United States Department of the Interior
Geological Survey
Water Resources Division
Surface Water Branch

Southern California Water Bulletin for 1953

General Review of the Water Resources of Southern California for the Water Year 1952-53 with Special Reference to the Surface Runoff for the Water Year 1951-52

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March, 1954

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Open-file report. Not reviewed for conformance with editorial standards of the Geological Survey

ILLUSTRATIONS

TABLES

GENERAL REVIEW OF THE WATER RESOURCES OF SOUTHERN CALIFORNIA
FOR THE WATER YEAR 1952-53
WITH SPECIAL REFERENCE TO THE SURFACE RUNOFF
FOR THE WATER YEAR 1951-52

INTRODUCTION

This WATER BULLETIN is one of a series issued annually since June 1944. Its main purpose is to present a brief analysis of those phases of the local water supply associated with the work of the Geological Survey. The first part of this review deals with the water resources for the water year ending September 30, 1953. It contains a brief analysis of the annual precipitation, the provisional runoff at a few stations, the changes in water reserves both in surface reservoirs and underground, and the imported waters. It concludes by pointing out the deficiences in the local water reserves. This bulletin has been prepared by the Surface Water Branch; the section on ground-water conditions was prepared chiefly from information supplied by the Ground Water Branch.

The second part of this review gives, in some detail, the runoff for the preceding water year ending September 30, 1952. It usually requires about one year of effort after the conclusion of a water year to obtain the complete computations of daily discharge for all of the gaging stations in southern California, because of the large amount of analytical work required. An additional six months to a year is required to process the data and present it in its published form in the annual Geological Survey Water-Supply Papers. Consequently this represents the first opportunity to release data on the magnitude of the runoff for all the stations now operated in southern California.

Some of the information presented in this bulletin was included in previous issues. The repetition is made so that the bulletin will be entirely independent of previous ones.

REVIEW OF WATER RESOURCES FOR WATER YEAR ENDING SEPTEMBER 30, 1953

Precipitation

Southern California's water supply, as in most areas, is dependent to a large degree upon the magnitude and distribution of local precipitation, records of which have been obtained by the U. S. Weather Bureau for many years. All precipitation records discussed in the WATER BULLETIN are for the climatic year ending June 30

The 1952-53 annual precipitation at three important regional stations having records of considerable length is presented in table 1. At San Diego the precipitation of 6.54 inches was 65 percent of the 103-year mean, with only 23 years during the period of record showing less precipitation. At Los Angeles the precipitation of 9.46 inches was 63 percent of the mean, with only 13 of the 76 years of record showing less rainfall. The precipitation of 13.44 inches at Santa Barbara was 75 percent of the 86-year mean, which indicates a smaller deficiency than the stations farther south. This is in marked contrast to the 1951-52 season when the precipitation of 18.16 inches at San Diego was fourth highest during the period of record, that of 26.21 inches at Los Angeles was fifth highest, and that of 31.23 inches at Santa Barbara was seventh highest.

Table 1.--Annual precipitation, in inches

Station	Period of record: Length in years	Period of record: Mean precipitation	Total precipitation 1952-53	Mean precipitation 10-yr. period 1943-53
San Diego	103	10.04	6.54	9.76
Los Angeles	76	15.13	9.46	12.48
Santa Barbara	86	17.98	13.44	14.72

In a semiarid and arid region such as southern California the annual precipitation distribution is extremely variable. Typical of this distribution is that obtained at San Diego where during 103 years of record the annual precipitation ranged from 3.87 inches in 1862-63 to 25.97 inches in 1883-84, with a mean of 10.04 inches. At Santa Barbara, where the record has been collected for 86 years, the precipitation ranged from 4.49 inches in 1876-77 to 45.21 inches in 1940-41, with a mean of 17.98 inches. If precipitation were distributed as alternating wet and dry years, many local water-supply problems would be simplified. However, this is not the case, as both wet and dry years tend to be associated with like years, producing a "cyclic" tendency in the precipitation distribution. The term "cyclic" is used here in a very loose sense as to both time and amplitude. One of the simplest ways to show this "cyclic" tendency is by plotting progressive 10-year means as shown in figure 1. In this graph, each plotted point represents the mean precipitation for the 10-year period indicated at the bottom of the diagram. The final column of table 1 gives the last 10-year value plotted on this "cyclic" diagram. The precipitation is expressed in terms of the "index of precipitation" which is merely the ratio of the individual 10-year mean to the average precipitation for the period of record.

Figure 1 shows that at Los Angeles the wettest 10-year mean occurred during the period 1883-93 when the mean precipitation was 20.32 inches. In contrast, the driest 10-year period was that of 1893-1903 with a mean annual precipitation of 11.50 inches.

The precipitation records for San Diego, Los Angeles, and Santa Barbara shown in figure 1 all indicate the same distinct "cyclic" tendency, with the "cycles" approximately 30 years in length. Tree-ring analysis a/ obtained from about 50 trees in

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a/ Schulman, Edmund, Tree-ring Hydrology in Southern California, University of Arizona, Laboratory of Tree-Ring Research, Bulletin 4, 1947.

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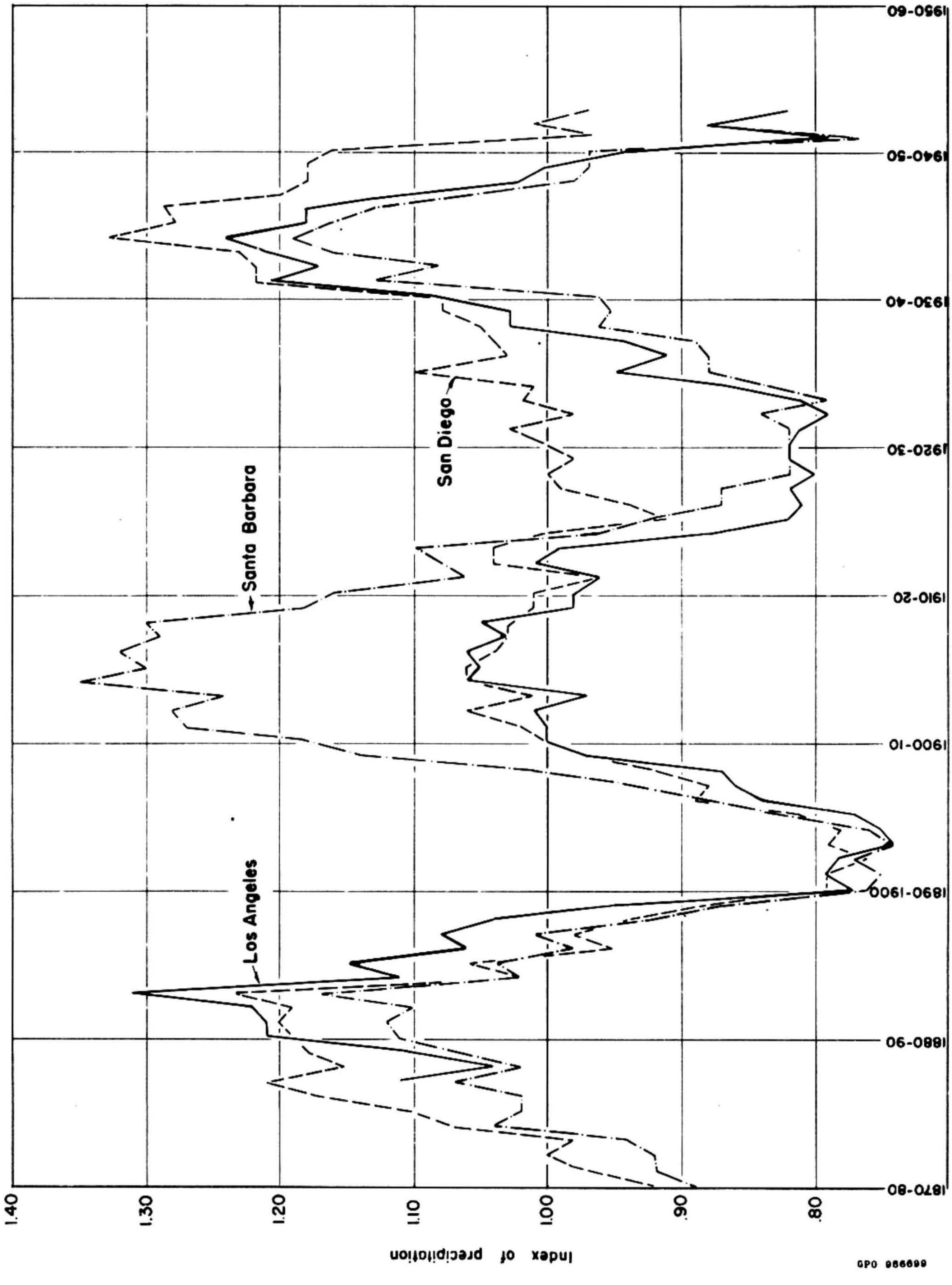
the mountains of southern California indicate that during the 559-year period extending from 1385 to 1944 the average length of dry periods was about 15 years and wet periods about 12 years. Thus the average length of a complete "cycle" was about 27 years. Individual dry periods range in length from 6 to more than 40 years, while individual wet periods range from 4 to more than 20 years.

