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GEOLOGICAL SURVEY CIRCULAR 399

WATER RESOURCES SUMMARY FOR SOUTHERN CALIFORNIA, 1956

UNITED STATES DEPARTMENT OF THE INTERIOR
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By Walter Hofmann and William C. Peterson

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WATER RESOURCES SUMMARY FOR SOUTHERN CALIFORNIA, 1956

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ABSTRACT

Current water requirements for southern California are more than 2,000,000 acre-feet per year. These requirements are being satisfied by supplementing limited local water reserves with imported water.

The average annual precipitation ranges from about 2 inches in parts of the desert to about 50 inches in the higher mountains. Also, there is a great variation in annual precipitation at any one place.

The annual variation is not entirely random in that the annual precipitation tends to occur in sequences of wet and dry years. Records of the 1955-56 climatological year indicate that the dry period which began in 1944 continues unabated.

Runoff follows the same cyclic pattern of wet and dry periods established by precipitation, but with even greater variability. Annual runoff for the 1955-56 water year at 15 selected gaging stations ranged from 0.02 to 7.6 inches with departures from the average annual runoff for the 30-year "base mean" period, 1920-50, ranging from minus 100 to plus 12 percent. The average annual runoff for the 1955-56 water year was 1.77 inches, a departure of minus 59 percent from the base mean. The average annual runoff for the 12-year dry period, 1944-56, ranged from 0.27 to 7.2 inches with an average departure of minus 50 percent.

As a result of these continuing dry years, most of the reservoirs storing natural runoff were practically dry. The combined contents of 12 selected reservoirs in September 1956 was only 9.2 percent of total capacity.

The trend in ground-water depletion that began in 1944 continued during the year. Although the increased use of imported water for recharge of ground-water basins reduced the rate of decline in some areas, water levels in most observation wells were the lowest of the period of record. In areas entirely dependent on local ground-water reserves for their supply, the problem of obtaining sufficient water became more critical.

The rapid increase in requirements of water stepped up the importation of water from the Colorado River from 20,000 acre-feet in 1944 to 430,000 acre-feet in 1956. During the same period importations from Owens Valley were running close to aqueduct capacity; 336,000 acre-feet was imported from this source during 1956.

Annual runoff data for the 1954-55 water year from all currently published gaging-station records establish that year as one of the driest in recent years.

INTRODUCTION

This water resources summary is the 14th in a series issued annually since June 1944. Its main purpose is to present a brief analysis of those phases of local water supply associated with the work of the Geological Survey in southern California.

The first part of this summary deals with water resources for the water year ending September 30, 1956. It contains a brief analysis of annual precipitation, annual runoff (provisional) at selected gaging stations, water reserves in both surface and underground reservoirs, and supplemental imported water.

The second part of this summary gives, in detail, annual runoff for the preceding water year ending September 30, 1955. About 1 year of effort after the conclusion of a water year is usually required to complete computations of daily discharge for all the gaging stations. An additional 6 months to a year is required to process and present the data in published form in the annual Geological Survey Water-Supply Papers. Consequently this report on the water resources summary represents the first opportunity to release data on magnitude of runoff for all stations now operated in southern California for the water year 1954-55.

Some of the information presented in this summary was included in previous issues. The repetition is made so that each water resources summary will be complete and entirely independent of previous issues.

For the purpose of this summary, southern California is that part of the State extending southward along the coast from the Arroyo Grande basin to the international boundary and inland to include all the area to the Colorado River and Nevada State line south of the Tehachapi Mountains and Inyo County. The inland part of this 47,000-square-mile area is predominantly an arid desert. Consequently most of the region's population centers and agricultural areas are concentrated in the long narrow band of coastal land. The chief exceptions are Antelope Valley in the Mojave Desert and Coachella and Imperial Valleys in the Colorado Desert. The area covered in this summary is shown in figure 1.

Because of many desirable climatic and economic factors, the population growth of southern California has been phenomenal, probably the greatest in the Nation. A population of about 300,000 at the turn of the century increased to 5,715,000 by the time the 1950 census was taken. About 80 percent of this population increase occurred in the three decades since 1920. Since 1950 the population growth has continued

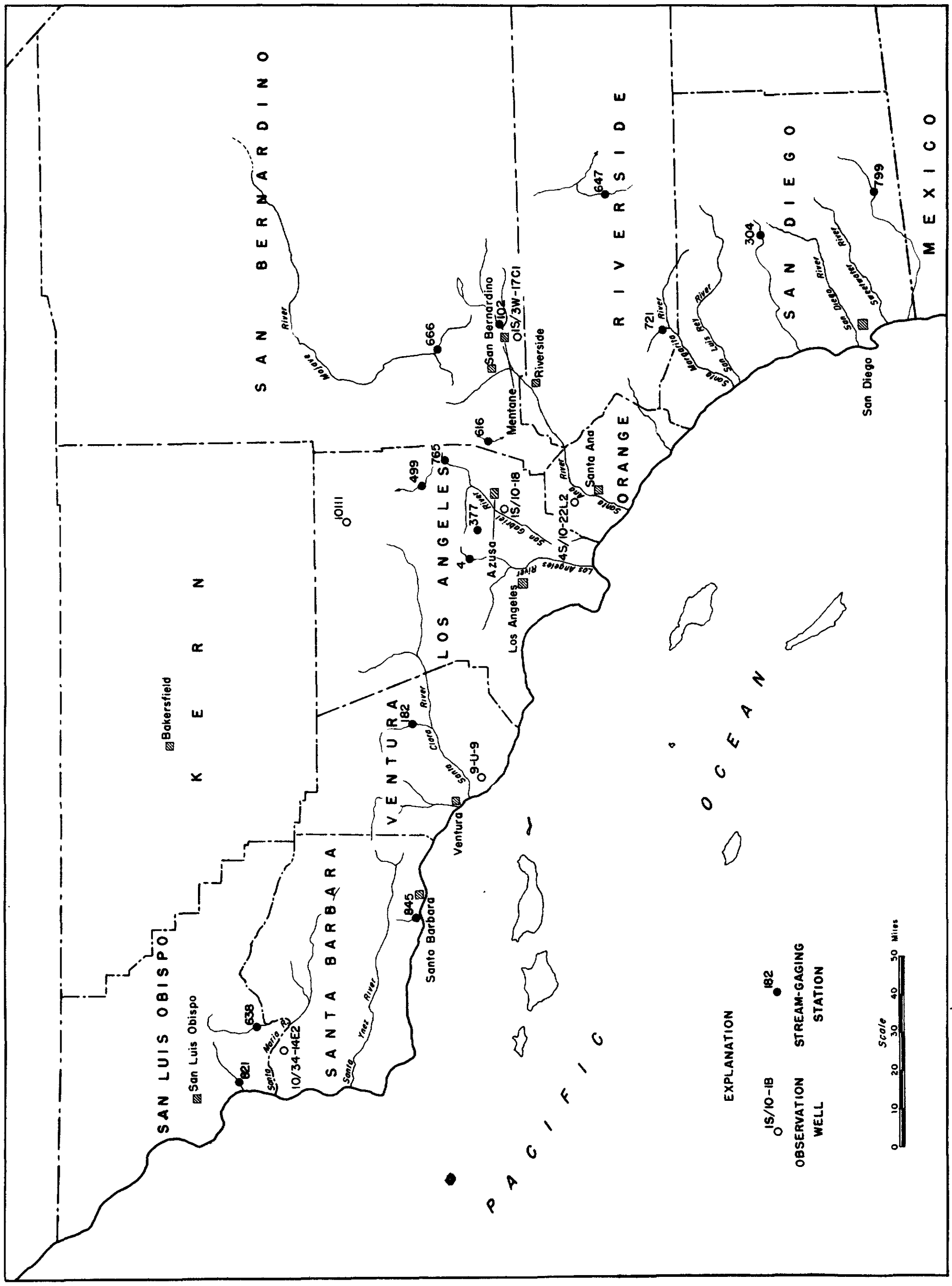

Figure 1. --Location of selected gaging stations and observation wells.

and it is estimated that the present population of southern California is about 8,000,000.

Such a vast increase in population greatly intensifies the water problems in these arid and semiarid regions of limited water reserves. It has been estimated that the water requirements for urban and agricultural purposes in the coastal areas amounted to about 1,800,000 acre-feet in 1950 and have been steadily increasing at a rate of about 40,000 acre-feet per year. As a result the water situation has changed from good to extremely critical in many areas. Just how critical the situation is depends largely upon the magnitude of the local ground-water reserves and the community's ability to import water from outside the basin.

Because of limited local water reserves, southern California has been forced to go greater distances for its water supply, and has paid more for it than any other area of comparable size in the Nation.

WATER RESOURCES FOR THE WATER YEAR 1955-56

Precipitation

Very few areas in the United States experience the wide range in the average annual precipitation as that observed in southern California. Because of modifications in the atmospheric-moisture circulation by local physiographic features, the observed average annual precipitation ranges from 2.24 inches at Bagdad in the Mojave Desert to 51.53 inches at Morse in the San Bernardino Mountains.

On an areal basis, the average annual precipitation of southern California is about 9.5 inches, or only about 32 percent of the national average of 30 inches. Not more than 2 percent of southern California has an average annual precipitation equal to or larger than that of the United States. More than 50 percent of southern California is arid, with an average annual precipitation of 5 inches or less.

In addition to the great range in average annual precipitation from place to place, there is often an even greater annual variation in the precipitation at the same place. For instance, the annual precipitation at Los Angeles for the climatological year, July 1 to June 30, has ranged from 5.59 inches in 1898-99 to 38.18 inches in 1883-84, and averaged 15.06 inches for the 79-year period of record. At Indio, in the desert area of southern California, the annual precipitation has ranged from 0.40 inch in 1879-80 to 11.50 inches in 1939-40, and averaged 3.18 inches for the 78-year period of record.

The annual variation in precipitation is not entirely of a random nature, as the annual precipitation occurs in sequences of wet and dry years. The sequences represent a time distribution in which the wet years are predominant, alternating with other periods in which dry years are predominant--resulting in an irregular cyclic pattern. This time distribution is most pronounced on the coastal side of the mountains and least defined in the arid desert regions.

