on the Coastal Plain in the southwest section of Los Angeles County and is bordered by Santa Monica Bay on the west, the Newport-Inglewood Uplift on the east, and Ballona Escarpment on the north. This area, shown on Plate 16, includes seven cities and portions of three others. It is highly developed industrially. Oil production and refining, aircraft, electronics, and chemicals are among the leading industries.

West Coast Basin contains numerous water-bearing zones. Of these, the principal aquifers are the Silverado and "400-foot gravel". Although the aquifers are separated by deposits of clay and silt throughout most of the basin, they merge in the coastal area adjacent to Santa Monica Bay. Under natural conditions, the deeper aquifers were recharged primarily by ground water moving southwesterly across the Newport-Inglewood Uplift. There has probably been a minor amount of recharge from overlying aquifers. There are no continuous geologic barriers to ground water movement in this basin which would prevent or retard sea-water intrusion into the principal aquifers.

Prior to 1900, West Coast Basin was an area devoted largely to agriculture, and use of ground water was limited, flowing wells were common in Ballona gap, and water levels were over 100 feet above sea level in the vicinity of Hawthorne. Favorable physiographic, geographic, and climatic conditions have led to rapid urban growth, and extreme changes have been experienced in this basin. Former agricultural lands are now covered with residential tracts and commercial and industrial centers. Phenomenal increases in water demands have occurred. Even with supplemental imports of water, ground water extractions continued to increase until 1953. Since that date, the majority of larger producers have voluntarily curtailed production and correspondingly increased importations so that extractions have been reduced.

Ground water levels in the fall of 1957 are shown on Plate 16. These levels stand out in sharp contrast to those that existed prior to 1900. Ground water levels have been reduced so that the piezometric surfaces in the confined aquifers are at sea level or below throughout virtually all of West Coast Basin. Static water levels in the vicinity of Hawthorne, four miles from the coast, have dropped to over 80 feet below sea level.

Plate 16 also shows lines of equal chloride concentration for 100, 500, and 1,000 ppm. Sea-water intrusion appears to have occurred along virtually the entire shore of Santa Monica Bay. The average rate of advance of the 100 ppm isochlor into this basin since 1950 is estimated to be approximately 700 feet per year. The 100 ppm isochlor located approximately 3.8 miles inland in an area between El Segundo and Manhattan Beach has moved inland at a rate of approximately 1,400 feet per year since 1950. It is notable that this rapid advance is in the direction of the pumping depression west of Hawthorne.

Fluctuations of chloride ion concentration with time in well 3S/15W-13R2 are shown on Plate 15. This well, located near El Segundo, is within the area of intrusion, and the chloride ion increase shown is typical of increases along the intrusion front.

The threat of ground water depletion and sea-water intrusion in this basin was recognized early in the 1900's, and sea-water intrusion first observed in 1912. Since that time, numerous engineering studies of the problem have been made. However, the first large scale action taken to alleviate these conditions was the importation of Colorado River water in 1949. Since that time, the importation has continuously increased.

In 1951, the State Legislature appropriated $750,000 for investigation of methods for prevention of sea-water intrusion. Effective October 1, 1951, the State Water Resources Board entered into a contract with the Los Angeles County Flood Control District for the installation and operation of an experimental recharge test in the vicinity of Manhattan Beach. This project consisted originally of nine injection wells, forming a line approximately one mile in length and parallel to the coast line. Softened Colorado River water was injected through these wells beginning February, 1953, to determine the feasibility of the maintenance of a pressure ridge above sea level along the one mile reach of coast for the repulsion of sea water. Initially, funds were made available for a period of one year. However, additional funds were later made available and the State Water Resources Board participated in the program until December 31, 1953, when funds were exhausted. Since January 1, 1954, the project has been operated by the Los Angeles County Flood Control District with the assistance from the West Basin Water Association and Zone 2 of the Flood Control District. One of the original injection wells has since been put out of operation but four additional wells have been drilled to extend the pressure ridge to the north and south. A complete description of this project will be contained in Bulletin No. 63, "Sea-Water Intrusion in California", to be published in the near future.

This well recharge project has been successful in the creation of a fresh water ridge. The beneficial effect of this project is shown by changes in ground water levels and in the slowing of the landward advance of the 100 ppm isochlor east of the injection wells. This halting of sea-water intrusion is, however, restricted only to the project line. Sea water appears to be moving around the line both to the north and south, and this important ground water reservoir is suffering further damage.

East Coastal Plain Pressure Area

The East Coastal Plain Pressure area is located in the westerly portion of Orange County bordering the Pacific Ocean, and includes the Cities of Costa Mesa, Newport Beach, and Huntington Beach. Major developments include both agricultural and oil production activities, although residential development and small industries are growing in importance.

Six water-bearing zones have been differentiated within East Coastal Plain Pressure area. Two of these, the Talbert water-bearing zone and "80-foot gravel", are the principal producing aquifers. These aquifers, which are of Recent age, are comprised chiefly of coarse sands and gravels.

Prior to the development and extensive use of these ground water reservoirs, a seaward gradient existed, and ground water moved southerly discharging as underflow to the ocean. The only significant barrier to this flow is the Newport-Inglewood structural zone which consists of a group of en echelon faults and folds. This zone acts as a partial barrier in all but the Recent deposits.

The history of this basin parallels that of others experiencing sea-water intrusion. Heavy pumping has depressed ground water levels below sea level and resulted in a landward gradient and sea-water intrusion. Ground water levels in the fall of 1957, as shown on Plate 17, were below sea level throughout most of the basin, and a landward gradient existed.

Plate 17 also shows lines of equal chloride concentration for 50, 100, and 500 ppm. The chloride content of the native ground water appears to be less than 30 ppm in this basin, and it is believed that the 50 ppm isochlor is indicative of degradation caused by sea-water intrusion. The variation of chloride ion content with time is shown on Plate 15 for well No. 6S/10W-6L2, which is located within the area of intrusion. It is notable that the chloride content increases very rapidly once a concentration of 50 ppm has been exceeded. This is considered typical of wells being degraded by sea-water intrusion. The Newport-Inglewood structural zone has apparently been an effective barrier to sea-water intrusion as the only deep penetration inland into Orange County by sea water has occurred in the Recent deposits of Santa Ana gap. Since 1932, sea water has moved inland in these deposits at an average rate of approximately 1,000 feet per year. A maximum rate of approximately 1,400 feet per year was estimated in one area within the gap. The 500 ppm isochlor now ranges from two to three miles inland from the coast. This intrusion has necessitated the abandonment of many wells and curtailment of pumping at others.

As early as 1941, Colorado River water was imported into Orange County to help alleviate the threat to valuable ground water reservoirs created by conditions of overdraft and sea-water intrusion. The imported water was utilized in the cities to reduce the draft on ground water storage. Since 1941, there has been an increasing importation of Colorado River water to meet increasing demands and to combat the problem of falling ground water levels. In 1949, the Orange County Water District initiated a recharge program by importing unsoftened Colorado River water and spreading it in the Santa Ana River channel. In 1951, the Orange County Flood Control District joined the Orange County Water District in this program. In 1954, the Talbert Water District was formed to use water reclaimed from sewage purchased from the County Sanitation Districts of Orange County for irrigation. This water reclamation project has enabled some reduction of pumping within the District.

These programs of importation and water reclamation have undoubtedly been very beneficial. However, during the last ten years, water levels have continued to lower, and sea-water intrusion is continuing. Until the water levels recover above sea level, intrusion will continue.

CHAPTER V. CONSTRUCTION ACTIVITIES AFFECTING WATER SUPPLY CONDITIONS

Although construction activities are not in themselves items of water supply, they will in the future directly affect water supply conditions in the Southern California District area. For this reason, a brief outline of important activities occurring in these fields during the 1956-57 season is presented below.

Construction of Dams

Construction was completed on several dams during 1956-57, and construction was initiated on other projects which are now in various stages of completion. The majority of these facilities are being constructed for water conservation and/or flood control purposes. In Table 24, there are listed the various dam projects with reservoir storage capacities over 100 acre-feet in the southern California area which have been under construction during the 1956-57 water year, together with approximate dates of starting and completion, and the agency responsible for the work.

TABLE 24

DAM PROJECTS* COMPLETED OR UNDER CONSTRUCTION
DURING WATER YEAR 1956-57

Dam project	Construction period: Started	Construction period: Completed	Agency responsible for construction	Purpose	Location	Reservoir capacity, in acre-feet
Twitchell Dam (Vaquero)	6-56	Incomplete	U.S. Bureau of Reclamation	Conservation and flood control	Cuyama River Santa Barbara and San Luis Obispo Counties	239,000
Casitas Dam	8-56	Incomplete	U.S. Bureau of Reclamation	Conservation	Coyote Creek Ventura County	250,000
Little Mountain Dam	9-57	Incomplete	San Bernardino County Flood Control District	Flood control	Devil Canyon San Bernardino County	150
Pigeon Pass Dam	6-57	Incomplete	Riverside County Flood Control and Water Conservation District	Flood control	Pigeon Pass Creek Riverside County	910
Alessandro Dam	6-56	12-56	Riverside County Flood Control and Water Conservation District	Flood control	Alessandro Creek Riverside County	370
Pleasant Valley Dam	5-54	8-57	L.A. Department of Water and Power	Flow regulation and terminal storage	Owens River north of Bishop Inyo County	3,825
Palo Verde Diversion Dam	2-56	Incomplete	U. S. Bureau of Reclamation	Diversion for irrigation	Colorado River at Blythe	None

DAM PROJECTS* COMPLETED OR UNDER CONSTRUCTION
DURING WATER YEAR 1956-57
(continued)

Dam project	Construction period		Agency responsible for construction	Purpose	Location	Reservoir capacity, in acre-feet
	Started	Completed				
San Marcos Dam	8-57	Incomplete	San Marcos County Water District	Terminal storage	Tributary San Marcos Creek San Diego County	320
Grossmont Dam (enlargement)	1-57	8-57	Helix Irrigation District	Terminal storage	Alvarado Creek Tributary San Diego River San Diego County	350

* Greater than 100 acre-feet capacity.