Figure I Index of precipitation for progressive 10-year means



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Although some of the driest years observed in southern California occurred during the last 10 years, this period was not as critical as those 10-year periods between 1890-1900 and 1893-1903. However, as suggested by figure 1, the full extent of the current dry period apparently has not yet been reached, as the upward trend caused by the wet year of 1951-52 has been reversed by the dry year of 1952-53.

Runoff

Runoff is the residual of the basin-wide precipitation after the basin-wide natural water loss has been satisfied. Natural water loss is by evaporation, either directly from soil and water surfaces or from the leaves of plants (transpiration). Because the evapotranspiration demand is nearly constant from year to year, and because these processes have the first claim on any water that becomes available, the natural water loss is relatively constant; thus, it follows that the below-normal precipitation previously discussed would result in subnormal runoff. This is borne out by table 2 which gives the provisional annual runoff during the 1953 water year for 14 typical drainage areas in southern California.

Table 2 shows that the 1952-53 runoff is less than 50 percent of the mean at all those stations having a period of record of 17 years or more. Furthermore, the runoff pattern appears to vary from less than 20 percent of average in the southern part of southern California to between 20 and 50 percent in the northern part.

Annual runoff is subject to the same "cyclic" effects as the precipitation pattern shown in figure 1. However, it fluctuates through a much wider range than the annual precipitation. To illustrate the runoff distribution, the 58-year record of San Gabriel River near Azusa and the 57-year record of Santa Ana River near Mentone are presented in figure 2. They are typical of southern California mountain streams. As expected, they show extended and alternating periods of above- and below-average runoff.

By utilizing the cumulative departures from the mean annual runoff, these records have been segregated into wet and dry periods, as shown in figure 2. They include two wet and three complete or partially complete dry periods. The average annual runoff for each of these periods is shown by the cross-hatched areas.

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Figure 2 Annual runoff distribution 1896-1953

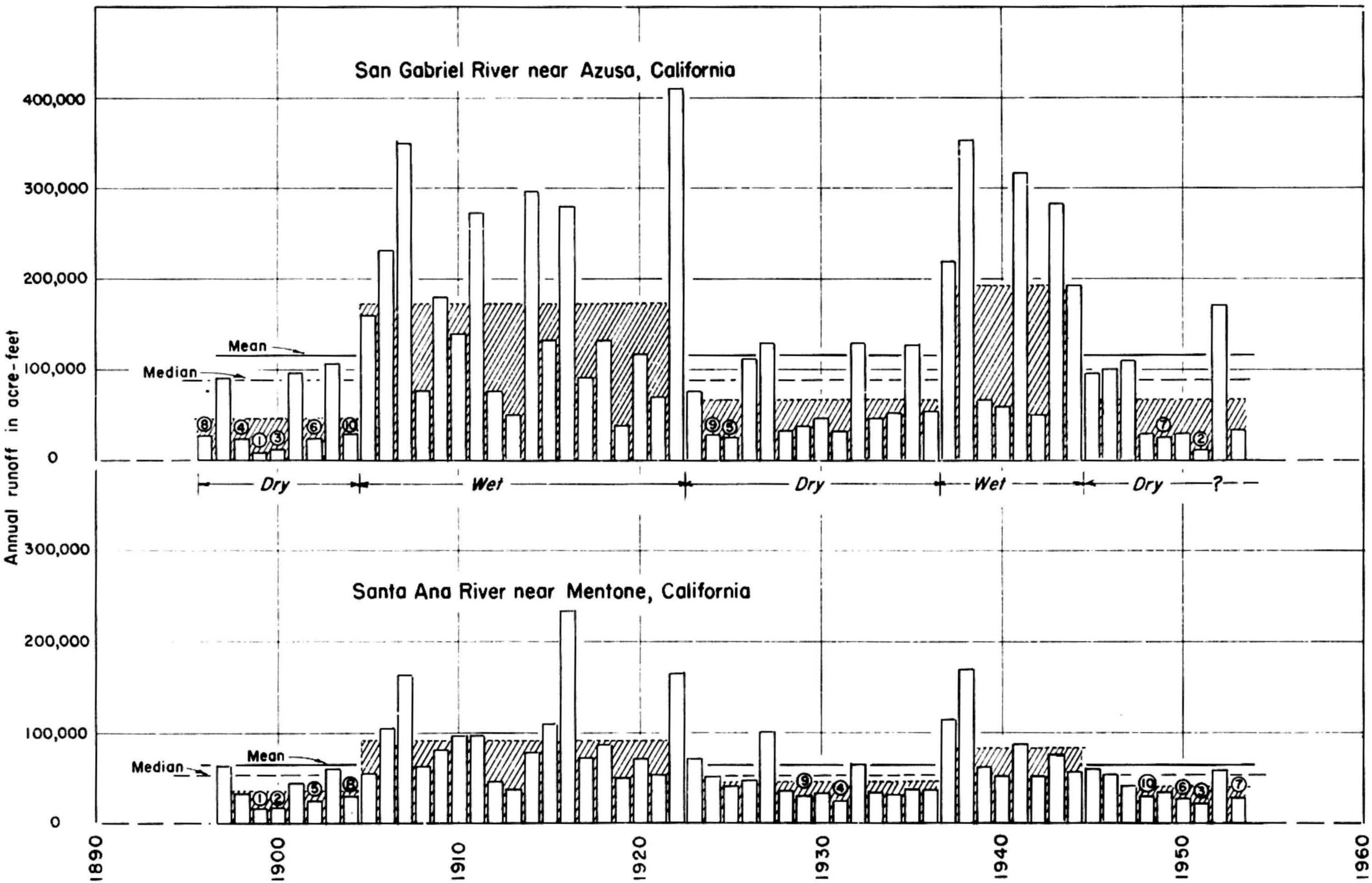

Table 2.--Annual runoff, in acre-feet

Station	Period of record: Length in years	Period of record: Mean	Period of record: Median	1952-53: Runoff	1952-53: Percent of mean
Campo Creek near Campo	17	2,700	2,400	130	5
Santa Ysabel Creek near Mesa Grande	32	16,800	9,400	2,000	12
Murrieta Creek at Temecula	23	8,550	2,500	1,230	14
Santa Ana River near Mentone	57	63,300	53,100	29,030	46
Cucamonga Creek near Upland	24	5,870	4,600	2,330	40
San Gabriel River near Azusa	58	113,600	84,800	33,640	30
Arroyo Seco near Pasadena	39	7,010	4,100	1,480	21
Santa Anita Creek near Sierra Madre	37	4,300	2,800	1,540	36
Sespe Creek near Fillmore	32	72,270	42,000	22,310	31
San Jose Creek near Goleta	12	966	610	619	64
Huasna River near Santa Maria	23	14,970	5,800	5,060	34
Arroyo Grande at Arroyo Grande	13	17,640	9,400	9,900	56
Deep Creek near Hesperia	40	54,670	39,800	10,890	20
Rock Creek near Valyermo	30	11,600	7,200	4,780	41

The first dry period, for which runoff records are only partially complete, is the 9-year period October 1895 to September 1904. The second dry period is complete and extends over the 14-year period October 1922 to September 1936. The latest dry period has apparently not yet ended. However, it will include the 9-year period October 1944 to September 1953. The above-average runoff during 1951-52 appears to be one of those isolated wet years which occasionally occurs during a predominately dry period.

The 10 driest years during the period of record for both stations have been indicated in figure 2 in the order of dryness. In the San Gabriel River drainage, 6 of the 10 driest years occurred in the first dry period, 2 in the second dry period, and 2 in the third dry period. In the Santa Ana River drainage 4 of the 10 driest years occurred in the first dry period, 2 in the second dry period, and 4 in the third dry period. Thus, on the basis of severity of individual years, the first dry period appears to be the most critical during the period of record, the latest or current dry period being the second most critical.

During the latest dry period, the mean annual runoff from the San Gabriel River drainage area was 67,000 acre-feet, which is 59 percent of the 58-year mean annual runoff and 80 percent of the median annual runoff. During the same dry period, the annual mean runoff from the Santa Ana River drainage area was 39,700 acre-feet. This is 63 percent of the 57-year mean and 75 percent of the median annual runoff. However, if adjusted for change in storage in Big Bear Lake, the annual mean runoff of the Santa Ana River for the latest dry period would be reduced to 35,700 acre-feet or 56 percent of the mean and 67 percent of the median annual runoff.