Possibly the longest existing record of these wet and dry sequences is to be found in the growth of annual tree rings in certain types of trees growing in the mountains of southern California. Schulman 1/ has been able to measure the annual tree-ring growth in big-cone spruce for the 559-year period of 1385 to 1944. These records indicate a definite cyclic pattern, with the average length of dry periods amounting to 14.5 years and wet periods amounting to 12.5 years, giving an average cyclic period of 27 years. Not all the individual years within a wet period are wet, but the wet years predominate; likewise, not all the individual years within a dry period are dry, but the dry years predominate.

A diagram showing the progressive 10-year means (fig. 2) is frequently used to show the existence of the alternating wet and dry periods. Points used to define these three curves represent the departures of the 10-year mean annual precipitation from the average annual precipitation for the period of record at Los Angeles, Santa Barbara, and San Diego for successive 10-year periods. The three pronounced peaks in this diagram represent wet periods; the valleys represent dry periods. Final points on these curves, in the incomplete valley, represent the mean annual precipitation for the last 10-year period ending on June 30, 1956.

The observed 1955-56 annual precipitation at these three typical southern California stations is given in table 1. During this year, the 12th in an extended dry period, the annual precipitation exceeded the mean annual for the period of record at Los Angeles and Santa Barbara for the first time since the wet year of 1952. However, precipitation at San Diego was the lowest since 1934, and fifth lowest during the 106 years of record. The influence of this year's precipitation on the last 10-year period (fig. 2) is such as to continue the downward trend at San Diego, and to improve the upward trend at Los Angeles and Santa Barbara. However, this upward trend in the incomplete valley (fig. 2) does not in itself furnish evidence of the end of the current drought because the variation may be due only to the influence of a relatively wet year or years within a dry period.

Runoff

The precipitation, after first satisfying the soil-moisture deficiencies in the root zone of the native vegetation in mountain and foothill areas and of the agricultural crops in the valley-floor areas, recharges the regional ground-water storage or drains into the stream channels as runoff. That part of the precipitation appearing as runoff follows the same cyclic tendency shown in figure 2. However, this cyclic tendency is often more pronounced because the annual runoff may represent only a very small part of annual basin-wide precipitation. For example, the annual runoff for San Gabriel River near Azusa has ranged from as little as 0.86 inch throughout the basin during the water year ending September 30, 1899, to a maximum of 36.4 inches in the water year ending September 30, 1922, with an average of 9.8 inches during the 61-year period of record.

This range in annual runoff, together with its time sequence, is shown in figure 3 for the gaging station

1/ Schulman, Edmund, 1947, Tree-ring hydrology in southern California: Univ. Ariz., Laboratory of Tree-ring Research, Bull. 4.

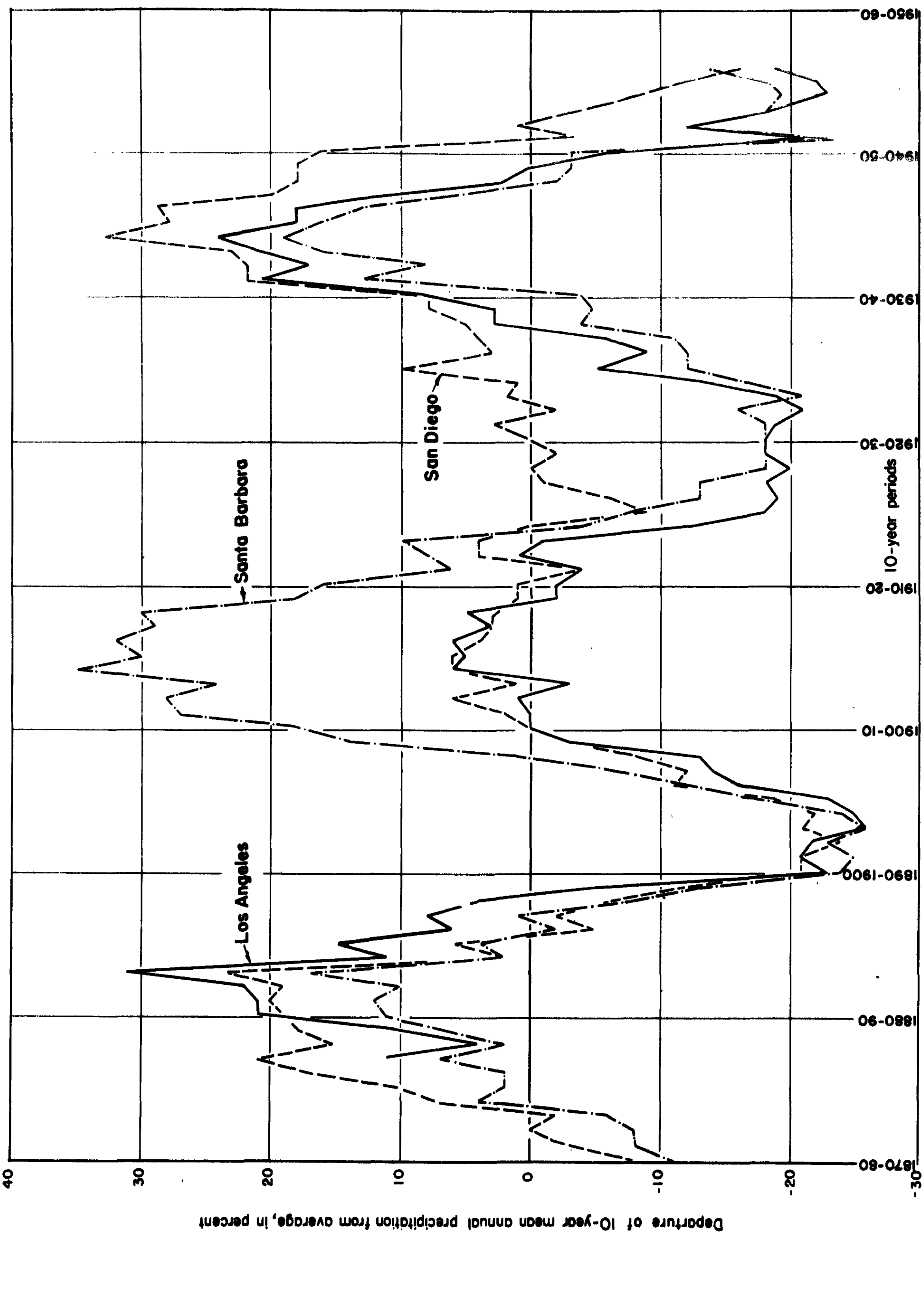

Figure 2. --Progressive 10-year mean annual precipitation.

Table 1.--Annual precipitation

Station	Period of record		1955-56 annual precipitation		10-year period 1946-56 mean annual precipitation	
	Length (years)	Mean annual precipitation (inches)	Inches	Departure from mean (percent)	Inches	Departure from mean (percent)
San Diego	106	9.95	4.52	-54.5	8.36	-16.0
Los Angeles	79	15.06	16.00	+6.2	12.23	-18.8
Santa Barbara	89	17.96	19.84	+10.5	15.48	-13.8

on San Gabriel River near Azusa and the gaging station on Santa Ana River near Mentone. Both stations reflect the runoff from rugged mountain basins within the San Bernardino and the Angeles National Forests, where efforts are made to protect and to maintain a native vegetative cover. The records for these two stations are assumed to be typical of the mountain runoff in those areas where the basin-wide average annual precipitation ranges from 30 to 40 inches. Both records display the same cycliclike tendencies shown by the annual precipitation. To accentuate this distribution the records have been segregated into the generally accepted wet and dry periods of the region, with the average annual runoff for each of these periods shown by the crosshatched area.

A measure of the relative dryness of the dry periods is afforded by numbering the 10 driest years for each station (fig. 3) in their order of dryness. Of these 20 years at both stations, 10 occurred in the very dry 9-year period ending September 30, 1904. The current dry period is next in order with 7 years, and the 14-year period ending on September 30, 1936, was the least dry, containing only 3 of the 20 years.

One of the methods used for determining wet and dry periods is that of cumulative departures as shown in figure 4. The diagrams show cumulative departures of annual runoff from the mean annual runoff, in percent, for the period of record (as of 1954) for both the San Gabriel River and Santa Ana River stations. A continuously downward trend represents a dry period; a continuously upward trend represents a wet period.

It is evident from an inspection of figure 4 that both records contain 3 dry and 2 wet periods and consequently the means for the periods of record tend to be biased because of the greater number of dry years. On the basis of the records for San Gabriel River near Azusa, the 49-year period of 1895-1944 and the 50-year period of 1904-54 represent the least biased records because each contains 2 wet and 2 dry periods. For Santa Ana River near Mentone, the least biased records are those for the 47-year period 1896-1943, and for the 49-year period 1925-54. There are but few gaging stations in southern California where records are of sufficient length to contain these optimum time periods.

Lack of sufficiently long records necessitates the use of shorter periods, each containing a single wet and dry sequence. The beginning and ending of each of these sequences, together with the mean annual runoff for each sequence, is included in figure 4.

Because of areal differences in the beginning and ending dates of the sequence of wet and dry groups of years and lack of definition of the sequences in drainage areas of meager precipitation, any time period selected for a "base mean" will be quite arbitrary; yet, when properly interpreted, it will have considerable hydrologic significance in many parts of southern California.

Consequently, the 30-year period beginning in October 1920 and ending in September 1950 has been selected for use as a base mean in the water-resources summary. The beginning date was selected to conform more nearly with the standard period of October 1920 to September 1945 for which median monthly discharge is computed and used for national coverage by the Water Resources Review of the U. S. Geological Survey and the Canadian Water Resources Division of the Department of Northern Affairs and National Resources.

One of the purposes of figures 3 and 4--and the water resources summary--is to show the weaknesses and shortcomings of the mean or median values in reference to most southern California water problems. The data suggest that it is doubtful whether the 30-year or the long-time mean annual runoff can be used as a direct measure of dependable runoff. Consequently the mean annual runoff becomes merely a measure of the relative runoff among basins rather than a measure of usable or available water during extended critical periods.