Major Distribution Facilities

The Metropolitan Water District of Southern California continued work during 1956-57 on its expansion program, designed to complete Colorado River Aqueduct facilities to carry their full 1,212,000 acre-foot annual entitlement from the Colorado River to the coastal area. The initial construction program, completed in 1939, provided tunnels, canals, and conduits sized to carry the full entitlement, but provided only one of the two barrels required for each siphon and an initial pumping capacity of only 600 cubic feet per second through three pumps at each of five stations. During the past year, two additional pumps were installed at each of the five pumping stations and installation of the sixth pump was initiated. These two additional pumps increased total installed capacity of each plant to 1,000 cubic feet per second. Contracts were awarded in January, 1957, for construction of 47 siphons comprising the second barrel of the double-barrel siphons for that portion of the aqueduct east of the San Jacinto Tunnel. The siphons, which total 12.1 miles in length, are scheduled for completion in December, 1958. The remaining 10 miles of the second barrel of the two-barrel siphon westerly of San Jacinto tunnel will be constructed at a future date.

In connection with alternate route studies conducted pursuant to Item 419.5 of the Budget Act of 1956, the Department of Water Resources completed its investigation of alternative aqueduct routes to San Diego County in February, 1957. The report for this investigation was Bulletin 61, entitled "Investigation of Alternative Aqueduct Routes to San Diego County". Pursuant to the recommendations presented in this bulletin, The Metropolitan Water District of Southern California and the San Diego County Water Authority proceeded with plans for a second San Diego Aqueduct.

This aqueduct, which will more than double the capacity of facilities to import water to San Diego County, will extend approximately 95 miles from its junction with the Colorado River Aqueduct near San Jacinto to Lower Otay Reservoir. The north portion of the aqueduct, to be constructed by The Metropolitan Water District of Southern California, will extend a distance of about 34 miles to a point about six miles south of the county line. The remainder of the aqueduct in San Diego County will be constructed by the San Diego County Water Authority.

Several portions of the distribution system of The Metropolitan Water District of Southern California were completed during the year. Additions to the Lower Feeder include 0.8 mile of line extending westerly from a point 18.5 miles west of Lake Mathews to the Santiago lateral turnout, as well as the Santiago lateral which extends 8.8 miles south to Santiago Reservoir. This section of the feeder, completed in November of 1956, has made possible the delivery of unsoftened Colorado River water to the Santa Ana River within Orange County for replenishment of this County's ground water supplies. Prior to this time, imported Colorado River water was released into the Santa Ana River for Orange County at Pedley Bridge near Arlington in Riverside County. A second portion of the Lower Feeder, extending from South Gate easterly 11.7 miles to the Los Angeles County boundary, as well as a 4.3-mile extension of the West Orange County Feeder northly to a junction with the Lower Feeder, increased by approximately 50 per cent the quantity of softened water available to Orange County users, and eased a shortage which had existed for several years.

The 21.1-mile section of the Middle Feeder from La Verne to Garvey Reservoir has been under construction throughout the entire year under three contracts. The last segment of this work was scheduled for completion on

November 30, 1957. The most easterly 5.4-mile section of the Middle Cross Feeder that extends westerly from the Middle Feeder in South Gate to the Palos Verdes Feeder was completed on November 23, 1956.

During 1956-57, the Los Angeles Department of Water and Power began the construction of an additional 4.1 miles of the Granada Trunk Line. This line is to extend from the Los Angeles Aqueduct above Van Norman Lake approximately 20 miles to a terminal reservoir or reservoirs to be established in the western San Fernando Valley.

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

ER SUPPLY CONDITIONS IN SOUTHERN
CALIFORNIA DURING 1956-57

LOCATION OF
OUTHERN CALIFORNIA DISTRICT

SCALE OF MILES
40 0 40 80

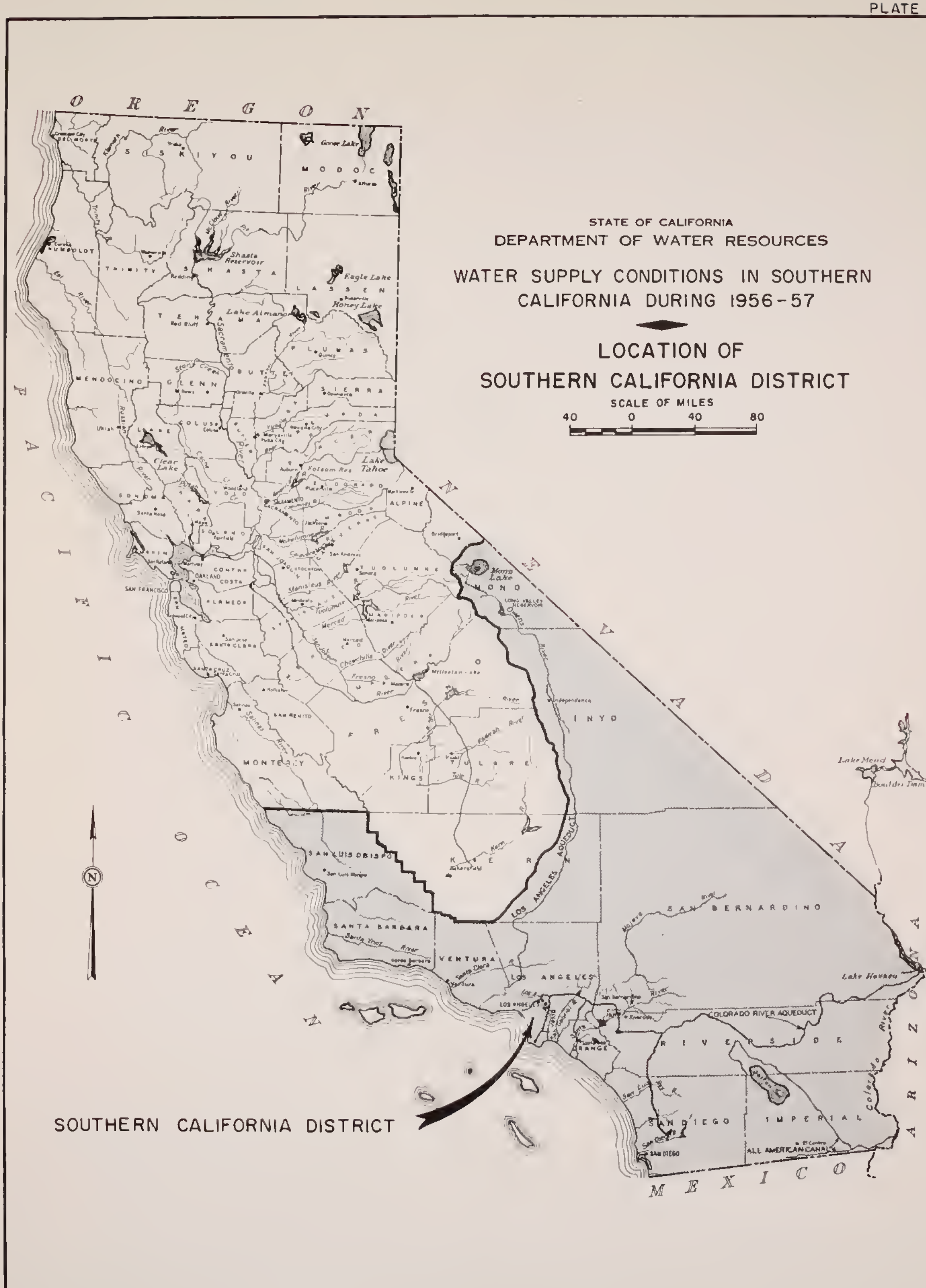
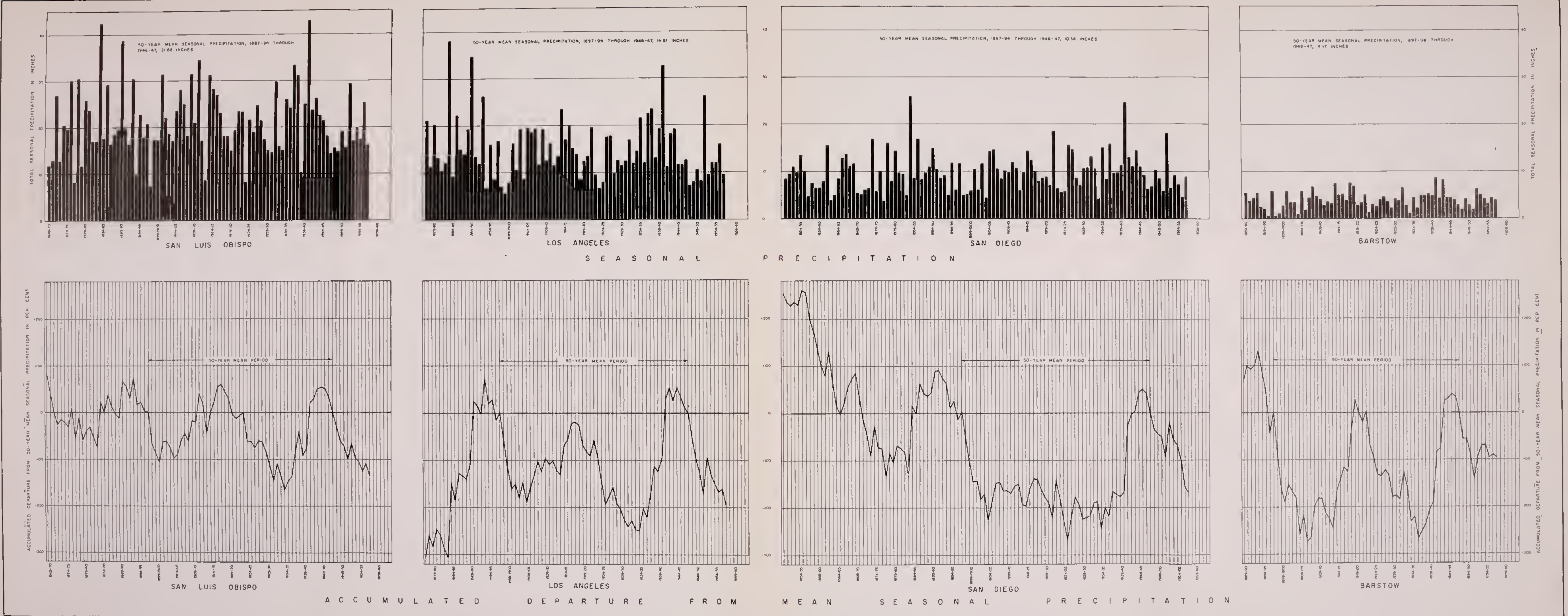
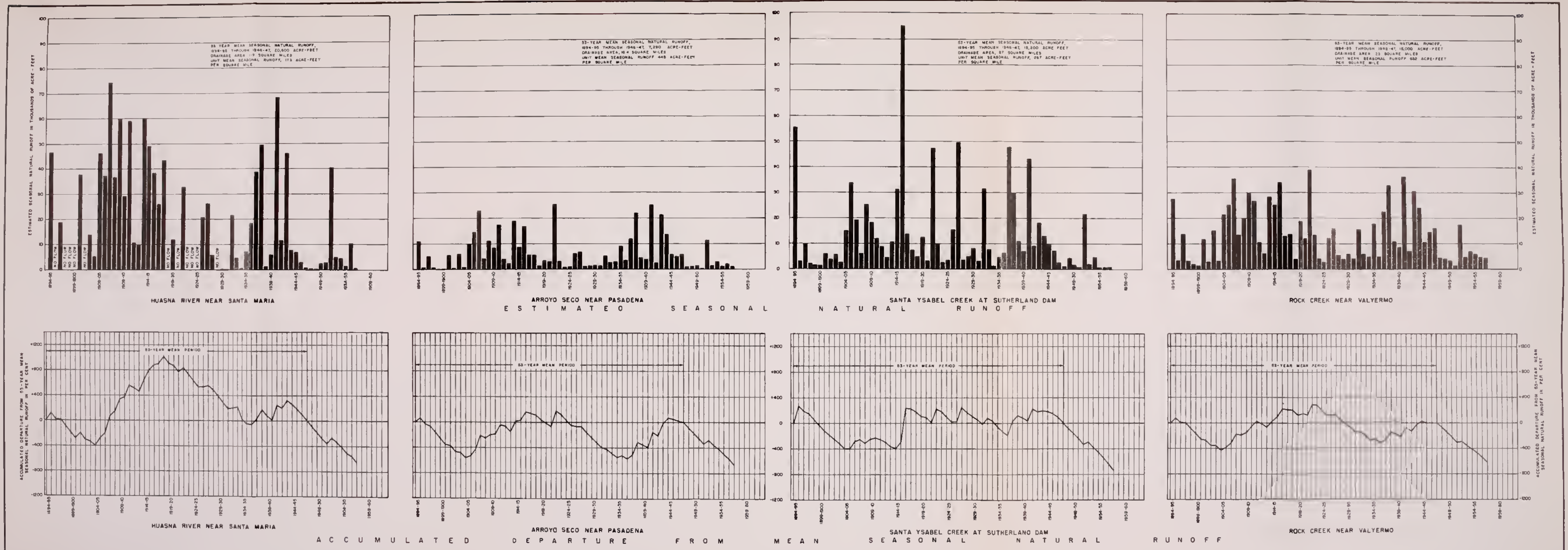