Surface storage

The economy of an area where the "cyclic" runoff pattern is pronounced, such as in southern California, can be more fully developed if some of the surplus runoff during wet periods can be salvaged and stored for use in the subsequent dry period. A number of reservoirs have been developed in the mountain areas for this purpose. The storage in nine typical reservoirs in southern California, which store only local runoff, is given in table 3.

Table 3.--Storage in surface reservoirs

Reservoir	Spilling capacity (Acre-feet)	Storage: Sept. 30, 1952 (Acre-feet)	Storage: Sept. 30, 1952 Percent of capacity	Storage: Sept. 30, 1953 (Acre-feet)	Storage: Sept. 30, 1953 Percent of capacity	Change in storage (Acre-feet)
Morena	50,210	5,190	10	4,980	10	-210
El Capitan	116,450	41,150	35	19,590	17	-21,560
Lake Henshaw	194,300	14,830	8	5,820	3	-9,010
Vail Lake	49,370	12,010	24	6,110	12	-5,900
Big Bear Lake	72,200	19,580	27	13,150	18	-6,430
Santiago	25,000	16,720	67	7,530	30	-9,190
Matilija	7,020	6,240	89	5,280	75	-960
Jameson Lake	6,760	6,260	93	5,360	79	-900
Gibraltar	16,000	14,500	91	13,000	81	-1,500
Total	537,310	136,480	25	80,820	15	-55,660

The water stored in these surface reservoirs exerted quite a modifying influence on the local water supply during the first few years of the latest dry period. On September 30, 1952, the total storage in the nine reservoirs listed in table 3 was 136,480 acre-feet or about 25 percent of their combined capacity.

One year later on September 30, 1953 this combined storage had been decreased to 80,820 acre-feet. This represents a decrease of 55,660 acre-feet in the hold-over storage together with all the additional natural runoff stored during the 1953 water year. Thus by September 30, 1953 the amount of water in storage in these reservoirs was reduced to 15 percent of their total capacity. This is clearly illustrative of the runoff deficiency experienced during the 1953 water year.

Ground-water Conditions

In southern California the development of surface reservoirs is restricted by the limited runoff, lack of suitable reservoir sites and the high evaporation loss from the water surface. However, much of the area is underlain by several ground-water reservoirs or aquifers, some of which are quite extensive. These are essentially underground storage reservoirs in which part of the precipitation, especially that of the wetter years, is detained for later use of eventual release to streams.

Ground-water development in California is rather recent, although as early as 1905 Mendenhall a/ made an inventory of

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a/ Mendenhall, W. C., Geological Survey Water-Supply Papers 137, 138, 139, 142, and 219.

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more than 10,000 wells in the South Coastal Basin. Since that time the great improvement in pumping equipment and cheaper power has resulted in a large increase in the use of ground water. The greatest demands on this supply are during periods of insufficient surface runoff.

Until comparatively recent years many of the ground-water users believed these supplies to be almost inexhaustible. They did not realize that they were tapping the accumulated storage of many centuries. Water users often fail to appreciate that ground-water reservoirs, like surface-water reservoirs, are dependent largely upon the wetter years for their recharge. This recharge is the result of penetration of the precipitation below the root zones of the vegetative cover and the absorption into the stream beds of a part of the runoff from the tributary mountain and foothill areas.

The increasing demand on the ground-water supply, due in part to the increase in population and economic development of southern California, as well as to the surface-water deficiency during the current dry period, has created an overdraft in some areas and has resulted in impairment of the aquifers along some of the coastal areas due to salt-water encroachment.

The many inland valleys of southern California contain ground-water basins, some of which are quite complex. The changes in ground-water storage vary considerably from basin to basin, being dependent upon the relation between demand and recharge in each. Consequently, the available ground-water information for southern California is presented as individual paragraphs for some of the various basins or subareas rather than as a general summary for the entire area. The fluctuation of ground-water level at certain key wells, for which observations are available for 20 to 60 years, are shown in figure 3. These records cannot be considered typical of the entire southern California area or even an entire valley area. The beginnings and endings of the wet and dry sequences shown on figure 3 are identical to those used on figure 2.

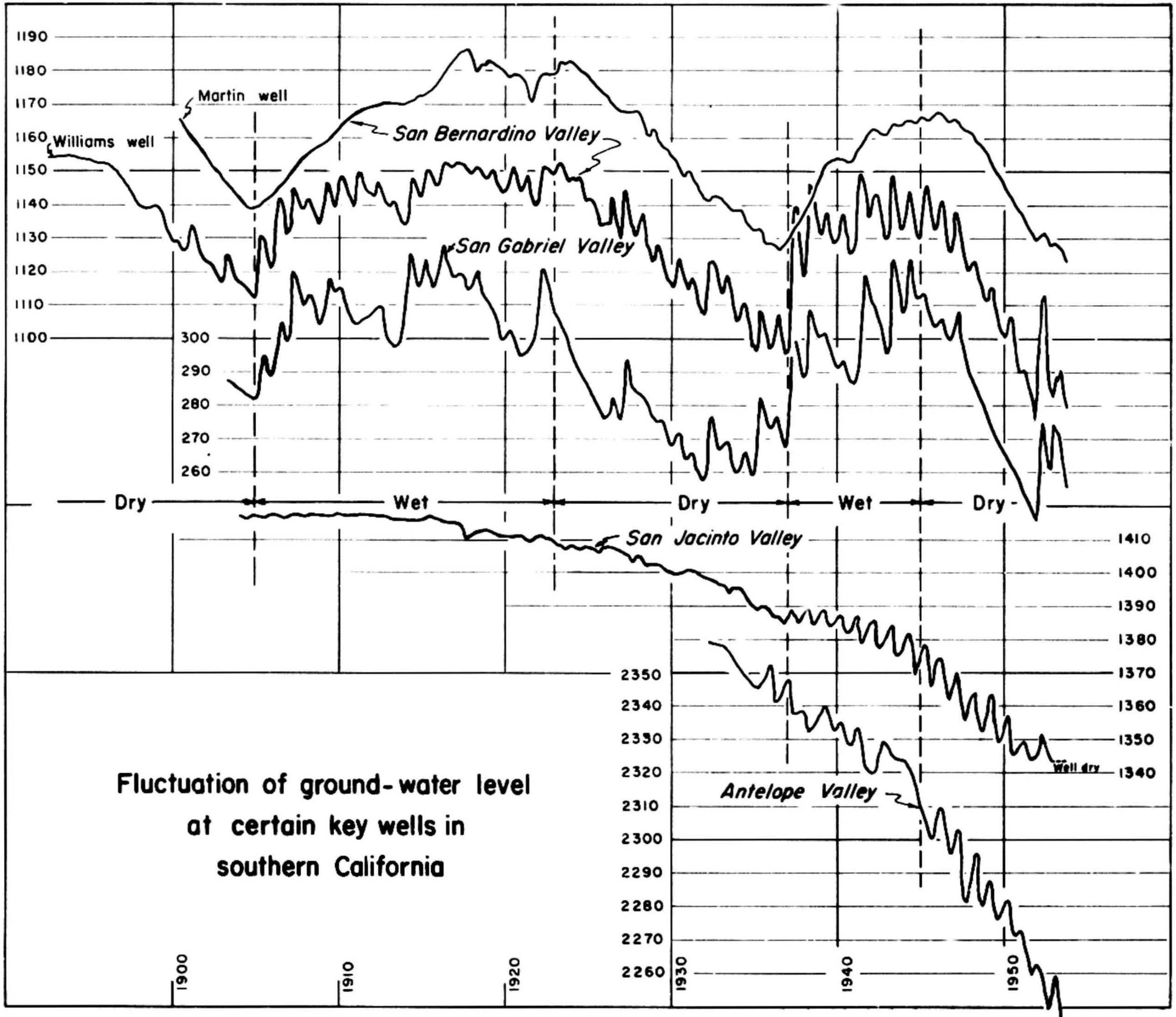
San Bernardino and San Gabriel Valleys

The upper two graphs on figure 3 are for the Martin well and the Williams well in San Bernardino Valley and the third graph is for the Baldwin Park well in San Gabriel Valley. These three wells have a similar over-all pattern in water-level fluctuations, although the Williams and Baldwin Park wells show a much more pronounced seasonal effect. The Williams well declined about 43 feet during the 12-years of record in the first dry period, most of the decline occurring during the last 9 years of this period at an annual rate of about 4.8 feet per year. The ground-water supply was recharged during the subsequent wet period, and at its close water levels returned to about the same elevation recorded during the years 1892 to 1895.