Annual runoff for the water year 1955-56

Annual runoff for the water year 1955-56 at the 15 gaging stations shown on figure 1 is briefly summarized in table 2 and compared to the average-annual runoff for the 30-year base period of 1920-50.

The intent of table 2 is to provide a general index of the surface runoff throughout southern California during each water year. The wide range of the 1955-56 runoff, 0.02 to 7.6 inches, is typical of the region and is due largely to the areal distribution of precipitation. In its relation to time distribution the departures of the 1955-56 runoff from the 30-year base mean were about the same as those of the preceding 1954-55 water year with the exception of the Huasna River in the Santa Maria basin, and Arroyo Grande in the Arroyo Grande basin. Runoff in these excepted basins at the extreme north end of coastal southern California was within relatively few percent of the base mean.

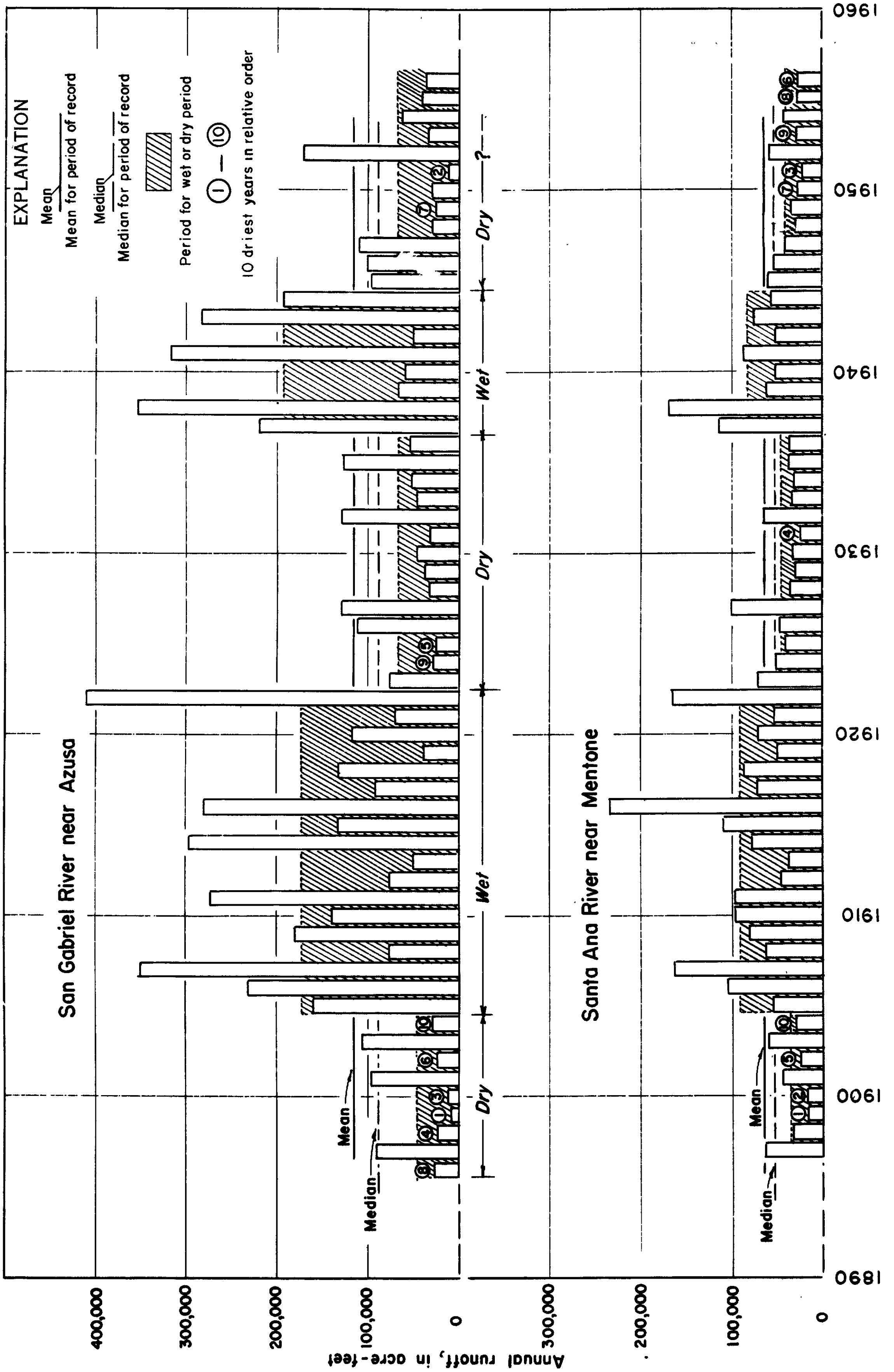

Figure 3. --Annual runoff distribution 1896-1956.

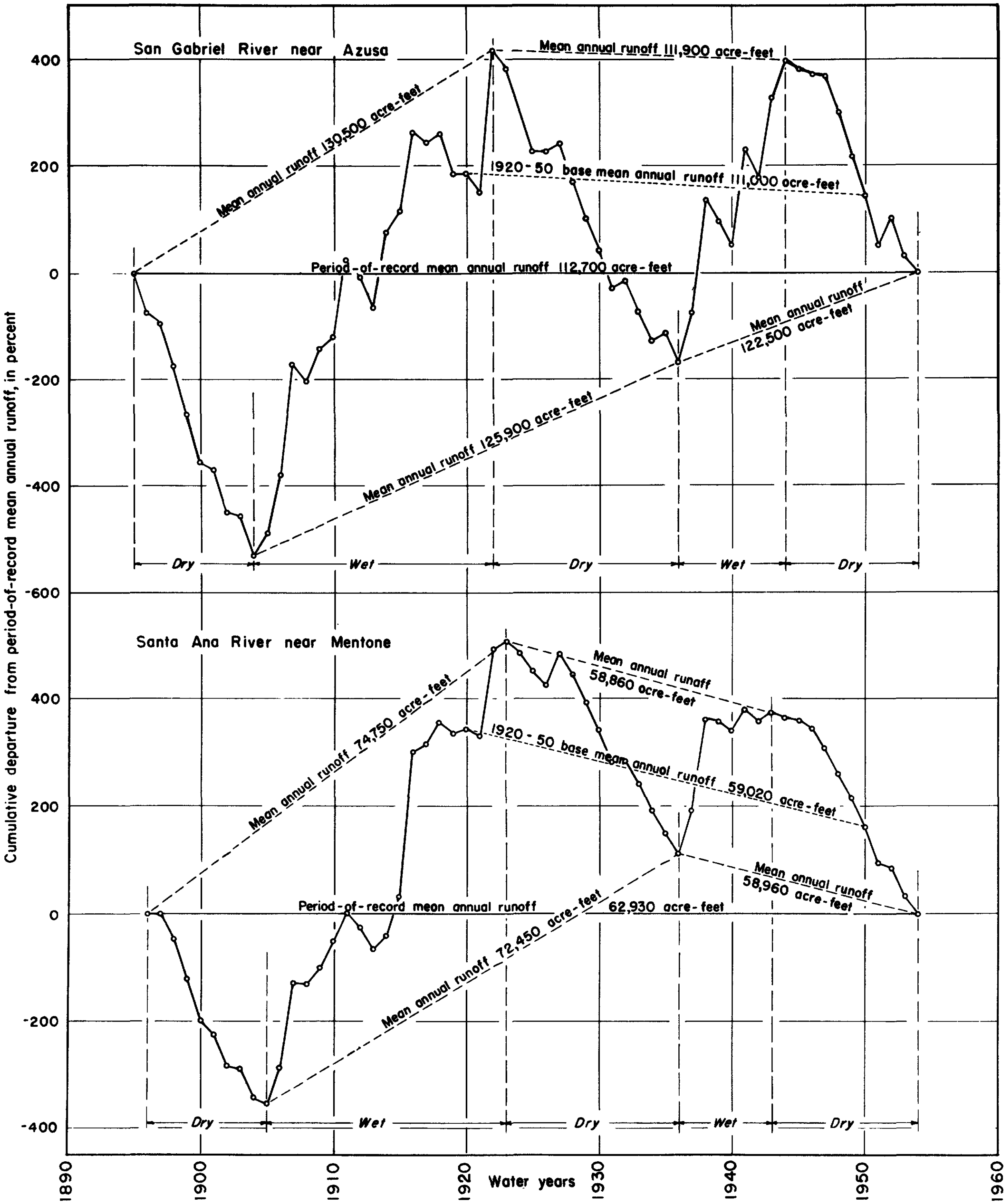

Figure 4. --Mean annual runoff for different periods.

Table 2.--Annual runoff for the water year 1955-56 and the average annual runoff for the dry period 1944-56 at selected gaging stations

No. on fig. 1	Station	Drainage area (square miles)	1920-50 base mean annual runoff (acre-feet)	1955-56 runoff			Average annual runoff for 1944-56 dry period		
				Acre-feet	Inches	Departure from base mean annual runoff (percent)	Acre-feet	Inches	Departure from base mean annual runoff (percent)
	Pacific Slope Basins:								
799	Cottonwood Creek at Morena Dam	120	12,720	136	0.02	- 99	3,190	0.50	-75
304	Santa Ysabel Creek at Sutherland Dam	58	13,400	856	.28	- 94	4,690	1.5	-65
721	Murrieta Creek at Temecula	220	9,930	610	.05	- 94	3,590	.31	-64
102	Santa Ana River near Mentone	202	59,020	26,890	2.5	- 54	37,810	3.5	-36
616	Cucamonga Creek near Upland	10.1	6,080	2,100	3.9	- 65	3,880	7.2	-32
765	East Fork San Gabriel River near Camp Bonita	88.2	51,610	22,200	4.8	- 57	32,040	6.8	-38
41	Arroyo Seco near Pasadena	16.4	6,720	2,160	2.5	- 68	3,390	3.9	-50
377	Santa Anita Creek near Sierra Madre	10.5	4,580	2,230	4.0	- 51	2,660	4.8	-42
182	Sespe Creek near Fillmore	254	75,290	29,600	2.2	- 61	37,800	2.8	-50
845	San Jose Creek near Goleta	5.54	--	2,230	7.6	-	840	2.8	-
638	Huasna River near Santa Maria	119	12,810	10,430	1.6	- 19	6,580	1.0	-49
821	Arroyo Grande at Arroyo Grande	106	a15,400	17,320	3.1	+ 12	9,150	1.6	-41
	The Great Basin:								
666	Deep Creek near Hesperia	137	47,150	16,980	2.3	- 64	26,460	3.6	-44
499	Rock Creek near Valyermo	23.0	12,890	4,800	3.9	- 63	7,890	6.4	-39
647	Palm Canyon Creek near Palm Springs	94.0	4,480	.2	0	-100	1,360	.27	-72

a Runoff for the period prior to 1940 obtained from State Water Resources Board Bull. 1.