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
WATER SUPPLY CONDITIONS IN SOUTHERN CALIFORNIA DURING 1956-57
LOCATION OF SOUTHERN CALIFORNIA DISTRICT
SCALE OF MILES
40 0 40 80
OREGON
NEVADA
ARIZONA
MEXICO
PACIFIC OCEAN
SOUTHERN CALIFORNIA DISTRICT
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
MENDOCINO
GLENN
BUTTE
SIERRA
COLUSA
LAKE
SONOMA
YOLO
NAPA
SOLANO
MARIN
CONTRA COSTA
SAN FRANCISCO
OAKLAND
ALAMEDA
ALPINE
TUOLUMNE
MONO
MARIPOSA
INYO
FRESNO
KINGS
TULARE
MONTEREY
SAN BENITO
SAN LUIS OBISPO
KERN
SANTA BARBARA
VENTURA
LOS ANGELES
SAN BERNARDINO
RIVERSIDE
ORANGE
SAN DIEGO
IMPERIAL
Shasta Reservoir
Eagle Lake
Honey Lake
Lake Almanor
Goose Lake
Clear Lake
Folsom Res.
Lake Tahoe
Mono Lake
Lake Mead
Boulder Dam
Lake Havasu
LOS ANGELES AQUEDUCT
COLORADO RIVER AQUEDUCT
ALL AMERICAN CANAL
Colorado River

PLATE 2

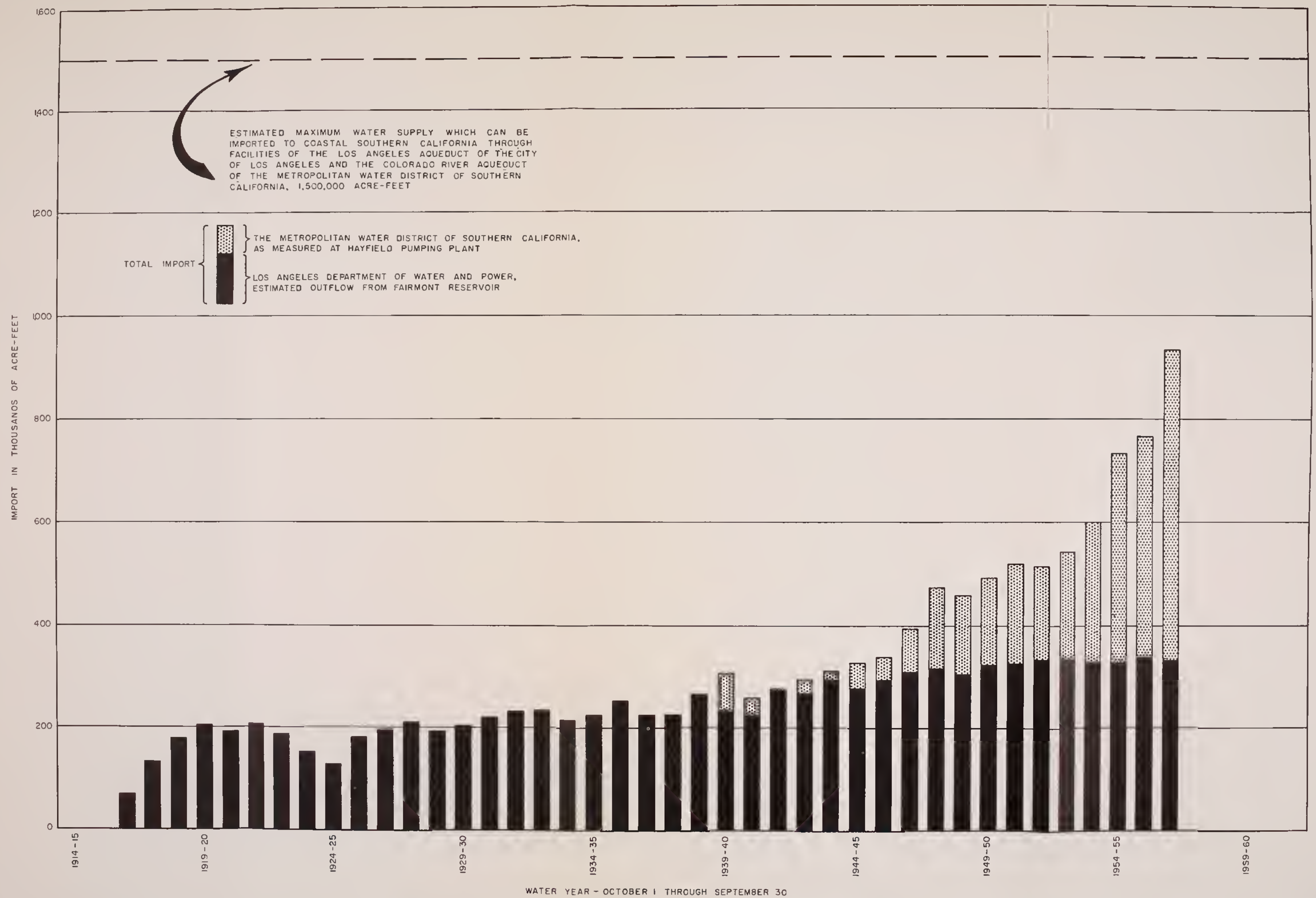

LEGEND
ZONES OF INTENSITY OF PRECIPITATION
MEAN ANNUAL PRECIPITATION FOR 50 YEAR PERIOD 1897-1947
LESS THAN 10 INCHES
10 TO 20 INCHES
20 TO 30 INCHES
MORE THAN 30 INCHES
20 ISOHYETAL LINES FOR 50 YEAR PERIOD
SOUTHERN CALIFORNIA DISTRICT BOUNDARY
80 PRECIPITATION DISTRIBUTION IN PER CENT OF MEAN JULY 1, 1956-JUNE 30, 1957
PACIFIC OCEAN
LOS ANGELES
SAN DIEGO
SALTON SEA
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
WATER SUPPLY CONDITIONS IN SOUTHERN CALIFORNIA DURING 1956-57
SEASONAL PRECIPITATION DISTRIBUTION FOR 1956-57 IN PER CENT OF 50-YEAR MEAN
SCALE OF MILES
20 10 0 20 40