The 14-year dry period 1923-36 resulted in a decline of about 58 feet in the Williams well, 57 feet in the Martin well, and 40 feet in the Baldwin Park well. This represents an average decline of 4.1 feet per year for the first two wells and 2.9 feet per year for the latter well. These rates are slightly smaller than those for the preceding dry period.

During the rather short wet period, 1937-44, the ground-water supply was recharged again, but not quite to the same extent as during the preceding wet period.

The latest dry period, 1944 to date, resulted in a marked decline in the water levels in these three wells to the lowest elevation during the period of record. During the first 7 years of this dry period, the water level declined about 65 feet in the Williams well, 34 feet in the Martin well, and 72 feet in the Baldwin Park well, which represents an average decline of about 8 feet per year for the three wells. This rate of decline is much greater than that of either of the two earlier dry periods and undoubtedly reflects the increasing draft from the ground-water bodies.



Fluctuation of ground-water level at certain key wells in southern California

Figure 3

The above-normal precipitation of 1951-52 resulted in a definite recharge of the ground-water supply as shown by the slight rise in the Martin well, the 35-foot rise in the Williams well, and the 30-foot rise in the Baldwin Park well. This rise in water-level was only temporary, however, as the current dry year of 1952-53 reversed the trend. By the close of the year, water levels were at a new low in the Martin well and only a few feet above the minimum elevation during the period of record at the Williams and Baldwin Park wells.

The increased rate of decline in water levels in these ground-water bodies during the latest dry period probably indicates a condition of overdraft, with the possibility that under existing demands the water levels will be lower for each succeeding dry cycle.

San Jacinto Valley

The record obtained at well 4/2W-7J1, shown on figure 3, is probably representative of only that portion of San Jacinto Valley near Lakeview. The water-level graph for this well shows a continuous decline during the period of record. Even in the extended wet period, 1905-22, the water-level declined about 7 feet. In this instance the water users not only used all the increased recharge supplied in the wetter years, but also used a sizable portion of the stored ground water. During the 1923-36 dry period the rate of decline increased to 2.2 feet per year, which represents a total decline of about 31 feet.

During the following wet period, 1937-44, the rate of decline was reduced slightly to about 2.0 feet per year. With the advent of the latest dry period the rate more than doubled and was about 4.7 feet per year. The wet year of 1951-52 had but little effect on this continued decline, and since about April 1953 this observation well has been dry. The above clearly indicates that in this area the annual demands exceed the average annual recharge, and that a condition of overdraft exists.

Antelope Valley

The graph for well 7/11-24C1 on figure 3 represents the observations at the Stevenson well in Antelope Valley. This record shows a continuous decline, except for seasonal fluctuations, since the observations were started in 1932. During the 1937-44 wet period the water level in this well declined about 37 feet, or 4.6 feet per year. This rate of decline was accelerated during the current dry period to about 7.1 feet per year and in July 1953 this well also went dry. Thus, the water level in this well declined more than 110 feet during the 21-year period of record, at an average rate of 5.2 feet per year. As in the San Jacinto Valley, the wet year of 1951-52 did not result in any perceptible recharge.

From the above, it is evident that the annual demands greatly exceed the average annual recharge, and that in Antelope Valley the ground water is overdeveloped.

San Diego County

The water levels in most of the observation wells in San Diego County declined during 1953, and in many of these wells the levels at the close of the year were the lowest of record. In the San Luis Rey River basin the water levels declined an average of 5.0 feet during the year, and in five of the six observation wells the levels were the lowest of record for the common period 1940-53. In the vicinity of the coast, water levels were near or below sea level, and within 3 miles of the coast, sea-water intrusion caused the abandonment of several public-supply and irrigation wells.

In the upper part of the San Diego River basin, water levels declined an average of 3.1 feet at three observation wells and rose 0.7 foot in the fourth during the year. In Mission Valley, the coastal part of San Diego River basin, the water levels declined about 2.9 feet during the year and were within 2 feet of the record low for the period 1937-53. However, water levels remained above sea level throughout the valley.

In the coastal part of the Tia Juana River basin, water levels in two observation wells declined an average of nearly 4 feet during the year, and at the end of the year the water levels were close to the lowest recorded. The level in one of the wells, about 2 miles from the ocean, was slightly below sea level and although there is no reported sea-water intrusion, the low levels are conducive to inland movement from the coast.

Coastal Plain

Water levels in the coastal plain region of Los Angeles and Orange Counties continued to decline at a fairly rapid rate. In Orange County 13 representative observation wells showed an average decline of 6.2 feet during the 1953 water year, and water levels in all but one of the thirteen were below mean sea level. The water level in five of these wells was at the low of record and in most of the others it was near the lowest water level for the period of record.

In the main coastal basin of Los Angeles County the water level at two observation wells was the lowest for the period of record, after an average decline of about 10 feet during the 1953 water year. The water level in two observation wells in the West Coastal Basin declined an average of about 6 feet during the year and was also at the lowest level of record. In part of the West Coastal Basin water levels were from 50 to 80 feet below sea level and sea-water intrusion contaminated several public-supply wells. At present a full-scale experimental project is being carried on at Manhattan Beach to determine the feasibility of artificial recharge to form a fresh-water barrier along the coast to halt sea-water intrusion.

Since the close of the previous dry period in 1936, the water levels for the selected observation wells show a regional decline of 18.5 feet in the main coastal basin in Orange County, 23.8 feet in the main coastal basin in Los Angeles County, and 53.5 feet in the West Coastal Basin. This indicates that in the coastal plain basin in recent years the average demands greatly exceed the average annual recharge, and that a condition of overdraft exists.

Santa Barbara County

During the water year ending September 30, 1953 ground-water withdrawals exceeded recharge in most of the ground-water basins in Santa Barbara County. The wet year of 1951-52 temporarily halted the downward trend of water levels, which began in 1945, but the dry year of 1952-53 caused the resumption of the downward trend. As a result, water levels throughout the county are now well below the highest levels on record and are considerably below sea level in large areas. Among the more extensively depleted ground-water basins in Santa Barbara County are the Santa Maria Valley, the Cuyama Valley, and the Carpinteria and Goleta basins.

In the Santa Maria Valley ground-water withdrawals have been in excess of replenishment since 1945, and water levels, except during the 1951-52 wet year, have steadily declined. In the Sisquoc area the water level dropped nearly 4 feet during the 1952-53 water year and about 40 feet during the current dry period. In the vicinity of Fugler Point the water level declined more than 8 feet during 1952-53 and about 20 feet since 1945.

In Cuyama Valley water levels are at or near the lowest levels on record. The water level in a key observation well has declined about 55 feet since 1944.

In both the Carpinteria and Goleta basins, ground-water levels have shown a more or less continuous decline since 1945 and are now locally considerably below sea level. This may result in salt-water encroachment. Present plans call for the delivery of Santa Ynez River flood runoff stored in Cachuma Reservoir into the Carpinteria and Goleta basins through the Tecolote Tunnel now under construction. This will reduce the draft on local ground-water supplies and thus may eliminate the threat of salt-water encroachment.

Imported water

The inadequacy of the local water supply for the city of Los Angeles was recognized as early as 1900, when a study was authorized to determine possible sources of supplemental water. After an extensive investigation, the waters of Owens River Valley, about 250 miles to the north, were selected as the most suitable for this purpose. In 1905 construction was started on an aqueduct to bring these waters to Los Angeles and the first delivery to the San Fernando terminal was made in 1913. The annual importations from Owens River Valley since that date are shown on figure 4. The importations prior to the 1916-17 water year are estimated, as the actual records were not readily available. These annual diversions gradually increased to a maximum of 332,000 acre-feet in 1951-52. There was a slight decrease to 331,000 acre-feet in 1952-53, due to the fact that there was one day less in this year as compared to the previous year. It is significant that during the last 7 years the aqueduct has been essentially operated at full capacity.

The dry period beginning in 1923 demonstrated that in spite of the importations from Owens Valley, the water supply available to the Los Angeles area was insufficient for the anticipated future development. Consequently, in December 1932 construction was started on another aqueduct, this time to Colorado River. This 240-mile aqueduct was completed and the first water was delivered to the Lake Mathews terminal in 1940. It supplies water to the city of San Diego and portions of San Diego County as well as to Los Angeles and vicinity. The upper graph on figure 4 shows that the importations from the Colorado River have steadily increased from 9,400 acre-feet in 1941-42 to 217,000 acre-feet in 1952-53.

During the fiscal year 1952-53 the Orange County Water District purchased 27,956 acre-feet of Colorado River water from the Metropolitan Water District of Southern California at a cost of $279,560 for the purpose of recharging the depleted ground-water basin in the Coastal Plain.

The combined supplemental water imported into the coastal part of southern California has increased through the years to a maximum of 548,000 acre-feet during the 1952-53 water year. Yet, even with this sizable addition to the local supply, the current ground-water overdraft has not been alleviated.