The derivation of an over-all average figure for runoff more or less obscures the purpose of table 2, that is, the emphasis of table 2 is on the range and areal distribution of runoff; however, an over-all average has the merit of simplicity and it is offered on that basis. The average annual runoff for the 1955-56 water year was 1.77 inches over the 1,463 square miles of mountain drainage listed in table 2, or about 41 percent of the 30-year base. During the preceding water year the average annual runoff for this group of basins was 1.44 inches, or about 0.8 as much as 1955-56.

Current dry period

The typical southern California runoff distribution shown on figure 3 indicates that the water year ending September 30, 1956, was among the driest during the observational period. Furthermore, this dry year was the 12th in a predominately dry period that has persisted since October 1944--and may not be ended for some time. The tree growth studies by Schulman suggest that southern California may have experienced dry periods of more than 40 years' duration.

The average runoff for this 12-year dry period and its relation to the base mean is included in table 2. At most of the stations the average runoff for the period 1944-56 was less than that for the period 1944-55. The average departure of the runoff from the 30-year base mean during the 12-year dry period for the basins listed was minus 50 percent, whereas that for the 11-year dry period was minus 45 percent.

Surface storage

Currently there exists about 1,500,000 acre-feet of surface storage in southern California for municipal, domestic, and irrigational purposes. Most of this storage has been obtained by building dams across mountain stream channels. However, because of the many adverse topographic features, such as steepness of the stream channels and narrowness of the canyons, construction costs are high and reservoir capacities small. Only 5 reservoirs of 115 built have a capacity in excess of 100,000 acre-feet. Because of these relatively small reservoir capacities, it is impossible in many instances to carry over the excessive flood runoff occurring during wet periods for use in the following dry periods. Furthermore, many of these reservoirs were not built for the purpose of storing local flood runoff, but were intended for the storing and distribution of imported waters from Owens Valley and the Colorado River.

Because of the necessity for flood control in the valley-floor areas, additional storage of more than 400,000 acre-feet has been developed. Even though these flood-control reservoirs are primarily for the purpose of retarding the flood runoff, there is generally a certain amount of water conservation involved in that, when possible, releases are controlled to increase ground-water recharge.

Data regarding the behavior of 12 reservoirs during the current dry period are given in table 3. All of these reservoirs were built for the purpose of supply-

Table 3.--Storage in selected surface reservoirs

Reservoir	Average annual 1920-50 inflow (acre-feet)	Present spilling capacity (acre-feet)	Ratio of storage to inflow	Storage Sept. 30, 1955 Acre-feet	Storage Sept. 30, 1955 Percent of capacity	Storage Sept. 30, 1956 Acre-feet	Storage Sept. 30, 1956 Percent of capacity	Change in storage (acre-feet)	Storage on Sept. 30, 1944 Acre-feet	Storage on Sept. 30, 1944 Percent of capacity	1944-56 Change in storage (acre-feet)
Morena and Barrett	[a]27,100	94,970	3.5	3,550	4.0	1,410	1.5	- 2,140	89,900	86	- 87,760
El Capitan	[a]35,100	112,810	3.2	12,300	11	6,690	5.9	- 5,610	79,700	68	- 73,010
Lake Hodges	37,310	33,550	.90	[b]3,680	11	[b]2,640	7.9	- 1,040	31,100	93	- 28,460
Lake Henshaw	27,090	194,300	7.2	2,070	1.1	[c]1,800	0	- 2,070	144,000	74	-142,200
Vail Lake	10,650	49,370	4.6	1,360	2.8	810	1.6	- 550	-	-	-
Big Bear Lake	-	72,200	-	11,700	16	2,830	3.9	- 8,870	47,600	66	- 44,770
Santiago	11,670	25,000	2.1	2,820	11	2,830	11	+ 10	20,400	82	- 17,570
Matilija	22,400	7,020	.31	4,580	65	5,560	79	+ 980	-	-	-
Jameson Lake	4,010	6,760	1.7	3,940	58	3,030	45	- 910	6,050	89	- 3,020
Gibraltar	31,360	14,780	.47	5,330	33	11,660	79	+ 6,330	6,120	38	+ 5,540
Cachuma	63,070	210,000	3.3	19,600	9.3	36,600	17	+17,000	-	-	-
Total	[d]280,000	820,760	2.9	70,930	8.7	75,860	9.2	+ 4,930	424,870	78	-391,250

[a] From State Water Resources Board Bull. 1.
[b] Mostly Colorado River water.
[c] Approximately.
[d] Average annual inflow to Big Bear Lake estimated.

ing domestic, municipal, or irrigational water. Except for Lake Hodges, the only source of inflow to each reservoir during 1956 was from local runoff. The combined capacity of these 12 reservoirs is about 55 percent of the total capacities thus far developed for these purposes.

Of this group the Morena and Barrett reservoirs are the most southerly in the Tia Juana River basin. At the end of the preceding dry year--on September 30, 1955 --these reservoirs were almost empty. At the end of the equally dry 1956 water year the reservoirs were still almost empty. This is typical of the larger reservoirs where the holdover storage from the preceding wet period has long been exhausted.

Farther north at the Matilija reservoir, the storage at the end of the 1955 water year amounted to 65 percent of capacity. At the end of the 1956 water year this storage increased to 79 percent of capacity. This relatively large retention is typical of those reservoirs in which the average annual inflow is large in terms of the reservoir's capacity.

Ground water

Over a large part of southern California, the most readily available and best distributed water reserve is the water stored in the deep alluvial deposits of the valley-floor area. A major part of the region's water requirements has been and is being satisfied by pumping from this source. The magnitude of these water reserves is difficult to measure; however, they have been estimated to be about 7,500,000 acre-feet in the alluvial deposits in the basins of the Los Angeles, San Gabriel, and Santa Ana Rivers in a zone 100 feet thick extending from 50 feet above to 50 feet below the January 1933 water levels. Eckis 2/.

The rapid growth of the industrial and urban developments has overtaxed these reserves. As a consequence the current rate of extraction often exceeds the average rate of recharge, creating an overdraft. Currently, large sections of southern California now have, or are threatened by, overdrafts.

The usefulness of a ground-water reservoir, like a surface-water reservoir, is dependent upon its size, the magnitude of the annual increments of recharge, and the annual rate of withdrawal. Also, like a surface reservoir, the ground-water reservoir must capture its water in the wet periods and retain it in storage to satisfy the needs of the following dry periods.

The valleys of southern California contain a large number of ground-water basins, many of which have complex geologic and hydrologic features. Changes in water levels differ considerably from basin to basin, depending upon the relationship between natural recharge and pumping draft. Consequently it has been necessary to confine the detailed analysis of the changes in water levels to the few observation wells indicated on figure 1.

The records of change in water level at six selected observation wells for their period of record are shown on figure 5. The division of wet and dry periods arbitrarily is based on figure 4. A light dashed line serves to indicate the rate of decline during each dry period, and is based chiefly on the group of years having the least precipitation during the period. Assuming that ground-water recharge during all dry periods is small and of about the same magnitude, an increase in the rate of decline becomes a measure of the increase in ground-water extractions.

At the end of the 1956 water year almost all water levels were the lowest for the period of record--a reflection of the great increase in regional water requirements and the excess of withdrawals over the small increments of recharge during the current 12-year dry period.

Western San Diego County

Ground-water levels in the coastal alluvial valleys of western San Diego County, including the basins of the Tia Juana, Otay, Sweetwater, San Diego, San Dieguito, and San Luis Rey Rivers, declined during the 1956 water year, continuing a downward trend which began about 12 years ago. By September 30, 1956, the levels in many wells were the lowest during the entire

2/ Eckis, Rollin, 1934, Geology and ground-water storage capacity of valley fill (South Coastal Basin Investigation): Calif. Dept. Public Works, Div. Water Resources. Bull. 45.