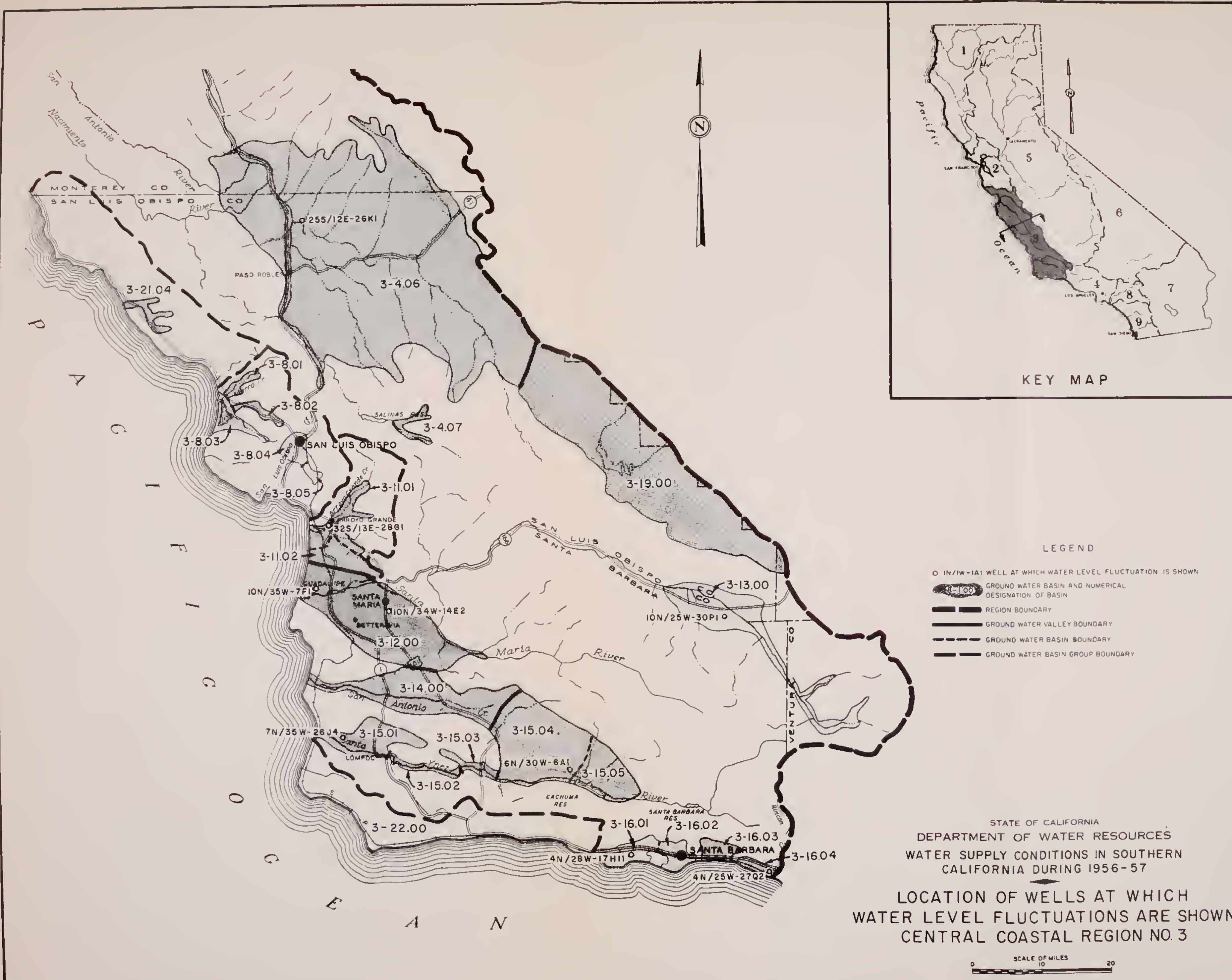
REPRESENTATIVE PRECIPITATION CHARACTERISTICS IN SOUTHERN CALIFORNIA



REPRESENTATIVE RUNOFF CHARACTERISTICS IN SOUTHERN CALIFORNIA



HISTORIC ANNUAL SUPPLY OF WATER IMPORTED TO COASTAL SOUTHERN CALIFORNIA



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
WATER SUPPLY CONDITIONS IN SOUTHERN CALIFORNIA DURING 1956-57

LOCATION OF WELLS AT WHICH WATER LEVEL FLUCTUATIONS ARE SHOWN
CENTRAL COASTAL REGION NO. 3

NUMERICAL DESIGNATIONS OF
GROUND WATER VALLEYS AND BASINS

4-1.00	Upper Ojai Valley
4-2.00	Ojai Valley
4-3.00	Ventura River Valley
4-3.01	Lower Ventura River Basin
4-3.02	Upper Ventura River Basin
4-4.00	Santa Clara River Valley
4-4.01	Oxnard Plain Pressure Area
4-4.02	Oxnard Plain Forebay Area
4-4.03	Mound Pressure Area
4-4.04	Santa Paula Basin
4-4.05	Fillmore Basin
4-4.06	Piru Basin
4-4.07	Eastern Basin
4-5.00	Acton Valley
4-6.00	Pleasant Valley
4-7.00	Arroyo Santa Rosa Valley
4-8.00	Las Posas Valley
4-8.01	West Las Posas Basin
4-8.02	East Las Posas Basin
4-9.00	Simi Valley
4-10.00	Conejo Valley
4-11.00	Coastal Plain (Los Angeles County)
4-11.01	West Coast Basin North
4-11.02	West Coast Basin
4-11.03	Central Coastal Plain Pressure Area
4-11.04	Los Angeles Forebay Area
4-11.05	Montebello Forebay Area
4-11.06	Hollywood Basin
4-11.07	Los Angeles Narrows Basin
4-11.08	La Habra Basin
4-12.00	San Fernando Valley
4-12.01	San Fernando Basin
4-12.02	Bull Canyon Basin
4-12.03	Sylmar Basin
4-12.04	Pacoima Basin
4-12.05	Tujunga Basin
4-12.06	Little Tujunga Basin
4-12.07	Verdugo Basin
4-13.00	San Gabriel Valley
4-13.01	Main San Gabriel Basin
4-13.02	Monk Hill Basin
4-13.03	Pasadena Subarea
4-13.04	Santa Anita Subarea
4-13.05	Upper Canyon Basin
4-13.06	Lower Canyon Basin
4-13.07	Glendora Basin
4-13.08	Way Hill Basin
4-13.09	San Dimas Basin
4-13.10	Foothill Basin
4-13.11	Spadra Basin
4-13.12	Puente Basin
4-14.00	Upper Santa Ana Valley (Los Angeles County)
4-14.01	Chino Basin
4-14.02	Pomona Basin
4-14.03	Live Oak Basin
4-14.04	Claremont Heights Basin
4-15.00	Tierra Rejada Valley
4-16.00	Malibu Coastal Group
4-16.01	Hidden Valley Basin
4-16.02	Russell Basin
4-16.05	Arroyo Sequit Canyon Basin
4-16.09	Trancas Canyon Basin
4-16.10	Zuma Canyon Basin
4-16.11	Ramera Canyon Basin
4-16.16	Malibu Creek Basin
4-16.19	Las Flores Canyon Basin
4-16.20	Piedra Gorda Canyon Basin
4-16.25	Las Virgenes Canyon Basin

PLATE 8

NUMERICAL DESIGNATIONS OF
GROUND WATER VALLEYS AND BASINS

6-9.00 Mono Valley
6-10.00 Adobe Lake Valley
6-11.00 Long Valley
6-12.00 Owens Valley
6-13.00 Black Springs Valley
6-14.00 Fish Lake Valley
6-15.00 Deep Springs Valley
6-16.00 Eureka Valley
6-17.00 Saline Valley
6-18.00 Death Valley
6-19.00 Wingate Valley
6-20.00 Middle Amargosa Valley
6-21.00 Lower Kingston Valley
6-22.00 Upper Kingston Valley
6-23.00 Riggs Valley
6-24.00 Red Pass Valley
6-25.00 Bicycle Valley
6-26.00 Avawatz Valley
6-27.00 Leach Valley
6-28.00 Pahrump Valley
6-29.00 Mesquite Valley
6-30.00 Ivanpah Valley
6-31.00 Kelso Valley
6-32.00 Broadwell Valley
6-33.00 Soda Lake Valley
6-34.00 Silver Lake Valley
6-35.00 Cronise Valley
6-36.00 Langford Valley
6-37.00 Coyote Lake Valley
6-38.00 Caves Canyon Valley
6-39.00 Troy Valley
6-40.00 Lower Mojave River Valley
6-41.00 Middle Mojave River Valley
6-42.00 Upper Mojave River Valley
6-43.00 El Mirage Valley
6-44.00 Antelope Valley
- 6-44.01 Neenach Basin
- 6-44.02 Willow Springs Basin
- 6-44.03 Gloster Basin
- 6-44.04 Chaffee Basin
- 6-44.05 Lancaster Basin
- 6-44.06 Buttes Basin
- 6-44.07 Rock Creek Basin
- 6-44.08 North Muroc Basin