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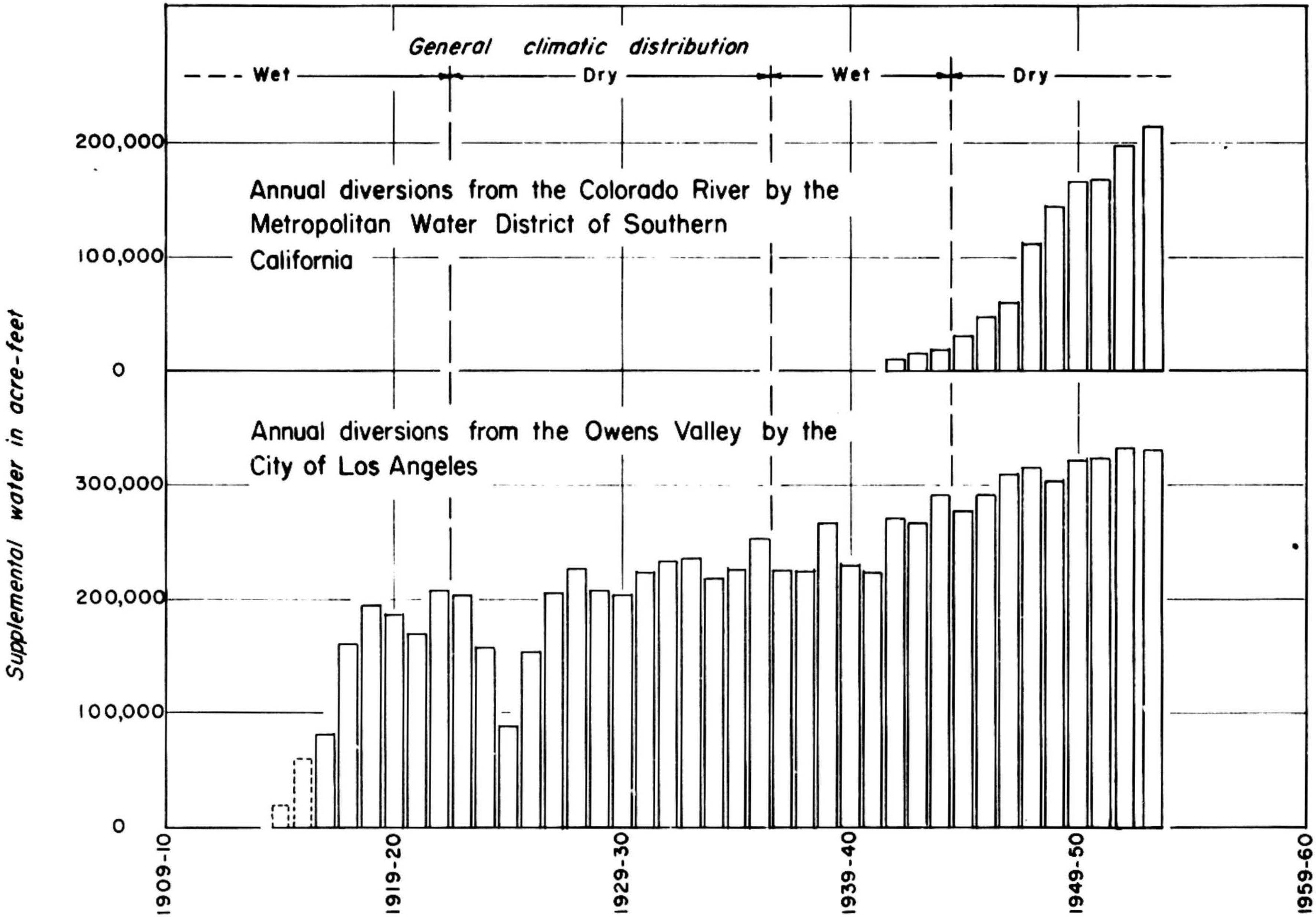
Figure 4 Supplemental waters imported into southern California



Deficient water supplies

The combination of deficient precipitation during the current year, declining ground-water supply, and the limitations of the imported water have again accentuated the critical water-supply problems in parts of southern California. The general deficiency of the precipitation since 1944 and the steadily increasing water demands of a growing population have resulted in excessive depletion of both surface- and ground-water storage. The greater precipitation during the wet year 1951-52 provided only temporary relief in some areas.

The city of San Diego and its adjacent areas is dependent to a large extent on the storage of local runoff in 10 surface reservoirs for its water supply, and limited importations of Colorado River water through the San Diego County Water Authority aqueduct. The supply in these reservoirs was at its lowest at the close of 1951, but was substantially replenished in the spring of 1952. Since then there has been a gradual depletion of this supply but it is still considerably larger than it was in 1951.

The depletion of ground-water supplies also continued at a fairly rapid rate and the water levels in parts of San Diego County were the lowest of record. The water supply in some of the coastal areas was threatened by sea-water intrusion, and unless remedial measures are provided the result may be forced curtailment of withdrawal from these sources.

The city of Los Angeles and its adjacent areas have a generally adequate over-all water supply because of the availability of imported water. However, the ground-water reserves of this region have been seriously depleted and in those areas that do not have access to imported water, the water-supply problem is critical. This is particularly true of the coastal areas where the ground-water level is much below sea level, and as a result the remaining ground-water reserves are threatened with contamination by sea-water intrusion.

The cities of Ventura and Santa Barbara and their associated communities were seriously affected by a water shortage at the close of 1951. This was alleviated by an increase in both surface- and ground-water storage during 1952. However, the depletion resulting from the current dry year has reduced the supply to Ventura to where it is again approaching a critical stage.

The only source of water to the agriculturally rich Antelope Valley is the underlying ground-water supply. This has been continuously withdrawn at what appears to be an excessive rate and if this rate of withdrawal continues it will not be long before the ground-water supplies economically available are depleted.

The San Jacinto Valley, including some of the adjacent areas, appears to be overdeveloped. However, there is a possibility that at some time in the future this area may be able to use Colorado River water.

In addition to the areas mentioned above there are many smaller inland valleys such as Simi Valley, Ojai Valley, Pleasant Valley, Las Posas Valley, etc., where water-supply problems are either at, or approaching, a critical condition. Several areas along the coast of southern California also have the problem of depleted ground-water bodies and critical water-supply conditions. Their proximity to the ocean poses the ever serious threat of ground-water supply contamination by salt-water encroachment.

RUNOFF FOR THE WATER YEAR ENDING SEPTEMBER 30, 1952

This is the second part of the WATER BULLETIN and deals with the magnitude of the runoff for the water year ending September 30, 1952, and its relation to the runoff of previous years. The appended table 4 lists the 1951-52 runoff in acre-feet, the number of years of record, the mean and median annual runoff for the period of record, the 1951-52 runoff in percent of mean annual runoff, and the 1951-52 peak discharge and its relation to the mean annual peak. The mean and median values are not given for stations at which the record is less than 10 years in length.

Annual runoff

As shown in table 4, the 1951-52 water year runoff was considerably above the mean throughout most of southern California. The distribution of the 1951-52 runoff in percent of mean annual runoff is given in table 5. This shows that at 81 percent of the gaging stations with more than 10 years of record the runoff was greater than the mean annual runoff. Furthermore, at 56 percent of the stations the runoff ranged from 100 to 250 percent of the mean, while only 25 percent had a runoff greater than 250 percent of the mean annual runoff. The 1951-52 average runoff for all the streams listed in table 4 amounted to 192 percent of the mean annual runoff.

Table 5.--Distribution of 1951-52 runoff

1951-52 Runoff in percent of mean annual runoff	Percent of gaging stations
0 - 49	7
50 - 99	12
100 - 149	21
150 - 199	24
200 - 249	11
250 - 299	9
300 - 399	10
400 or above	6

The general distribution on an areal basis of the 1951-52 runoff is shown on the map presented as figure 5. In preparing this map an attempt was made to evaluate the individual station records on basis of upstream regulation or diversions. Also taken into consideration was the length of the record at each station in that the stations with only 10 to 15 years of record included a preponderance of dry years. Thus the mean annual discharge for a short record would be considerably less than if a balanced period of wet and dry years were averaged. The runoff distribution is shown in terms of the mean rather than the median annual runoff in order to be consistent with previous WATER BULLETINS, even though the median would be a more conservative measure of the stream's usable runoff.

The general runoff pattern for the 1951-52 water year in southern California is illustrated by figure 5. The runoff decreases both from north to south and from the coast inland. The runoff was greatest with reference to the mean runoff throughout most of Santa Barbara County, the coastal area around Santa Monica Bay, and a small area north of Santa Ana. It was least in an area along the Mexican border, a small area at the head of San Luis Rey River, and the desert area east of the San Bernardino Mountains.