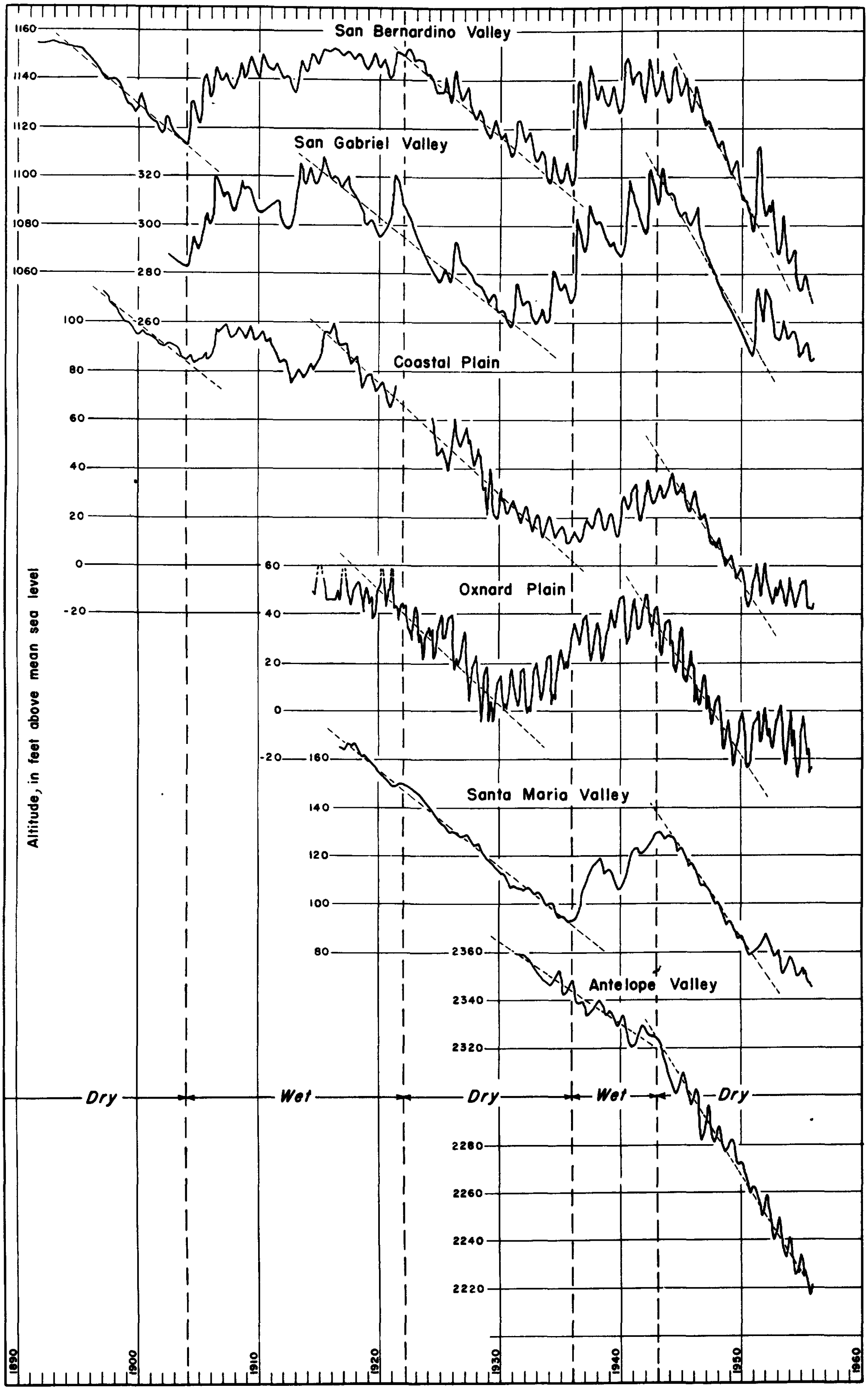

Figure 5. --Water level fluctuations at selected observation wells.

period of record. The water levels were below sea level during all or part of the year near the coast in the San Luis Rey and Otay River basins. At the present time areas of known or threatened sea-water intrusion exist in the basins of the Tia Juana, Otay, San Diego, and San Luis Rey Rivers.

Riverside County

The ground-water levels in the arid and semiarid San Jacinto basin have declined steadily since the first observations of 1904. The Riverside County Flood Control and Water Conservation District reports that the water level in the key well 4S/1W35-R1, near the city of San Jacinto, which was flowing in 1917, was about 180 feet below land surface in September 1956. Similarly the water level in a second well 4S/3W33-R1, near the city of Perris, was about 189 feet below the land surface during September 1956 in an area where the water level was about 20 feet below the land surface during March 1904. Both areas now are using a limited amount of Colorado River water--at double the cost of locally pumped water--in an effort to supplement the declining water reserves.

Rapidly dropping ground-water levels in the Elsinore, Beaumont, Yacaipa, and Whitewater basins have indicated the need for supplemental supplies. The Murrieta and Temecula basins have not provided sufficient water for irrigation for some time, and the area is largely dry farmed as a result.

San Bernardino Valley

The San Bernardino Valley is a relatively deep alluvial valley in the upper Santa Ana River basin east of metropolitan Los Angeles. The water needs of the valley's prominent agricultural and urban developments are satisfied from both local surface and ground-water reserves.

The longest available record of changes in the valley's ground-water levels is that for the Williams well 1S/3W-17C1. This record, started in 1892, and shown on figure 5, represents a continuous cumulative balance between the annual recharge during the winter rainfall period and the annual depletion caused by pumping during the summer months. These cumulative differences give the water-level fluctuations a general cyclic time distribution that coincides closely with the wet and dry periods of figure 4.

The rate of decline during the first and second dry periods amounted to about 4.2 feet per year. However, during the current dry period the rate of decline increased to about 10 feet per year. This increase in rate of decline reflects an increase in ground-water use, which, together with substantial prolongation of the current dry period, forecasts a condition of overdraft in the near future.

The San Bernardino Valley Water Conservation District reports that the valley's ground-water levels at the end of the 1956 water year averaged about 98 feet below the levels at the beginning of the current dry period. Many wells have gone dry, or the yields have diminished to the point where the wells have become unusable. Among these was the Williams well, which went dry in July 1956 and was still dry in January 1957. The estimated part of the record shown on figure 5 is based on the levels in nearby wells.

Deepening of wells, lowering of pumps, and increased pumping costs are imposing serious economic hardships on water users, particularly in the fringe areas of the valley.

San Gabriel Valley

The San Gabriel Valley is a deep alluvial valley in the San Gabriel River basin along the toe of the San Gabriel Mountains. The ground-water-storage capacity of these deposits is believed to be about 1,200,000 acre-feet in a zone 100 feet thick, ranging from 50 feet above to 50 feet below the January 1933 water level. Eckis 2/. The once extensive agricultural acreage in this valley is rapidly being converted to an urban area. Most of the valley's water requirements are satisfied from local ground-water reserves.

The record obtained at the Baldwin Park observation well 1S/10-18, shown on figure 5, is assumed to represent ground-water conditions throughout the valley. During the dry period 1922-36 the average rate of decline amounted to about 3.9 feet per year increasing to 8.8 feet per year during the current dry period. During the last few years this rate of decline has moderated, owing in part to the wet year 1951-52 and in part to the increased use of imported Colorado River water in the area.

Coastal Plain

The coastal plain is the broad, flat area extending along the coast from Santa Monica to Newport Beach and inland to the Santa Monica and Santa Ana Mountains, the Puente and San Jose Hills, and lesser foothills. The three major streams of the Los Angeles area--the Santa Ana, San Gabriel, and Los Angeles Rivers--cross this plain to discharge into the ocean. The plain's rich agricultural lands have been converted gradually into extensive urban and suburban developments. Currently the coastal plain is the most densely populated and industrialized section of southern California.

The fresh-water-bearing deposits underlying the plain are composed of marine and alluvial deposits which locally attain a thickness of 2,500 feet or more. Less than 20 years ago the water stored in these deposits was the principal source of water for the area. Because of the rapid increase in water needs during recent years, it has been necessary to import a substantial portion of the water requirements from Owens Valley and the Colorado River. Even with these imported waters, the ground-water reserves have been so depleted that sea water has intruded many sections of the coast.

Systematic observations of change in ground-water level in the coastal plain have been noted at the Neff well 4S/10-22L2 and its companion wells near Anaheim since 1898. These records, shown on figure 5, have been used as an index of changes in the water level of the coastal plain. During the 58-year period of record at this site, a net decline of 130 feet, from 112 feet

2/ See footnote p. 9.

above sea level to 18 feet below sea level was observed. This decline, which has not been uniform, was concentrated largely in the three dry periods. A rate of decline of 3.9 feet per year in the first dry period increased to 4.6 feet per year during the second dry period and to 7.6 feet per year in the current dry period. During the last few years, this rate of decline has moderated owing in part to the wet year of 1952 and in part to greater use of imported waters.

The Orange County Flood Control District reports an average decline in ground-water level of about 3 to 4 feet throughout the eastern part of the coastal plain during 1956. About 13,000 acre-feet of Colorado River water was purchased by the district for recharging the ground-water reserves. In 1955 the average drop in water level was about 1 foot during a year in which about 52,000 acre-feet of Colorado River water was spread in order to replenish the under-ground basin.

Oxnard Plain

The Oxnard Plain is one of the most important agricultural and urban areas in Ventura County. Water-level observations made by Ventura County Department of Public Works, Division of Water Resources, at well 9-U-9 in the city of Oxnard, are shown on figure 5, and are assumed to represent changes in the ground-water reserves of this broad coastal plain. Since 1943 the water level at this site has declined almost continuously. Between 1943 and 1951 the rate of decline was about 7.4 feet per year. This trend was reversed temporarily by recharge in the wet year 1951-52. However, since 1953, the decline in water level has resumed at a rate somewhat less than that before 1952.

The Ventura County Division of Water Resources reports that the ground-water levels of the Oxnard Plain were generally about 20 feet below sea level in the fall of 1956. At this same time the water levels were about 50 feet below sea level in Pleasant Valley, an eastward extension of the Oxnard Plain. There is evidence of sea-water intrusion in wells near the ocean.

Santa Maria Valley

Changes in water level at well 10/34-14E2 (fig. 5) near the center of the Santa Maria Valley, generally reflect the status of ground water in storage for a large part of the valley. The records from this well show a continuous and almost uniform decline in water level at a rate of 4.0 feet per year during the dry years 1917-36. This decline was arrested by the large ground-water recharge during the wet period extending through 1944. With the advent of the current dry period the water level declined more sharply at the rate of 7.4 feet per year to the lowest level on record, indicating a substantial increased draft on the ground-water reserves.

Antelope Valley

Antelope Valley is in the extreme west end of the Mojave Desert in Los Angeles and Kern Counties. Parts of this arid valley have been farmed successfully for more than 60 years. However, the steadily increasing water needs for agricultural and other uses have created a critical overdraft in the valley.

In figure 5 are shown the changes in water level at a well near Lancaster; they are assumed to be an index of changes in the large, heavily pumped part of the valley. During the last 25-year period the water level in this or nearby wells has declined 143 feet. This decline, which persisted even during the wet years, clearly indicates that extractions exceeded the recharge. A rate of decline of about 3.4 feet per year during the 1922-36 dry period has increased to 8.1 feet per year during the current dry period.