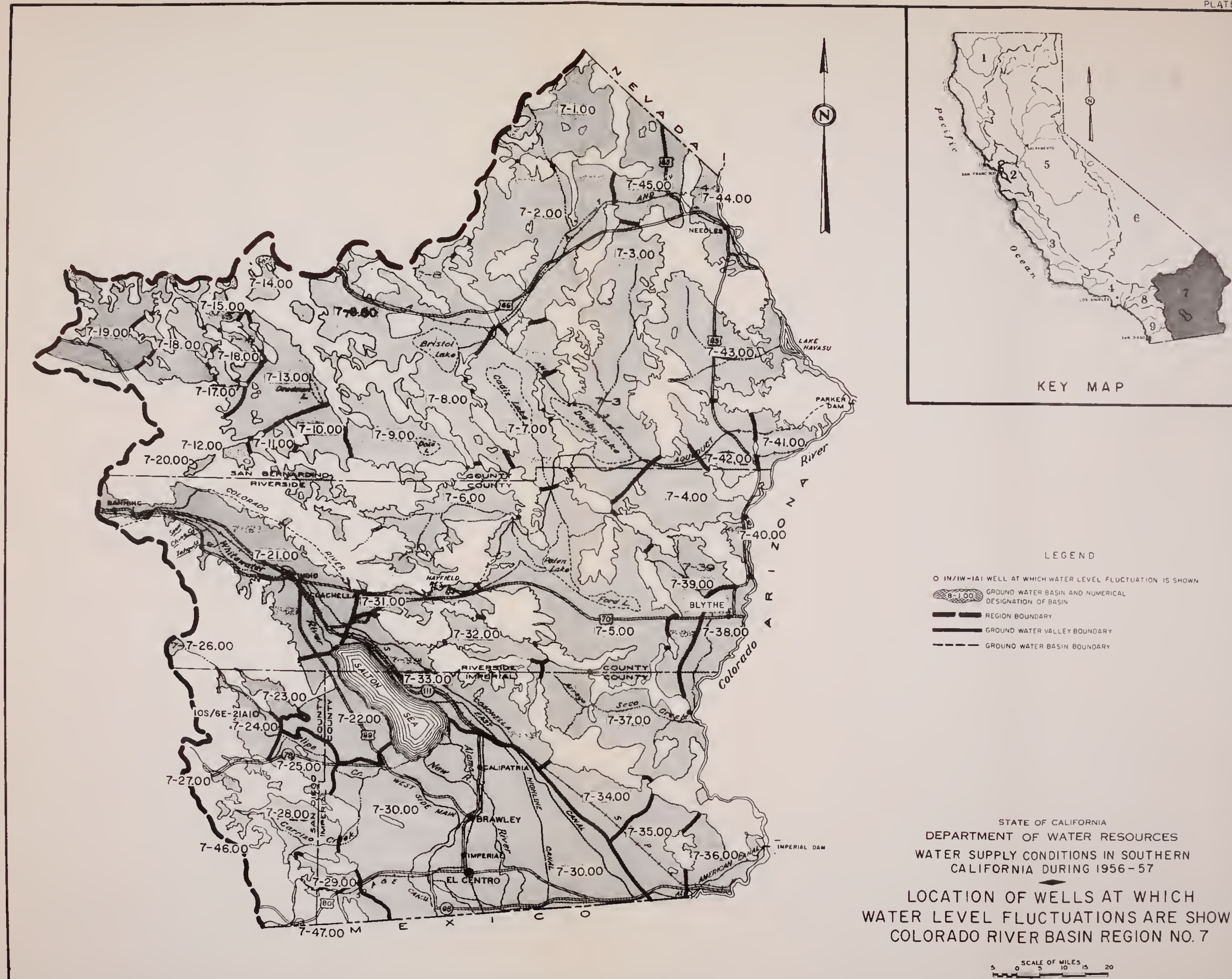
6-45.00 Tehachapi Valley East
6-46.00 Fremont Valley
6-47.00 Harper Valley
6-48.00 Goldstone Valley
6-49.00 Superior Valley
6-50.00 Cuddeback Valley
6-51.00 Pilot Knob Valley
6-52.00 Searles Valley
6-53.00 Salt Wells Valley
6-54.00 Indian Wells Valley
6-55.00 Coso Valley
6-56.00 Rose Valley
6-57.00 Darwin Valley
6-58.00 Panamint Valley

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
WATER SUPPLY CONDITIONS IN SOUTHERN CALIFORNIA DURING 1956-57

LOCATION OF WELLS AT WHICH WATER LEVEL FLUCTUATIONS ARE SHOWN
LAHONTAN REGION NO 6

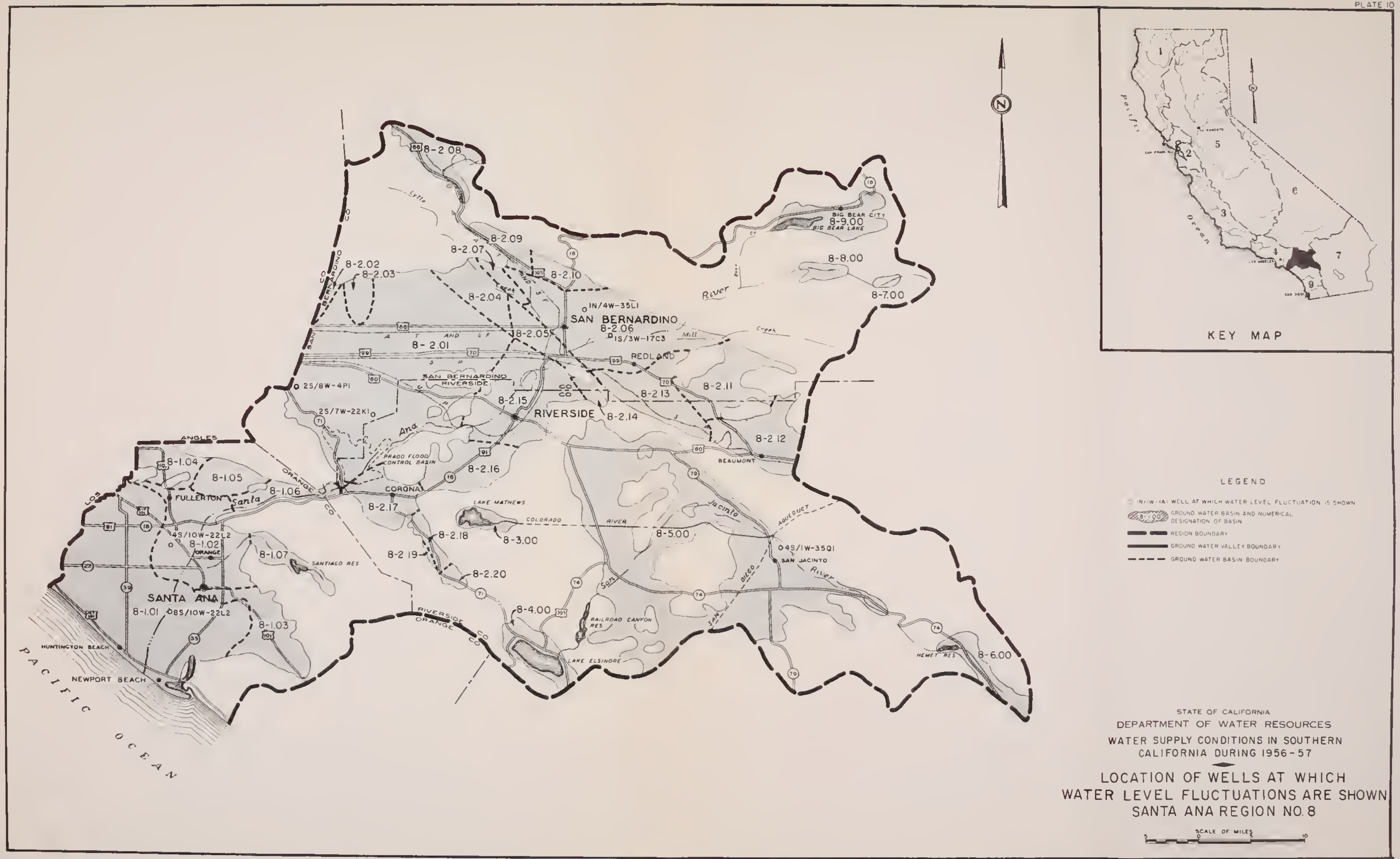
NUMERICAL DESIGNATIONS OF
GROUND WATER VALLEYS AND BASINS

7-1.00	Lanfair Valley
7-2.00	Fenner Valley
7-3.00	Ward Valley
7-4.00	Rice Valley
7-5.00	Chuckawalla Valley
7-6.00	Pinto Valley
7-7.00	Cadiz Valley
7-8.00	Bristol Valley
7-9.00	Dale Valley
7-10.00	Twentynine Palms Valley
7-11.00	Copper Mountain Valley
7-12.00	Warren Valley
7-13.00	Deadman Valley
7-14.00	Lavic Valley
7-15.00	Bessemer Valley
7-16.00	Ames Valley
7-17.00	Means Valley
7-18.00	Johnson Valley
7-19.00	Lucerne Valley
7-20.00	Morongo Valley
7-21.00	Coachella Valley
7-22.00	West Salton Sea Valley
7-23.00	Clark Valley
7-24.00	Borrego Valley
7-25.00	Ocotillo Valley
7-26.00	Terwilliger Valley
7-27.00	San Felipe Valley
7-28.00	Vallecito-Carrizo Valley
7-29.00	Coyote Wells Valley
7-30.00	Imperial Valley
7-31.00	Orocopia Valley
7-32.00	Chocolate Valley
7-33.00	East Salton Sea Valley
7-34.00	Amos Valley
7-35.00	Ogilby Valley
7-36.00	Yuma Valley
7-37.00	Arroyo Seco Valley
7-38.00	Palo Verde Valley
7-39.00	Palo Verde Mesa
7-40.00	Quien Sabe Point Valley
7-41.00	Calzona Valley
7-42.00	Vidal Valley
7-43.00	Chemehuevis Valley
7-44.00	Needles Valley
7-45.00	Piute Valley
7-46.00	Canebrake Valley
7-47.00	Jacumba Valley