Peak discharge

The peak discharge for the 1951-52 water year and its relation to the mean annual peak discharge for each station are tabulated in the last two columns of table 4. The first of these columns gives the maximum discharge during 1951-52, in cubic feet per second, and the second column gives the relation of the maximum, in percent, to the mean annual peak discharge for the period of record. This latter column has been designated "Index." The distribution of the 1951-52 peak discharge expressed as a percent of the mean annual peak is given in table 6. This table shows that at 61 percent of the gaging

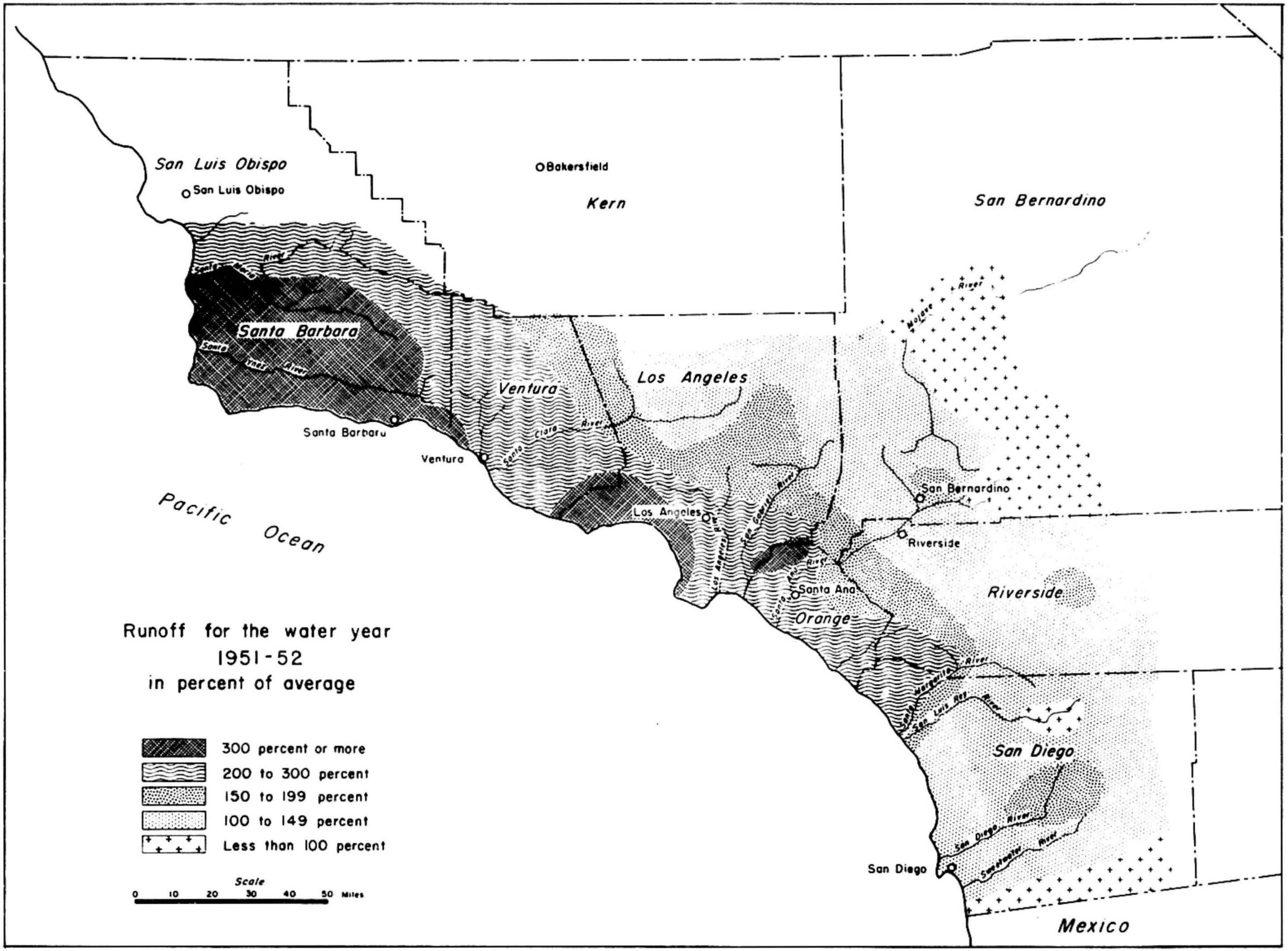


Figure 5 Relationship between 1951-52 and average annual runoff

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stations the 1951-52 peak was larger than the mean annual peak. The percent of gaging stations falling in the various peak "Index" sub-groups is fairly well distributed through the range experienced except in the 50 - 99 percent group, which includes 29 percent of the stations. The average "Index" for the streams listed in table 4 for the 1951-52 water year amounted to 183 percent of the mean annual peak discharge, which is about 10 percent less than the average 1951-52 runoff index.

Table 6.--Distribution of 1951-52 peak discharge

1951-52 Peak discharge in percent of mean annual peak discharge	Percent of gaging stations
0 - 49	10
50 - 99	29
100 - 149	11
150 - 199	11
200 - 249	11
250 - 299	11
300 - 399	8
400 or above	9

In general the 1951-52 peak discharges on streams in the northern part of southern California were considerably larger in comparison to the mean than were those in the southern part. This is similar to the areal runoff distribution shown on figure 5. Four of the gaging stations with more than 15 years of record had an "Index" greater than 400 percent. One was Coyote Creek near Artesia, with a 1951-52 peak of 7,360 cubic feet per second, which represents an index of 527 percent. This peak is 76 percent larger than the previous maximum discharge of 4,190 cubic feet per second on February 6, 1937. Another was Pacoima Creek near San Fernando with a peak of 2,640 cubic feet per second, and an index of 527 percent. This peak is 8 percent larger than the previous maximum discharge of 2,440 cubic feet per second on March 3, 1938. The third station was Malibu Creek at Crater Camp near Calabasas, with a peak discharge of 13,560 cubic feet per second and an index of 404 percent. This peak is 11 percent larger than the previous maximum of 12,200 cubic feet per second on January 22, 1943. The last station was Santa Ynez River near Santa Ynez with a peak of 39,400 cubic feet per second and an index of 432 percent. This peak is 10 percent less than the maximum peak during the period of record of 43,700 cubic feet per second on March 2, 1938.

From the above it is evident that the 1951-52 water year would definitely be classified as "wet." But it cannot be assumed that this wet year ended the latest dry period, as frequently one or more wet years will occur during a dry period.

Table 4 --Runoff in the 1951-52 water year in southern California streams

Basin and stream	1951-52 annual runoff (ac-ft)	Length of record (years)	Mean annual runoff (ac-ft)	Median annual runoff (ac-ft)	1951-52 runoff (percent of mean)	1951-52 peak discharge (cfs)	
						(cfs)	Index
Tia Juana River							
Cottonwood Creek at Morena Dam (a)	8,283	16	-	-	-	-	-
Cottonwood Creek above Tecate Creek, near Dulzura	6,580	16	9,580	3,800	69	700	103
Campo Creek near Campo	1,180	16	2,860	2,700	41	623	215
Tia Juana River near Dulzura	9,000	16	15,440	6,800	58	600	59
Tia Juana River near Nestor	19,880	16	42,430	15,000	47	2,460	62
Otay River							
Jamul Creek near Jamul	27,640	12	-	-	-	1,710	-
Sweetwater River							
Sweetwater River at Loveland Dam, near Alpine (b)	21,906	8	-	-	-	-	-
Sweetwater River at Sweetwater Dam (b)	11,469	65	-	-	-	-	-

(a) Basic data furnished by city of San Diego.
(b) Basic data furnished by California Water and Telephone Co.

Table 4.--Runoff in the 1951-52 water year in southern California streams--Continued

Basin and stream	1951-52 annual runoff (ac-ft)	Length of record (years)	Mean annual runoff (ac-ft)	Median annual runoff (ac-ft)	1951-52 runoff (percent of mean)	1951-52 peak discharge (cfs)	Index
San Diego River							
Boulder Creek at Cuyamaca Reservoir, near Julian (c)	8,821	31	2,550*	-	346	-	-
San Diego River at El Capitan Dam (a)	57,177	16	34,660	21,900	165	-	-
San Diego River near Santee	14,020	37	22,450	4,100	62	4,390	-
San Dieguito River							
Santa Ysabel Creek near Mesa Grande	21,620	31	17,280	10,100	125	1,220	57
Santa Ysabel Creek near Ramona	32,850	19	24,230	12,300	136	2,510	73
Guejito Creek near San Pasqual	3,210	5	-	-	-	842	-
Guejito Creek at San Pasqual	2,860	7	-	-	-	about 900	-
Santa Maria Creek near Ramona	4,990	13	5,100	1,100	98	882	91

* 8 years (1944-52).
(a) Basic data furnished by city of San Diego.
(c) Basic data furnished by La Mesa, Lemon Grove and Spring Valley Irrigation District.