Artificial recharge of ground-water storage

The Metropolitan Water District of Southern California reported that it sold about 81,000 acre-feet of Colorado River water at a cost of about $800 000 to the people of Los Angeles and Orange counties during the 1956 water year for the major purpose of retarding the rapid rate of decline in ground-water levels. This water was either permitted to infiltrate into the stream channel deposits or spread into highly permeable specially prepared basins overlying the main ground-water bodies.

About 3,000 acre-feet of this Colorado River water was put into injection wells along the coast in the vicinity of Manhattan Beach for the purpose of determining the feasibility of maintaining a fresh-water barrier against sea-water intrusion.

An additional 8,000 acre-feet of local storm runoff from the mountain and foothill areas during the 1956 water year was diverted from natural stream channels into specially prepared basins for the purpose of recharging the ground-water storage in Los Angeles County.

Imported water

Southern California extends over a predominately arid region which has less than 2 percent of the State's natural water supplies. Consequently, to satisfy the ever-increasing water requirements of the area, water must be imported from distant sources.

Since 1913 the city of Los Angeles has diverted water from the Owens Valley east of the Sierra Nevada for use in the city some 250 miles to the south. During the 1956 water year the Owens River aqueduct, operating at full capacity as in previous years, delivered 336,000 acre-feet to the Los Angeles area.

By means of a 1,617-foot pumping lift and a 242-mile aqueduct from the Colorado River, the Metropolitan Water District of Southern California delivered 430,000 acre-feet to the greater Los Angeles and San Diego areas during the 1956 water year.

As indicated on figure 6, these annual imports have increased from 310,000 acre-feet in 1944 to 766,000 acre-feet in 1956--an increase of 148 percent. About 37 percent of the annual water requirements in the coastal areas now are satisfied by imported water.

ANNUAL RUNOFF FOR THE WATER YEAR 1954-55

Annual runoff data for the water year ending September 30, 1955, for all gaging-station records currently published by the Geological Survey, are presented in table 4. The mean and median values of the annual

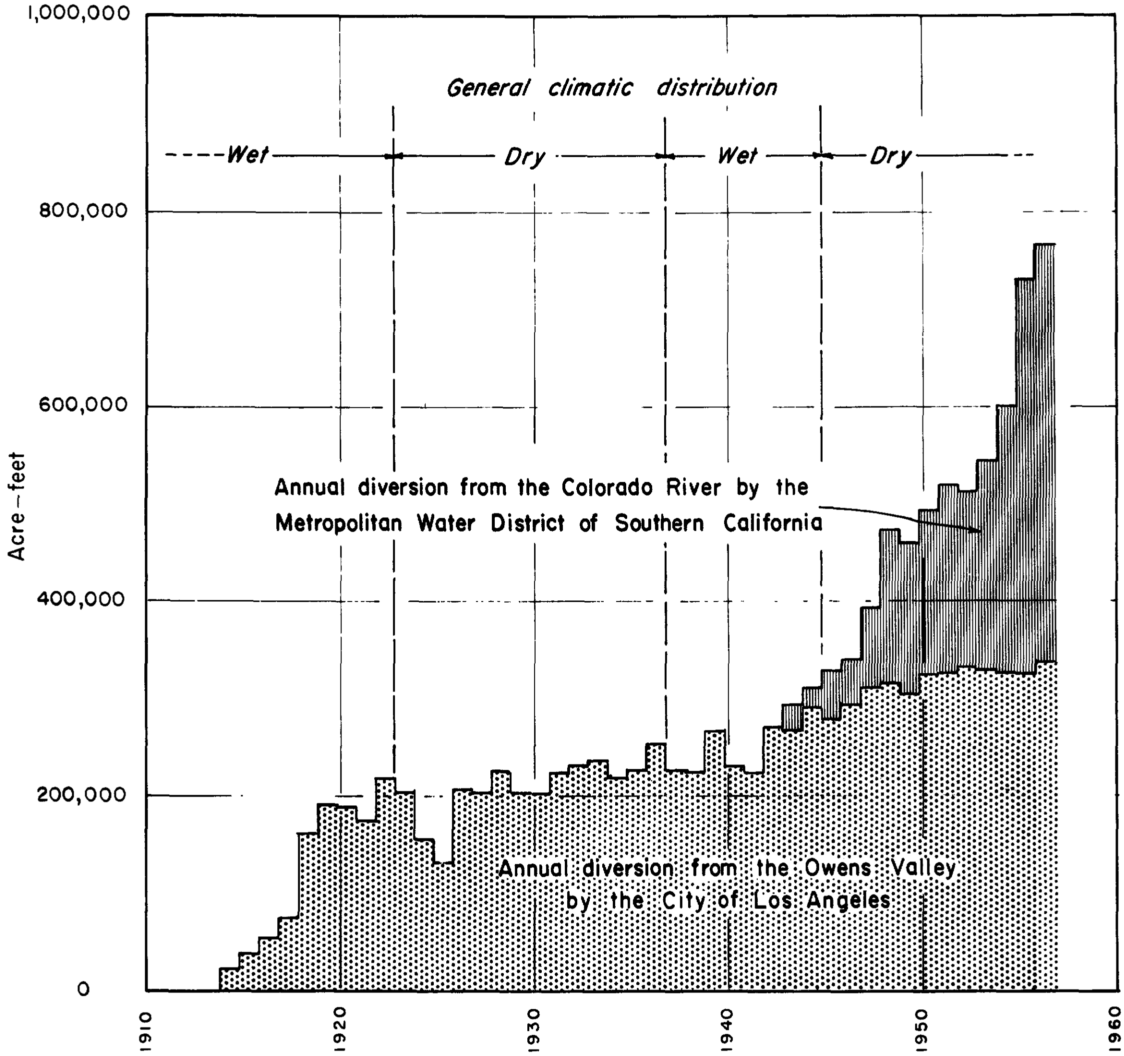

Figure 6. --Water imported into southern California.

runoff for the period of record and the relation of the annual runoff to the base mean are included for the stations with sufficient length of record.

Areal distribution

The normal storm tracks moving over southern California are such that the precipitation along the coast generally decreases from north to south. The eastward movement of these storms is blocked by the high mountain barriers which cause the greatest precipitation on the windward side of these barriers. Across the barriers the precipitation decreases rapidly to near zero in the desert areas.

A generalized areal distribution of the annual runoff for the water year ending on September 30, 1955, is shown on the map of figure 7. The runoff quantities used to define this distribution were obtained from table 4; the quantities are relative in that they express the departure, in percent, of the runoff for the 1955 water year from the mean of the 30-year period 1920-50.

The 1955 water year was a very dry year--the 11th year in a series of dry years. The annual runoff in many valley streams in the agricultural areas was zero, or nearly zero, representing departures as much as 100 percent below the 30-year base mean. However, this was not the case in many highly urbanized valley-floor areas in or near metropolitan Los Angeles. During 1955 the precipitation on the paved streets and the roofs of buildings in these urban areas tributary to the Los Angeles River resulted in a runoff of 60,130 acre-feet into the ocean at Long Beach. Annual runoff of this magnitude is only 32 percent below the average runoff of the base period at this site.

Unit runoff

Unit rates of runoff generally decrease rapidly as the streams cross the valley-floor areas and discharge into the ocean. In the predominantly agricultural areas, the 1955 runoff into the ocean was zero from the basins of the Tia Juana, San Luis Rey, and Santa Margarita Rivers. In contrast the highly urbanized areas tributary to the Los Angeles River discharged into the ocean the equivalent of 73.2 acre-feet per square mile, or 1.4 inches, over the basin. The street drainage in the Beverly Hills and Hollywood areas produced a 1955 runoff of 244 acre-feet per square mile, or 4.6 inches, over the Ballona Creek basin.