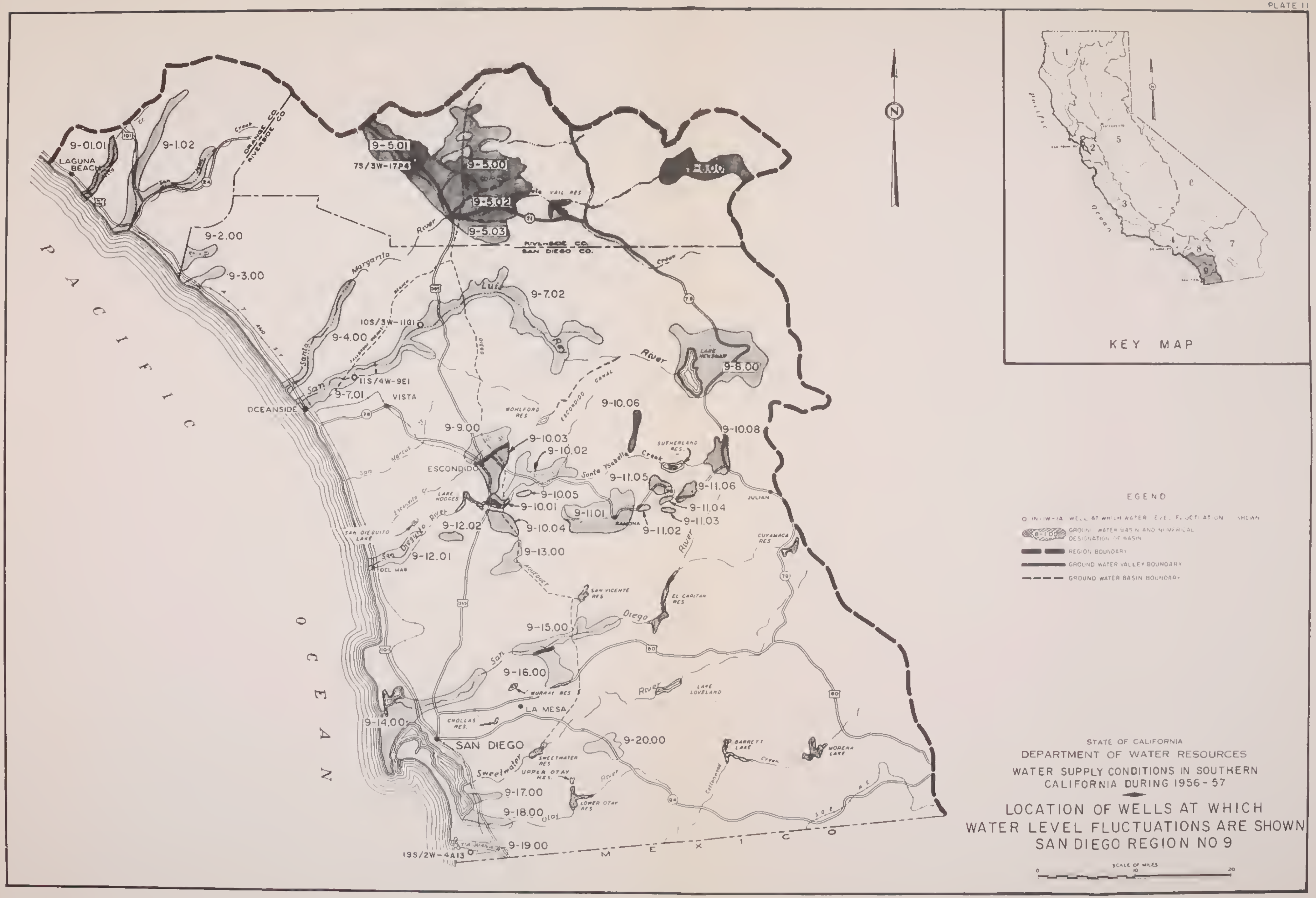
NUMERICAL DESIGNATIONS OF
GROUND WATER VALLEYS AND BASINS

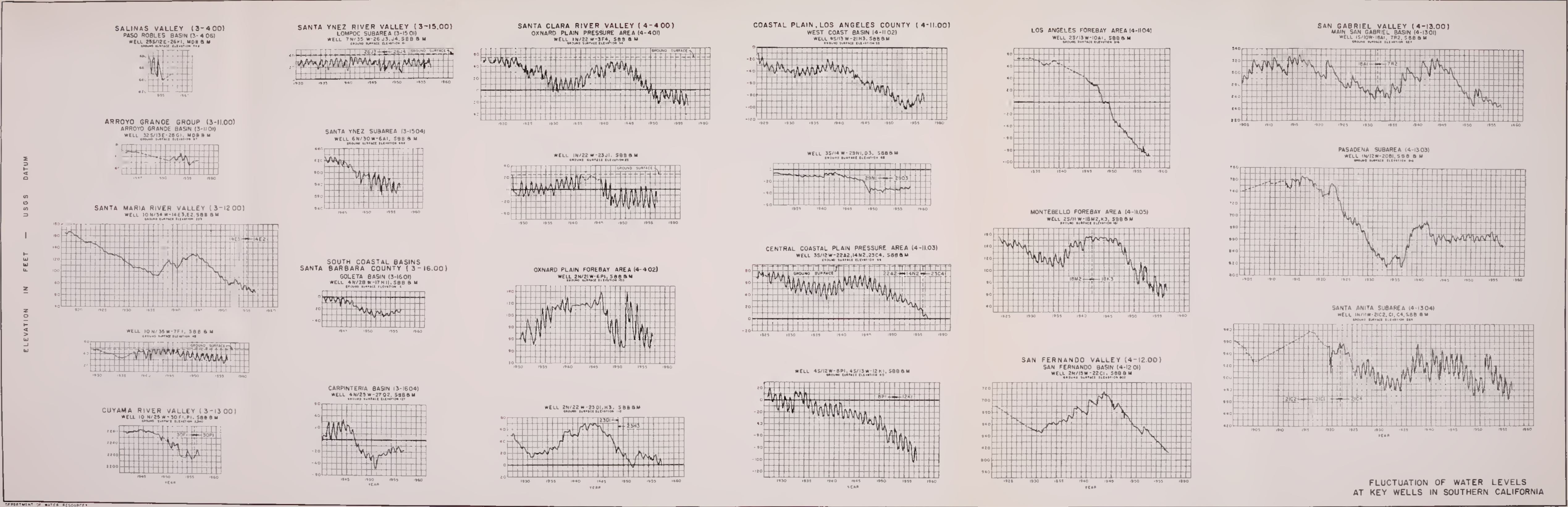
8-1.00	Coastal Plain (Orange County)	
	8-1.01	East Coastal Plain Pressure Area
	8-1.02	Santa Ana Forebay Area
	8-1.03	Irvine Basin
	8-1.04	La Habra Basin
	8-1.05	Yorba Linda Basin
	8-1.06	Santa Ana Narrows Basin
	8-1.07	Santiago Basin
8-2.00	Upper Santa Ana Valley	
	8-2.01	Chino Basin
	8-2.02	Claremont Heights Basin
	8-2.03	Cucamonga Basin
	8-2.04	Rialto Basin
	8-2.05	Colton Basin
	8-2.06	Bunker Hill Basin
	8-2.07	Lytle Basin
	8-2.08	Upper Cajon Basin
	8-2.09	Lower Cajon Basin
	8-2.10	Devil Canyon Basin
	8-2.11	Yucaipa Basin
	8-2.12	Beaumont Basin
	8-2.13	San Timoteo Basin
	8-2.14	Reche Canyon Basin
	8-2.15	Riverside Basin
	8-2.16	Arlington Basin
	8-2.17	Temescal Basin
	8-2.18	Bedford Basin
	8-2.19	Coldwater Basin
	8-2.20	Lee Lake Basin
8-3.00	Cajalco Valley	
8-4.00	Elsinore Valley	
8-5.00	San Jacinto Valley	
8-6.00	Hemet Lake Valley	
8-7.00	Big Meadows Valley	
8-8.00	Seven Oaks Valley	
8-9.00	Bear Valley	



NUMERICAL DESIGNATIONS OF
GROUND WATER VALLEYS AND BASINS

9-1.00	San Juan Valley	
9-1.01		Aliso Creek Basin
9-1.02		San Juan Creek Basin
9-2.00	San Mateo Valley	
9-3.00	San Onofre Valley	
9-4.00	Santa Margarita Valley	
9-5.00	Temecula Valley	
9-5.01		Murrieta Basin
9-5.02		Pauba Basin
9-5.03		Wolf Basin (Pechanga)
9-6.00	Coahuila Valley	
9-7.00	San Luis Rey Valley	
9-7.01		Mission Basin
9-7.02		Bonsall Basin
9-8.00	Warner Valley	
9-9.00	Escondido Valley	
9-10.00	San Pasqual Valley	
9-10.01		Lake Hodges Basin
9-10.02		San Pasqual Basin
9-10.03		Felicita Basin
9-10.04		Green Basin
9-10.05		Highland Basin
9-10.06		Pamo Basin
9-10.08		Santa Ysabel Basin
9-11.00	Santa Maria Valley	
9-11.01		Ramona Basin
9-11.02		Lower Hatfield Basin
9-11.03		Wash Hollow Basin
9-11.04		Upper Hatfield Basin
9-11.05		Santa Teresa Basin
9-11.06		Ballena Basin
9-12.00	San Dieguito Valley	
9-12.01		San Dieguito Basin
9-12.02		La Jolla Basin
9-13.00	Poway Valley	
9-14.00	Mission Valley	
9-15.00	San Diego River Valley	
9-16.00	El Cajon Valley	
9-17.00	Sweetwater Valley	
9-18.00	Otay Valley	
9-19.00	Tia Juana Valley	
9-20.00	Jamul Valley	