Table 4.--Runoff in the 1951-52 water year in southern California streams--Continued

Basin and stream	1951-52 annual runoff (ac-ft)	Length of record (years)	Mean annual runoff (ac-ft)	Median annual runoff (ac-ft)	1951-52 runoff (percent of mean)	1951-52 peak discharge	
						(cfs)	Index
San Luis Rey River							
San Luis Rey River at Lake Henshaw, near Mesa Grande (d)	23,098	41	29,330	16,000	79	-	-
San Luis Rey River at Monserate Narrows, near Pala	15,060	9	-	-	-	855	-
San Luis Rey River near Bonsall	5,630	25	25,330	12,600	22	1,290	51
San Luis Rey River at Oceanside	1,040	20	19,150	2,900	5	468	20
Santa Margarita River							
Temecula Creek at Vail Dam	12,553	29	9,750	5,400	129	-	-
Murrieta Creek at Temecula	24,750	22	8,880	2,700	279	9,140	244
Temecula Creek at Railroad Canyon, near Temecula (e)	33,680	29	19,200	8,200	175	13,200	286
Santa Margarita River near Fallbrook (e)	47,010	27	24,820	10,900	189	14,590	250
Santa Margarita River at Ysidora	47,640	28	28,710	12,300	166	7,670	142
San Juan Creek							
San Juan Creek near San Juan Capistrano	22,480	24	10,580	2,600	212	3,330	202
Trabuco Creek near San Juan Capistrano (f)	7,080	22	4,300	870	165	850	89

(d) Basic data furnished by Vista Irrigation District.
(e) Flow regulated by Vail Reservoir (capacity, 49,370 acre-feet) since November 1948.
(f) Records furnished by Orange County Flood Control District.

Table 4.--Runoff in the 1951-52 water year in southern California streams--Continued

Basin and stream	1951-52 annual runoff (ac-ft)	Length of record (years)	Mean annual runoff (ac-ft)	Median annual runoff (ac-ft)	1951-52 runoff (percent of mean)	1951-52 peak discharge (cfs)	1951-52 peak discharge Index
Aliso Creek							
Aliso Creek at El Toro (f)	1,460	22	621	280	235	950	166
Peters Canyon Wash							
San Diego Creek near Irvine	5,910	3	-	-	-	4,040	-
Santa Ana River							
Santa Ana River near Mentone	56,980	56	63,910	53,500	89	1,020	26
Mill Creek near Craftonville	23,920	24	25,590	18,800	93	738	52
Mill Creek near Mentone	3,820	13	2,440	800	157	249	77
Plunge Creek near East Highlands	8,960	33	†5,720	4,300	157	340	58
Little San Gorgonio Creek near Beaumont	116	4	-	-	-	13	-
San Timoteo Creek near Redlands	1,780	26	1,210	430	147	842	71
Santa Ana River at E Street Bridge, near San Bernardino	16,350	13	9,930	6,100	153	-	-
Strawberry Creek near Arrowhead Springs	5,520	32	3,540	2,600	156	467	134
Waterman Canyon Creek nr. Arrowhead Sprgs.	2,830	34	2,080	1,400	136	115	70
City Creek near Highland	11,850	28	7,610	5,500	156	937	111
Devil Canyon Creek near San Bernardino	3,120	33	2,120	1,500	147	79	55

† Antecedent records have been adjusted for diversion.
(f) Records furnished by Orange County Flood Control District.

Table 4.--Runoff in the 1951-52 water year in southern California streams--Continued

Basin and stream	1951-52 annual runoff (ac-ft)	Length of record (years)	Mean annual runoff (ac-ft)	Median annual runoff (ac-ft)	1951-52 runoff (percent of mean)	1951-52 peak discharge (cfs)	1951-52 peak discharge Index
Santa Ana River (continued)						about	
Lytle Creek near Fontana	33,930	33	32,880	26,800	103	1,500	84
Cajon Creek near Keenbrook	9,840	32	7,060	4,600	125	1,420	82
Lone Pine Creek near Keenbrook	873	21	1,070	430	82	302	55
Lytle Creek (east channel) at San Bernardino	594	23	-	-	-	-	-
Warm Creek near Colton	35,750	32	45,350	44,200	79	1,980	88
Santa Ana River at Riverside Narrows, near Arlington (g)	74,380	23	-	-	-	4,880	-
Day Creek near Etiwanda	5,110	23	4,300	3,600	119	214	55
Cucamonga Creek near Upland	7,100	23	6,020	4,800	118	208	30
San Jacinto River near San Jacinto	33,750	29	-	-	-	1,660	-
Bautista Creek near Hemet	2,920	5	-	-	-	578	-
San Jacinto River near Elsinore	16,600	36	11,550	330	144	658	-
Temescal Creek near Corona	765	23	3,290	290	23	450	33
San Antonio Creek near Claremont	20,200	35	16,470	13,000	123	74	17
Santa Ana River below Prado Dam, near Prado (g)	123,300	33	-	-	-	-	-
Santiago Creek at Santiago Dam, near Villa Park	24,257	21	14,250	7,900	170	-	-

(g) Metropolitan Water District discharged 19,237 acre-feet of Colorado River water into Santa Ana River at Riverside Narrows.

Table 4.--Runoff in the 1951-52 water year in southern California streams--Continued

Basin and stream	1951-52 annual runoff (ac-ft)	Length of record (years)	Mean annual runoff (ac-ft)	Median annual runoff (ac-ft)	1951-52 runoff (percent of mean)	1951-52 peak discharge	
						(cfs)	Index
Santa Ana River (continued)							
Santiago Creek near Villa Park	4,260	32	6,760	1,830	63	3,300	-
Santiago Creek at Santa Ana	5,840	23	4,540	580	129	3,740	342
Santa Ana River at Santa Ana	16,680	29	16,590	2,300	101	3,790	96
San Gabriel River							
East Fork San Gabriel River near Camp Bonita (h)	79,260	19	57,080	44,900	139	1,110	22
West Fork San Gabriel River at Camp Rincon (h)	83,540	25	51,610	29,000	162	7,520	176
San Gabriel River near Azusa	170,900	57	115,000	86,900	149	-	-
Rogers Creek near Azusa	5,100	35	2,300	1,400	222	867	182
Fish Creek near Duarte	6,060	35	3,100	2,100	195	1,360	259
San Gabriel River below Santa Fe Dam, near Baldwin Park	32,800	10	39,420	21,000	83	861	-
San Dimas Creek near San Dimas	5,110	35	3,380	2,200	151	292	77
Dalton Creek near Glendora	2,080	32	857	290	243	132	100
Little Dalton Creek near Glendora (h)	935	23	625	420	150	118	109
San Jose Creek near Whittier (h)	17,870	23	6,590	4,300	271	4,400	169
San Gabriel River at Pico (h)	50,930	24	35,990	18,800	142	14,000	252

(h) Records furnished by Los Angeles County Flood Control District.

Table 4.--Runoff in the 1951-52 water year in southern California streams--Continued

Basin and stream	1951-52 annual runoff (ac-ft)	Length of record (years)	Mean annual runoff (ac-ft)	Median annual runoff (ac-ft)	1951-52 runoff (percent of mean)	1951-52 peak discharge (cfs)	Index
San Gabriel River (continued)							
Brea Creek below Brea Dam, near Fullerton	1,920	10	601	[illegible]	319	288	-
Brea Creek at Fullerton (f)	1,990	22	941	360	211	538	94
Fullerton Creek below Fullerton Dam, near Brea	671	11	154	22	436	115	-
Fullerton Creek at Fullerton (f)	1,470	17	568	290	259	500	142
Coyote Creek near Artesia (h)	23,920	23	6,270	3,100	381	7,360	527
Carbon Creek near Yorba Linda	986	3	-	-	-	616	-
Los Angeles River							
Los Angeles River at Sepulveda Dam	42,580	9	-	-	-	8,520	-
Pacoima Creek near San Fernando (h)	5,550	35	6,910	3,700	80	2,640	527
Tujunga Creek below Mill Creek, near Colby Ranch (h)	19,390	4	-	-	-	1,380	-
Tujunga Creek near Sunland (h)	41,320	35	21,940	13,000	188	2,960	92
Haines Creek near Tujunga	208	20	326	220	64	89	356
Little Tujunga Creek near San Fernando (h)	5,570	24	2,140	580	260	2,110	187
Tujunga Creek below Hansen Dam	8,810	12	19,800	7,000	44	about 3,000	-
Los Angeles River at Los Angeles (h)	108,000	23	45,040	27,500	240	25,260	250

(f) Records furnished by Orange County Flood Control District.
(h) Records furnished by Los Angeles County Flood Control District.