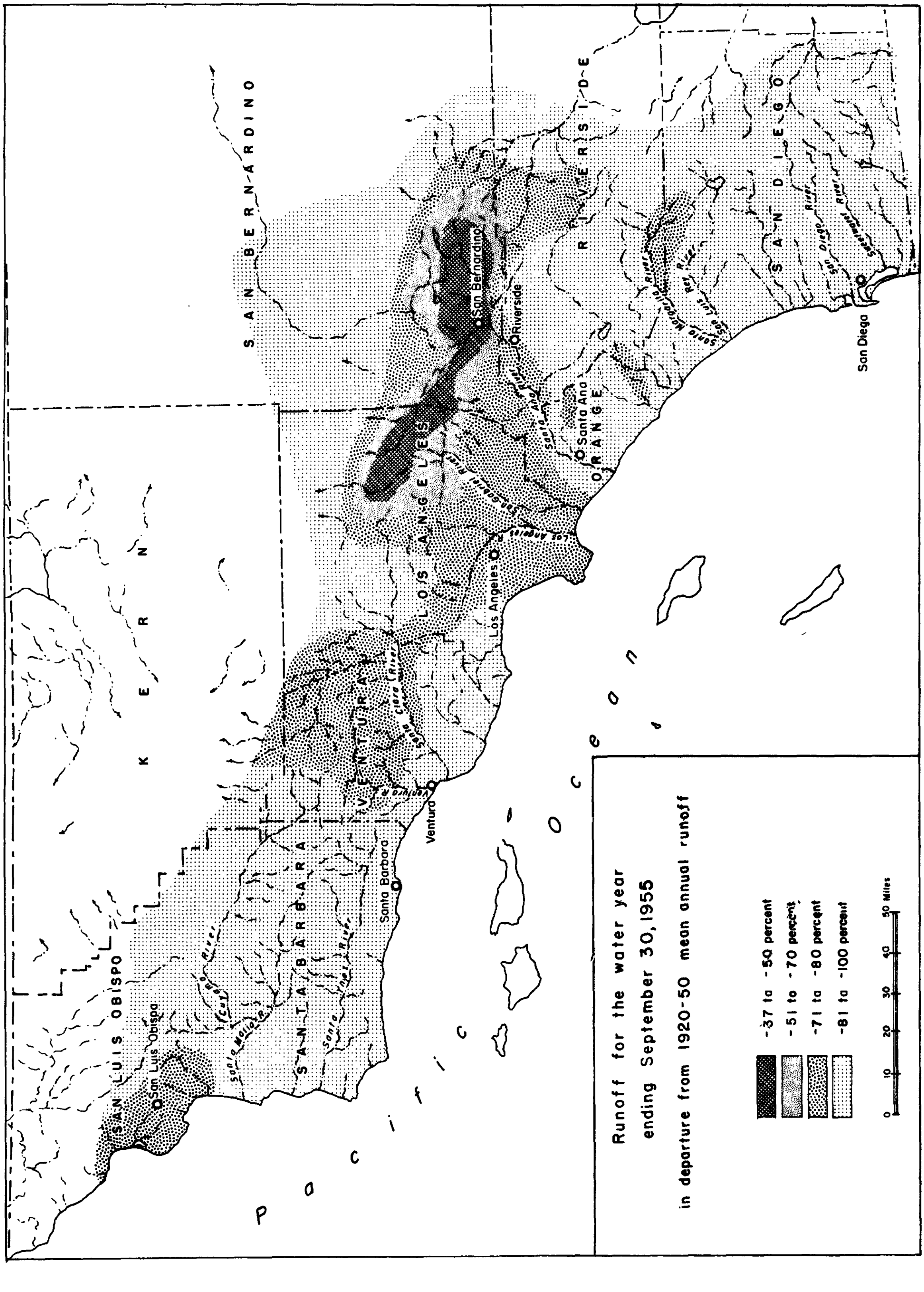

Figure 7.--Areal distribution of annual runoff for the water year 1954-55.

Table 4.--Annual runoff for the water year 1954-55

[Basic data furnished by: [a] city of San Diego; [b] California Water and Telephone Co.; [c] La Mesa, Lemon Grove, and Spring Valley Irrigation District; [d] Vista Irrigation District; [i] Montecito County Water District; [j] city of Santa Barbara.
Flow: [e] regulated by Vail Reservoir (capacity, 49,370 acre-ft) since November 1948.
Records furnished by: [f] Orange County Flood Control District; [g] Los Angeles County Flood Control District; [h] Ventura County Water Resources Division.]

Basin and stream	Drainage area (square miles)	1954-55 annual runoff			Period of record			Base mean
		Acre-feet	Acre-feet per square mile	Departure from base mean (percent)	Length (years)	Mean annual runoff (acre-feet)	Median annual runoff (acre-feet)	Mean annual runoff 1920-50 (acre-feet)
PACIFIC SLOPE BASINS								
Tia Juana River basin:								
Cottonwood Creek at Morena Dam [a]	120	506	4.22	-96	19	11,480	7,400	12,720
Cottonwood Creek above Tecate Creek, near Dulzura	316	10	.03	----	19	8,140	2,000	-------
Campo Creek near Campo	84	70	.83	----	19	2,420	1,800	-------
Tia Juana River near Dulzura	478	80	.17	----	19	13,160	4,800	-------
Tia Juana River near Nestor	1,668	0	0	----	19	35,880	10,100	-------
Otay River basin:								
Jamul Creek near Jamul	72	26	.36	----	15	------	------	-------
Sweetwater River basin:								
Sweetwater River at Loveland Dam, near Alpine [b]	100	906	9.06	----	11	4,660	2,300	-------
Sweetwater River at Sweetwater Dam [b]	181	1,639	9.06	----	68	------	------	-------
San Diego River basin:								
Boulder Creek at Cuyamaca Reservoir, near Julian [c]	12.0	573	47.8	-88	34	*2,240	*1,300	4,640
San Diego River at El Capitan Dam [a]	190	2,519	13.3	----	19	30,420	17,400	-------
San Diego River near Santee	380	325	.86	-99	40	20,870	3,800	23,200
San Dieguito River basin:								
Santa Ysabel Creek at Sutherland Dam	58	713	12.3	-95	34	15,980	8,900	13,400
Santa Ysabel Creek near Ramona	110	158	1.44	----	22	21,220	8,600	-------
Guejito Creek near San Pasqual	24	159	6.62	----	8	------	750	-------
Guejito Creek at San Pasqual	28	0	0	----	10	572	140	-------
Santa Maria Creek near Ramona	58	33	.57	----	16	4,240	800	-------
San Dieguito River at Lake Hodges [a]	303	**-55	-.18	-100	39	31,800	15,400	37,310
San Luis Rey River basin:								
San Luis Rey River at Lake Henshaw, near Mesa Grande [d]	209	1,599	7.65	-94	44	27,700	15,600	27,090
San Luis Rey River at Monserate Narrows, near Pala	383	670	1.75	----	12	9,050	3,300	-------
San Luis Rey River near Bonsall	514	.2	0	-100	28	22,620	8,200	25,440
San Luis River at Oceanside	557	0	0	----	23	16,650	1,400	-------
Santa Margarita River basin:								
Temecula Creek at Vail Dam, near Temecula	319	1,820	5.71	-83	32	9,140	5,100	10,650
Murrieta Creek at Temecula	220	970	4.41	-90	25	8,030	2,300	9,930
Santa Margarita River near Temecula [e]	592	4,750	8.02	-77	32	1,790	7,400	20,420
Santa Margarita River near Fallbrook [e]	645	3,420	5.30	-86	30	22,840	9,000	24,790
Santa Margarita River at Ysidora [e]	740	0	0	-100	31	26,210	10,400	30,140
San Juan Creek basin:								
San Juan Creek near San Juan Capistrano	110	2,170	19.7	-78	27	9,820	2,200	9,960
Trabuco Creek near San Juan Capistro [f]	36.5	76	2.08	-98	25	3,830	430	3,840
Aliso Creek basin:								
Aliso Creek at El Toro [f]	8.5	6.1	.72	-99	25	552	220	547

* 11 years (1944-55).
** Adjusted for 9,202 acre-ft of Colorado River water.

Table 4.--Annual runoff for the water year 1954-55--Continued

Basin and stream	Drainage area (square miles)	1954-55 annual runoff: Acre-feet	1954-55 annual runoff: Acre-feet per square mile	1954-55 annual runoff: Departure from base mean (per cent)	Period of record: Length (years)	Period of record: Mean annual runoff (acre-feet)	Period of record: Median annual runoff (acre-feet)	Base mean: Mean annual runoff 1920-50 (acre-feet)
Peters Canyon Wash basin:								
San Diego Creek near Irvine	------	328	-----	----	6	------	------	-------
Santa Ana River basin:								
Santa Ana River near Mentone	202	27,860	13.8	-53	59	62,170	52,300	59,020
Mill Creek near Yucaipa	39.9	13,510	339	-49	27	24,490	17,400	26,270
Mill Creek near Mentone	-------	292	------	----	16	2,085	580	-------
Plunge Creek near East Highlands	16.9	2,120	125	----	36	------	------	-------
Santa Ana River near San Bernardino	-------	1,330	------	----	10	6,780	830	-------
Little San Gorgonio Creek near Beaumont	2.61	73	28.0	----	7	------	------	-------
San Timoteo Creek near Redlands	123	123	1.00	-92	29	1,120	430	1,410
San Timoteo Creek near Loma Linda	-------	569	------	----	1	------	------	-------
East Twin Creek near Arrowhead Springs	8.6	2,020	235	-43	35	3,420	2,500	3,560
Waterman Canyon Creek near Arrowhead Springs	4.55	958	211	-52	37	2,000	1,400	2,000
City Creek near Highland	19.8	2,830	143	-64	36	7,580	5,700	7,920
Devil Canyon Creek near San Bernardino	6.16	1,540	250	-37	36	2,350	1,700	2,450
Lytle Creek near Fontana	46.9	14,800	316	-53	51	31,920	26,200	31,640
Cajon Creek near Keenbrook	40.9	2,730	6.67	-62	35	6,720	4,300	7,150
Lone Pine Creek near Keenbrook	15.0	257	17.1	-80	24	989	430	1,280
Lytle Creek (east channel) at San Bernardino	-------	343	------	----	26	------	------	-------
Warm Creek near Colton	-------	20,400	------	-52	35	43,510	40,500	42,830
Santa Ana River at Riverside Narrows, near Arlington	-------	†22,470	------	-61	25	41,220	30,400	57,790
Day Creek near Etiwanda	4.8	1,420	296	-66	26	4,020	3,100	4,220
Cucamonga Creek near Upland	10.1	2,270	225	-63	26	5,680	4,300	6,080
San Jacinto River near San Jacinto	140	5,900	42.1	-78	35	24,550	14,800	26,400
Bautista Creek near Hemet	39.4	297	7.54	----	8	------	------	-------
San Jacinto River near Elsinore	717	56	.08	-100	39	10,660	230	12,610
Temescal Creek near Corona	-------	23	------	----	26	2,910	43	-------
San Antonio Creek near Claremont	16.9	†8,510	504	-50	38	15,900	12,300	17,090
Santa Ana River below Prado Dam	-------	43,950	------	----	15	-------	------	-------
Santa Ana River at county line, below Prado Dam	-------	†44,220	------	-56	36	95,630	81,200	100,500
Santiago Creek at Santiago Dam, near Villa Park	63	3,168	50.3	-73	24	13,190	7,500	11,670
Santiago Creek near Villa Park	83.8	51	.61	-99	35	6,210	1,000	6,070
Santiago Creek at Santa Ana	-------	528	------	-90	26	4,080	510	5,310
Santa Ana River at Santa Ana	2,418	178	.07	-99	32	15,103	2,000	21,880
San Gabriel River basin:								
East Fork San Gabriel River near Camp Bonita *g*	88.2	26,090	296	-49	22	52,850	37,600	51,610
West Fork San Gabriel River at Camp Rincon *g*	102	12,850	126	-76	28	48,200	27,500	53,040
San Gabriel River near Azusa	211	40,070	190	-64	60	111,500	81,100	111,020
Rogers Creek near Azusa	6.4	311	48.6	-87	38	2,170	1,200	2,380
Fish Creek near Duarte	6.5	567	87.2	-82	38	2,930	1,900	3,210
San Gabriel River below Santa Fe Dam, near Baldwin Park	231	0	0	----	13	-------	-------	-------
San Dimas Creek near San Dimas	18.3	603	33.0	-83	38	3,200	2,000	3,540
Dalton Creek near Glendora	7.5	20	2.67	-98	35	801	220	845
Little Dalton Creek near Glendora *g*	2.7	45	16.7	-93	26	569	350	602
San Jose Creek near Whittier *g*	85.2	1,170	13.7	-80	26	6,090	3,600	5,980
San Gabriel River at Pico *g*	-------	9,250	------	-75	27	33,260	15,900	37,460
San Gabriel River at Spring Street, near Los Alamitos *g*	584	820	1.40	----	28	19,360	1,800	-------
Brea Creek below Brea Dam, near Fullerton	23.4	53	2.26	----	13	502	140	-------
Brea Creek at Fullerton *f*	26.2	114	4.35	----	25	861	330	-------
Fullerton Creek below Fullerton Dam, near Brea	3.05	49	16.1	----	14	131	22	-------
Fullerton Creek at Fullerton *f*	6.2	165	26.6	----	20	513	220	-------
Coyote Creek near Artesia *g*	110	1,210	11.0	-78	26	5,790	3,200	5,500
Carbon Creek near Yorba Linda	20.4	17	.83	----	6	-------	------	-------