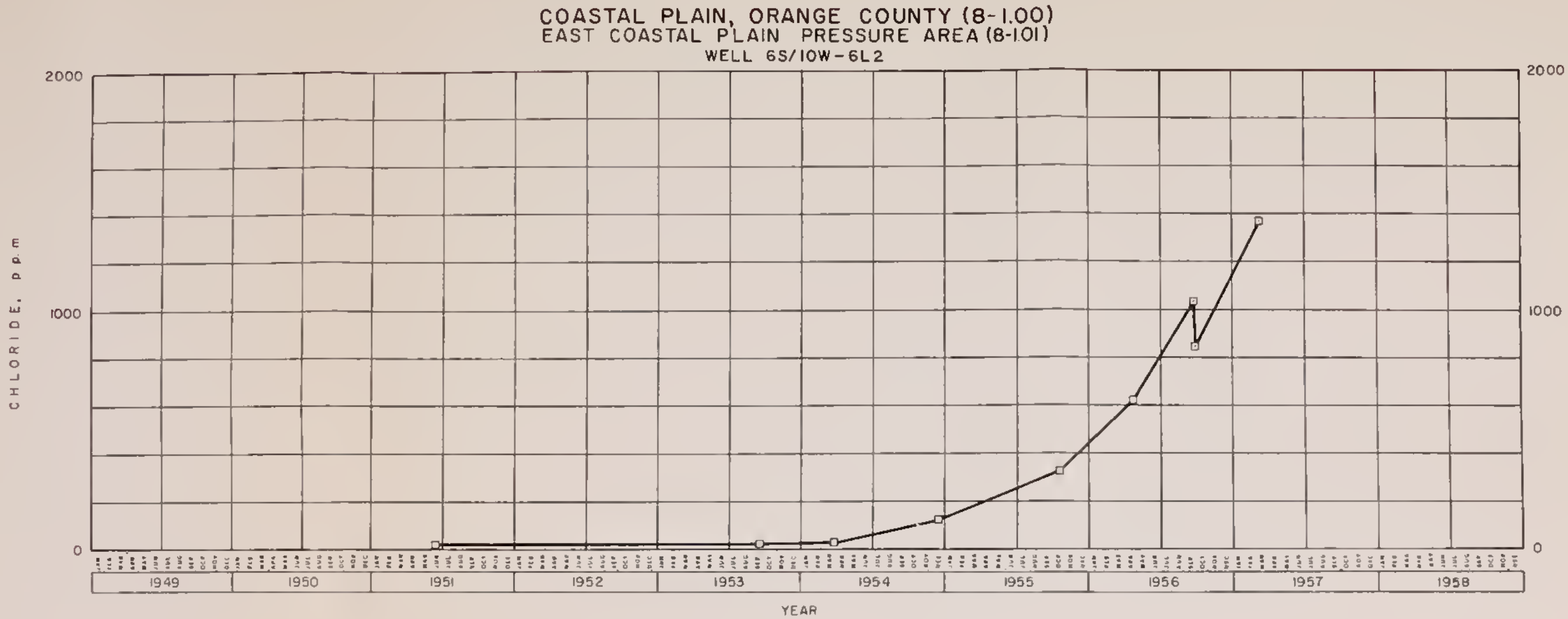


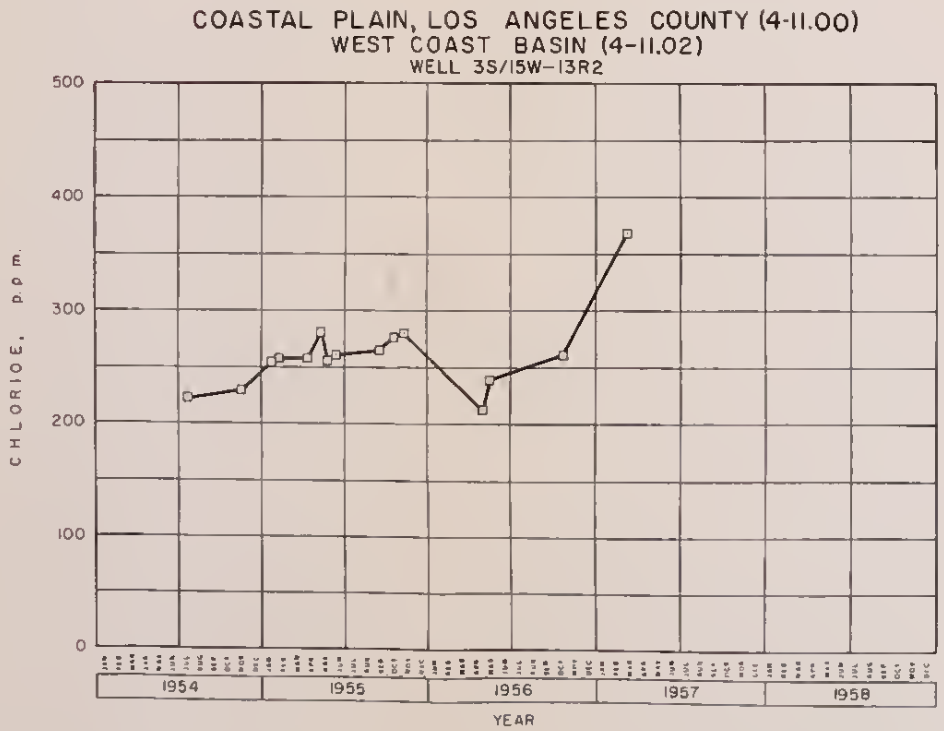


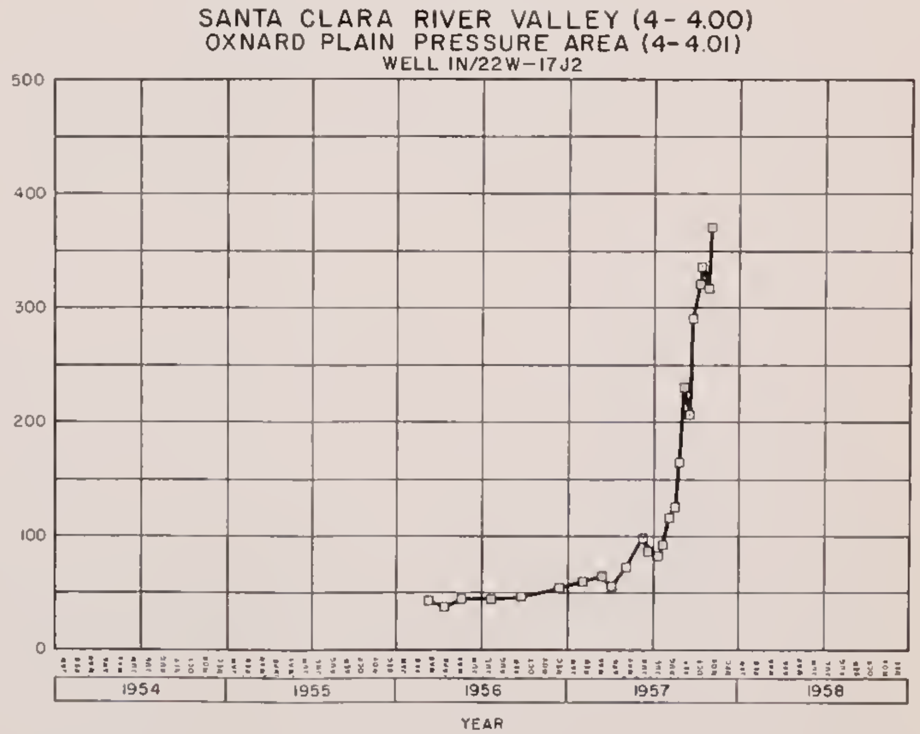
FLUCTUATION OF WATER LEVELS
AT KEY WELLS IN SOUTHERN CALIFORNIA

FLUCTUATION OF WATER LEVELS
AT KEY WELLS IN SOUTHERN CALIFORNIA

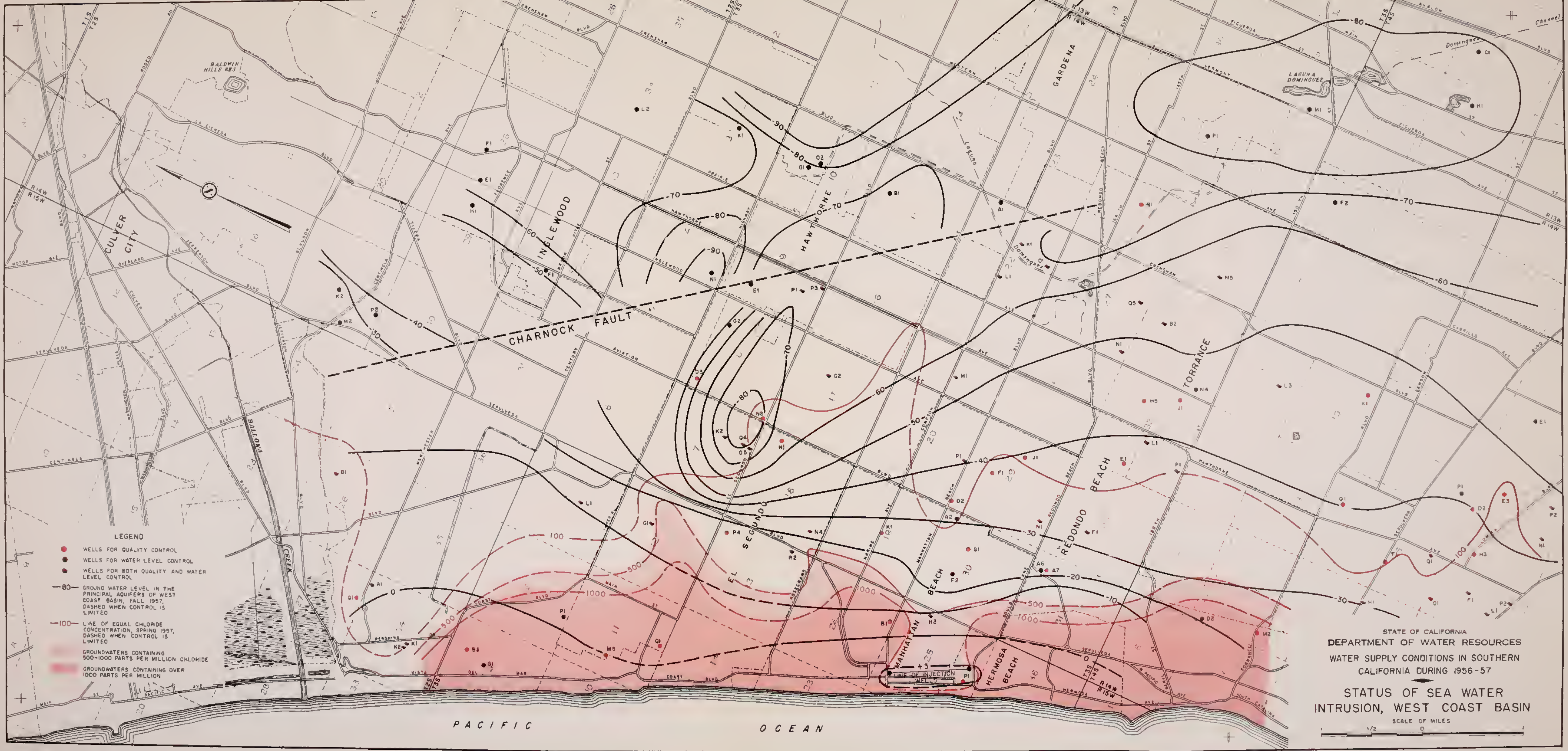

LEGEND
CITY BOUNDARY
RESERVATION BOUNDARY
EDGE OF NONWATER-BEARING AREA (HILLS)
WELLS FOR QUALITY CONTROL
WELLS FOR WATER LEVEL CONTROL
WELLS FOR BOTH QUALITY AND WATER LEVEL CONTROL
40 GROUND WATER LEVEL IN THE OXNARD AQUIFER, SUMMER 1957, DASHED WHEN CONTROL IS LIMITED
100 LINE OF EQUAL CHLORIDE CONCENTRATION, SUMMER 1957, DASHED WHEN CONTROL IS LIMITED
GROUNDWATERS CONTAINING OVER 500 PARTS PER MILLION
PACIFIC OCEAN
OXNARD
PORT HUENEME
NAVAL RESERVATION
POINT MUGU NAVAL RESERVATION
MUGU LAGOON
SOUTHERN PACIFIC RAILROAD
FIFTH STREET
WOOLEY ROAD
LAGUNA ROAD
PLEASANT VALLEY ROAD
HUENEME ROAD
R 23 W
R 22 W
R 21 W
T 1 N
T 1 S
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
WATER SUPPLY CONDITIONS IN SOUTHERN CALIFORNIA DURING 1956-57
STATUS OF SEA WATER INTRUSION
OXNARD PLAIN PRESSURE AREA
SCALE OF MILES
1/2
0

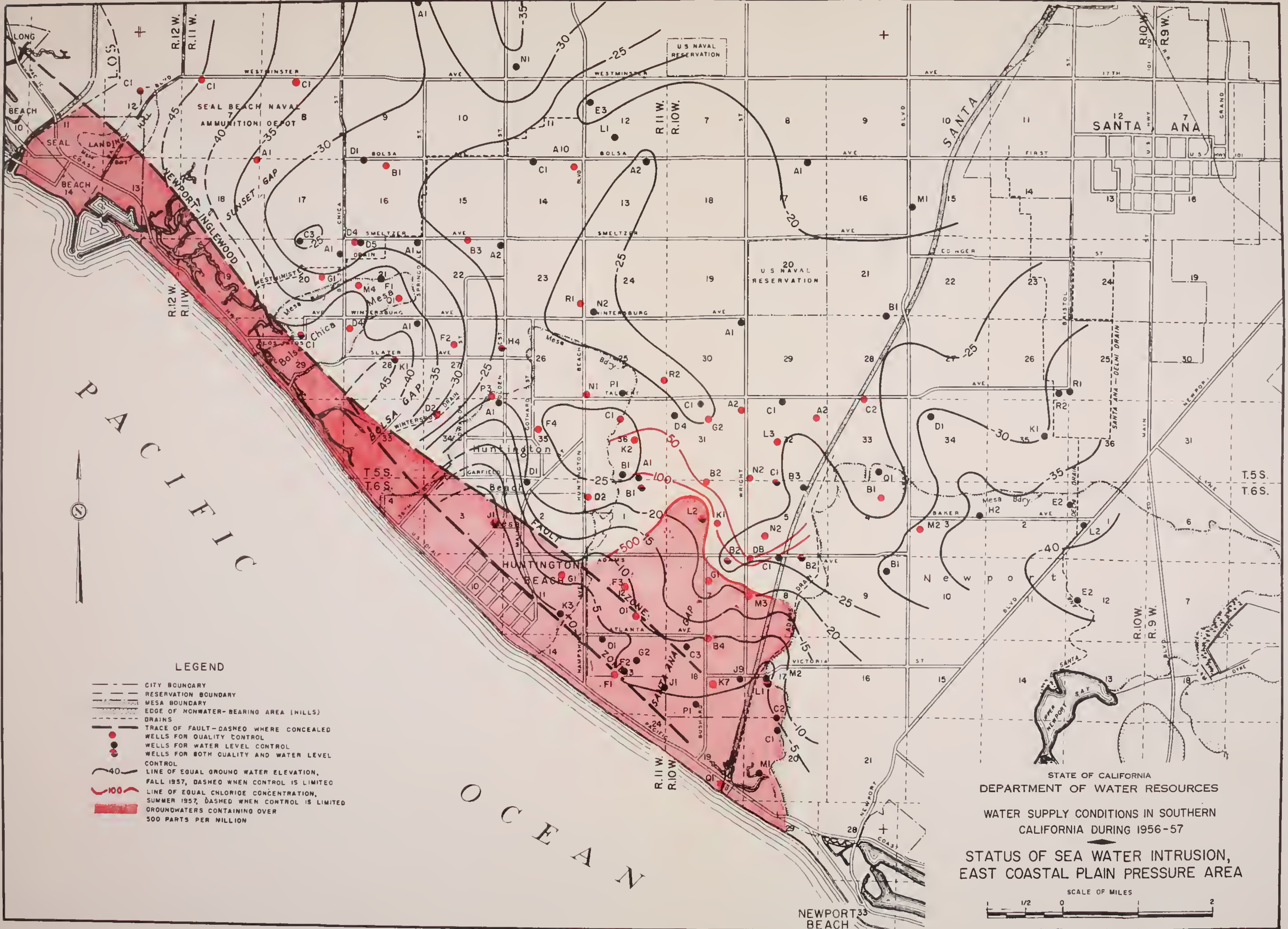






CHLORIDE FLUCTUATIONS IN SELECTED WELLS


LEGEND
WELLS FOR QUALITY CONTROL
WELLS FOR WATER LEVEL CONTROL
WELLS FOR BOTH QUALITY AND WATER LEVEL CONTROL
—80— GROUND WATER LEVEL IN THE PRINCIPAL AQUIFERS OF WEST COAST BASIN, FALL 1957, DASHED WHEN CONTROL IS LIMITED