Table 4.--Runoff in the 1951-52 water year in southern California streams--Continued

Basin and stream	1951-52 annual runoff (ac-ft)	Length of record (years)	Mean annual runoff (ac-ft)	Median annual runoff (ac-ft)	1951-52 runoff (percent of mean)	1951-52 peak discharge	
						(cfs)	Index
Los Angeles River (continued)							
Arroyo Seco near Pasadena	11,530	38	7,150	4,300	161	1,090	89
Los Angeles River near Downey (h)	180,500	24	73,260	44,200	246	32,890	226
Sawpit Creek near Monrovia	2,400	35	1,920	1,400	125	154	75
Santa Anita Creek near Sierra Madre	8,620	36	4,380	2,800	197	1,260	230
Little Santa Anita Creek near Sierra Madre	1,230	35	672	360	183	105	149
Eaton Creek near Pasadena	5,180	29	2,920	1,900	177	454	123
Rio Hondo near Montebello (h)	34,580	24	41,500	29,700	83	6,930	119
Mission Creek near Montebello (h)	6,090	22	12,970	12,300	47	71	-
Rio Hondo near Downey (h)	26,040	24	21,270	8,000	122	2,670	53
Los Angeles River at Long Beach (h)	212,200	23	109,100	71,000	195	47,800	255
Ballona Creek							
Ballona Creek near Culver City (h)	53,350	24	-	-	-	12,800	-
Topanga Creek							
Topanga Creek near Topanga Beach (h)	16,900	21	4,490	1,700	376	6,050	293

(h) Records furnished by Los Angeles County Flood Control District.

Table 4.--Runoff in the 1951-52 water year in southern California streams--Continued

Basin and stream	1951-52 annual runoff (ac-ft)	Length of record (years)	Mean annual runoff (ac-ft)	Median annual runoff (ac-ft)	1951-52 runoff (percent of mean)	1951-52 peak discharge (cfs)	1951-52 peak discharge Index
Malibu Creek							
Malibu Creek at Crater Camp near Calabasas (h)	58,200	21	16,060	5,500	362	13,560	404
Santa Clara River							
Santa Clara River near Saugus (h)	16,760	23	11,600	3,800	144	7,600	158
Piru Creek near Piru	78,900	25	44,330	23,200	178	7,010	133
Hopper Creek near Piru (i)	6,480	20	3,950	2,000	164	2,200	178
Sespe Creek near Wheeler Springs	17,770	4	-	-	-	2,260	-
Sespe Creek near Fillmore	150,200	31	73,880	44,200	203	23,200	192
Santa Paula Creek near Santa Paula	30,880	25	14,780	8,700	209	7,300	276
Ventura River							
Matilija Cr. above reservoir, nr. Matilija	43,780	4	-	-	-	8,800	-
Matilija Creek at Matilija	36,700	25	23,100	12,400	159	3,530	-
North Fork Matilija Creek at Matilija (i)	14,480	23	6,820	3,500	212	2,820	321
Coyote Creek near Ventura	29,060	24	9,940	4,100	281	9,180	228
Ventura River near Ventura	124,900	25	49,430	23,200	252	29,500	274

(h) Records furnished by Los Angeles County Flood Control District.
(i) Records furnished by Ventura County Water Survey.

Table 4.--Runoff in the 1951-52 water year in southern California streams--Continued

Basin and stream	1951-52 annual runoff (ac-ft)	Length of record (years)	Mean annual runoff (ac-ft)	Median annual runoff (ac-ft)	1951-52 runoff (percent of mean)	1951-52 peak discharge (cfs)	1951-52 peak discharge Index
Carpinteria Creek							
Carpinteria Creek near Carpinteria	6,140	11	1,400	430	439	2,440	392
Atascadero Creek							
Atascadero Creek near Goleta	7,940	11	1,710	650	464	4,500	553
San Jose Creek							
San Jose Creek near Goleta	3,550	11	997	600	356	1,340	221
Santa Ynez River							
Santa Ynez River at Jameson Lake, near Montecito (j)	11,585	21	5,000	2,400	232	-	-
Santa Ynez River above Gibraltar Dam, near Santa Barbara (k)	101,274	32	32,560	13,000	311	-	-
Santa Ynez River below Gibraltar Dam, near Santa Barbara (k)	85,500	32	28,500	9,400	300	32,600	-
Santa Ynez River below Los Laureles Canyon, near Santa Ynez	123,900	5	-	-	-	33,000	-
Santa Cruz Creek near Santa Ynez	29,500	10	8,240	6,200	358	2,690	226

(j) Basic data furnished by Montecito County Water District.
(k) Basic data furnished by city of Santa Barbara.

Table 4.--Runoff in the 1951-52 water year in southern California streams--Continued

Basin and stream	1951-52 annual runoff (ac-ft)	Length of record (years)	Mean annual runoff (ac-ft)	Median annual runoff (ac-ft)	1951-52 runoff (percent of mean)	1951-52 peak discharge (cfs)	Index
Santa Ynez River (continued)							
Cachuma Creek near Santa Ynez	8,800	2	-	-	-	4,300	-
Santa Ynez River near Santa Ynez	199,300	22	74,160	23,200	269	39,400	432
Santa Agueda Creek near Santa Ynez	6,380	11	2,090	1,100	305	1,670	248
Santa Ynez River at Solvang	239,100	14	37,550	10,900	637	37,000	639
La Zaca Creek at Buellton	1,090	11	245	40	445	622	305
Salsipuedes Creek near Lompoc	16,870	11	5,070	1,800	333	11,400	438
Santa Ynez River near Lompoc	261,900	27	96,640	38,400	271	39,000	351
Santa Ynez River at H Street, near Lompoc	256,700	5	-	-	-	37,900	-
Santa Ynez River at barrier, near Surf	295,200	5	-	-	-	36,000	-
San Antonio Creek							
San Antonio Creek at Harris	4,230	11	971	290	436	1,800	357
Santa Maria River							
Cuyama River near Ventucopa	14,500	7	-	-	-	-	-
Cuyama River near Santa Maria	45,310	22	16,790	8,700	270	6,200	258
Alamo Creek near Santa Maria	20,980	9	-	-	-	2,820	-
Huasna River near Santa Maria	40,520	22	15,420	6,100	263	4,060	185
Sisquoc River near Sisquoc	76,660	9	-	-	-	6,880	-
La Brea Creek near Sisquoc	20,670	9	-	-	-	3,320	-

Table 4.--Runoff in the 1951-52 water year in southern California streams--Continued

Basin and stream	1951-52 annual runoff (ac-ft)	Length of record (years)	Mean annual runoff (ac-ft)	Median annual runoff (ac-ft)	1951-52 runoff (percent of mean)	1951-52 peak discharge	
						(cfs)	Index
Santa Maria River (continued)							
Tepusquet Creek near Sisquoc	2,680	9	-	-	-	318	-
Sisquoc River near Garey	73,720	11	20,230	8,700	364	8,910	224
Santa Maria River at Guadalupe	104,700	11	18,740	3,300	559	23,800	414
Arroyo Grande							
Arroyo Grande at Arroyo Grande	36,760	12	18,280	8,700	201	5,370	442
Salton Sea							
Whitewater River at Whitewater	8,330	4	-	-	-	265	-
Tahquitz Creek near Palm Springs	6,560	5	-	-	-	135	-
Palm Canyon Creek near Palm Springs	6,390	17	4,200	1,400	152	1,010	18
Andreas Creek near Palm Springs	2,720	4	-	-	-	96	-
Coyote Creek near Borrego Springs	2,320	2	-	-	-	312	-
Palm Canyon Creek near Borrego Springs	985	2	-	-	-	50	-
Mojave River							
Deep Creek near Hesperia	62,640	39	55,790	40,800	112	2,830	54
West Fork Mojave River near Hesperia	43,820	40	34,160	22,600	128	6,780	163

Table 4.--Runoff in the 1951-52 water year in southern California streams--Continued

Basin and stream	1951-52 annual runoff (ac-ft)	Length of record (years)	Mean annual runoff (ac-ft)	Median annual runoff (ac-ft)	1951-52 runoff (percent of mean)	1951-52 peak discharge (cfs)	Index
Mojave River (continued)							
Mojave River at lower narrows, near Victorville	66,790	27	61,360	37,600	109	3,690	51
Mojave River at Barstow	12,540	22	26,140	800	48	960	-
Antelope Valley							
Rock Creek near Valyermo	17,540	29	11,840	8,000	148	224	37
Little Rock Creek near Little Rock (h)	22,960	20	14,030	8,000	164	502	26

(h) Records furnished by Los Angeles County Flood Control District.