—100— LINE OF EQUAL CHLORIDE CONCENTRATION, SPRING 1957, DASHED WHEN CONTROL IS LIMITED
GROUNDWATERS CONTAINING 500-1000 PARTS PER MILLION CHLORIDE
GROUNDWATERS CONTAINING OVER 1000 PARTS PER MILLION
CULVER CITY
INGLEWOOD
HAWTHORNE
GARDENA
TORRANCE
EL SEGUNDO
MANHATTAN BEACH
HERMOSA BEACH
REDONDO BEACH
CHARNOCK FAULT
LINE OF INJECTION WELLS
BALDWIN HILLS RES
LAGUNA DOMINGUEZ
BALLONA CREEK
PACIFIC OCEAN
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
WATER SUPPLY CONDITIONS IN SOUTHERN CALIFORNIA DURING 1956-57
STATUS OF SEA WATER INTRUSION, WEST COAST BASIN
SCALE OF MILES
1/2
0


PACIFIC OCEAN
SANTA ANA
HUNTINGTON BEACH
NEWPORT BEACH
SEAL BEACH NAVAL AMMUNITION DEPOT
U S NAVAL RESERVATION
NEWPORT-INGLEWOOD FAULT ZONE
SUNSET GAP
BOLSA GAP
SANTA ANA GAP
LEGEND
CITY BOUNDARY
RESERVATION BOUNDARY
MESA BOUNDARY
EDGE OF NONWATER-BEARING AREA (HILLS)
DRAINS
TRACE OF FAULT—DASHED WHERE CONCEALED
WELLS FOR QUALITY CONTROL
WELLS FOR WATER LEVEL CONTROL
WELLS FOR BOTH QUALITY AND WATER LEVEL CONTROL
LINE OF EQUAL GROUND WATER ELEVATION, FALL 1957, DASHED WHEN CONTROL IS LIMITED
LINE OF EQUAL CHLORIDE CONCENTRATION, SUMMER 1957, DASHED WHEN CONTROL IS LIMITED
GROUNDWATERS CONTAINING OVER 500 PARTS PER MILLION
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
WATER SUPPLY CONDITIONS IN SOUTHERN CALIFORNIA DURING 1956-57
STATUS OF SEA WATER INTRUSION, EAST COASTAL PLAIN PRESSURE AREA
SCALE OF MILES
1/2
0
2
T.5S.
T.6S.
R.12W.
R.11W.
R.10W.
R.9W.