† Adjusted for 52,430 acre-ft of Colorado River water released by Metropolitan Water District into Santa Ana River above Riverside Narrows.

Table 4.--Annual runoff for the water year 1954-55--Continued

Basin and stream	Drainage area (square miles)	1954-55 annual runoff			Period of record			Base mean
		Acre-feet	Acre-feet per square mile	Departure from base mean (per cent)	Length (years)	Mean annual runoff (acre-feet)	Median annual runoff (acre-feet)	Mean annual runoff 1920-50 (acre-feet)
Los Angeles River basin:								
Los Angeles River at Sepulveda Dam	155	16,080	104	----	12	15,000	11,600	------
Pacoima Creek near San Fernando [g]	28.2	736	26.1	-90	38	6,780	3,300	7,360
Tujunga Creek below Mill Creek, near Colby Ranch [g]	64.9	1,910	29.4	----	7	------	------	------
Tujunga Creek near Sunland [g]	106	3,580	33.8	-84	38	20,690	11,600	22,680
Haines Creek near Tujunga	1.2	45	37.5	----	38	------	------	------
Little Tujunga Creek near San Fernando [g]	21.0	47	2.24	-98	27	1,920	510	2,160
Tujunga Creek below Hansen Dam	148	20	.14	----	15	16,020	3,700	------
Los Angeles River at Los Angeles [g]	510	18,270	35.8	-56	26	42,070	24,600	41,800
Arroyo Seco near Pasadena	16.4	1,280	78.0	-81	41	6,770	3,800	6,720
Los Angeles River near Downey [g]	614	39,310	64.0	----	27	70,000	43,400	------
Sawpit Creek near Monrovia	5.3	686	129	-66	38	1,840	1,400	2,000
Santa Anita Creek near Sierra Madre	10.5	1,440	137	-69	39	4,200	2,700	4,580
Little Santa Anita Creek near Sierra Madre	1.9	178	93.7	-75	38	644	360	710
Eaton Creek near Pasadena	6.5	700	108	-80	37	2,740	1,800	3,420
Rio Hondo near Montebello [g]	------	11,350	------	-73	27	38,770	27,500	42,670
Mission Creek near Montebello [g]	------	3,100	------	----	25	11,920	11,600	------
Rio Hondo near Downey [g]	------	8,010	------	----	27	19,720	8,000	------
Los Angeles River at Long Beach [g]	822	60,130	73.2	-32	26	103,300	67,300	88,580
Ballona Creek basin:								
Ballona Creek near Culver City [g]	88.6	21,600	244	----	27	------	------	------
Topanga Creek basin:								
Topanga Creek near Topanga Beach [g]	17.9	354	19.8	-90	24	4,050	1,400	3,640
Malibu Creek basin:								
Malibu Creek at Crater Camp, near Calabasas [g]	103	758	7.36	-94	24	14,410	4,900	12,660
Santa Clara River basin:								
Santa Clara River near Saugus [g]	410	612	1.49	-94	26	10,360	2,500	10,440
Piru Creek near Piru	432	11,880	27.5	-73	28	41,050	20,300	43,280
Hopper Creek near Piru [h]	23.0	740	32.2	----	23	3,550	1,600	------
Sespe Creek near Wheeler Springs	50	1,110	22.2	----	7	------	------	------
Sespe Creek near Fillmore	254	17,060	67.2	-77	34	69,490	38,100	75,290
Santa Paula Creek near Santa Paula	39.8	3,010	75.6	-79	28	13,670	8,000	14,040
Ventura River basin:								
Matilija Creek above Reservoir, near Matilija Hot Springs	51	3,820	74.9	----	7	------	------	------
Matilija Creek at Matilija Hot Springs	55	4,630	84.2	-79	28	21,420	10,900	22,380
North Fork Matilija Creek at Matilija Hot Springs [h]	15.5	1,350	87.1	-78	26	6,290	3,200	6,110
Coyote Creek near Ventura	41.1	750	18.2	-92	27	9,090	3,600	8,820
Ventura River near Ventura	187	4,910	26.3	-90	28	48,630	24,900	48,900
Carpinteria Creek basin:								
Carpinteria Creek near Carpinteria	13.8	16	1.16	----	14	1,130	290	------
Atascadero Creek basin:								
Atascadero Creek near Goleta	18.3	387	21.1	----	14	1,450	510	------
San Jose Creek basin:								
San Jose Creek near Goleta	5.54	475	85.7	----	14	904	580	------
Santa Ynez River basin:								
Santa Ynez River at Jameson Lake, near Montecito [i]	16.0	312	19.5	-92	24	4,470	2,200	4,010
Santa Ynez River above Gibralter Dam, near Santa Barbara [j]	219	3,978	18.2	-87	35	30,540	12,100	31,360

Table 4.--Annual runoff for the water year 1954-55--Continued

Basin and stream	Drainage area (square miles)	1954-55 annual runoff: Acre-feet	Acre-feet per square mile	Departure from base mean (per cent)	Period of record: Length (years)	Mean annual runoff (acre-feet)	Median annual runoff (acre-feet)	Base mean: Mean annual runoff 1920-50 (acre-feet)
Santa Ynez River basin--Continued								
Santa Ynez River below Gibralter Dam, near Santa Barbara [j]	219	84	.38	----	35	26,560	8,700	------
Santa Ynez River below Los Laureles Canyon, near Santa Ynez	-------	930	------	----	8	------	------	------
Santa Cruz Creek near Santa Ynez	77.2	1,890	24.5	----	13	7,230	5,100	------
Cachuma Creek near Santa Ynez	-------	485	------	----	5	------	------	------
Santa Ynez River near Santa Ynez	435	2,610	6.00	-96	25	65,860	16,200	63,070
Santa Agueda Creek near Santa Ynez	56.4	150	2.66	----	14	1,710	720	------
Zanja Cota near Santa Ynez	-------	1,360	------	----	1	------	------	------
Santa Ynez River at Grand Avenue near Santa Ynez	-------	3,090	------	----	1	------	------	------
Santa Ynez River at Solvang	585	4,200	7.18	----	17	32,340	12,400	------
Santa Ynez River at Buellton	-------	1,860	------	----	1	------	------	------
La Zaca Creek at Buellton	38.7	7.4	.19	----	14	195	22	------
Santa Ynez River near Buellton	-------	2,640	------	----	3	------	------	------
Santa Ynez River at Santa Rosa Damsite, near Buellton	-------	2,020	------	----	1	------	------	------
Santa Ynez River at Cooper's Reef, near Lompoc	-------	1,670	------	----	1	------	------	------
Santa Ynez River below Santa Rita Creek, near Lompoc	-------	1,480	------	----	1	------	------	------
Salsipuedes Creek near Lompoc	46.6	1,320	28.3	----	14	4,579	2,000	------
Santa Ynez River at narrows, near Lompoc	-------	2,060	------	----	3	------	------	------
Santa Ynez River near Lompoc	790	1,650	2.09	-98	30	87,850	31,800	86,420
Santa Ynez River at H Street, near Lompoc	-------	209	------	----	8	------	------	------
Santa Ynez River at 13th Street, near Lompoc	-------	47	------	----	1	------	------	------
Santa Ynez River at barrier, near Surf	-------	413	------	----	8	------	------	------
San Antonio Creek basin:								
San Antonio Creek at Harris	101	65	.64	----	14	844	250	------
Santa Maria River basin:								
Cuyama River near Ventucopa	90	2,130	23.7	----	10	3,980	2,700	------
Cuyama River near Santa Maria	912	1,230	1.35	-91	25	15,230	8,000	14,400
Alamo Creek near Santa Maria	87.7	1,240	14.1	----	12	3,210	1,300	------
Huasna River near Santa Maria	119	1,420	11.9	-89	25	14,010	5,400	12,810
Sisquoc River near Sisquoc	290	5,260	18.1	----	12	17,450	9,400	------
La Brea Creek near Sisquoc	86.7	572	6.60	----	12	2,880	360	------
Tepusquet Creek near Sisquoc	28.9	539	18.7	----	12	730	360	------
Sisquoc River near Garey	442	609	1.38	----	14	17,010	7,000	------
Santa Maria River at Guadalupe	1,763	0	0	----	14	14,840	1,800	------
Arroyo Grande basin:								
Arroyo Grande at Arroyo Grande	106	4,320	40.8	-72	15	16,050	8,800	15,400
THE GREAT BASIN								
Salton Sea basin:								
Whitewater River at Whitewater	57.4	9,562	167	----	7	------	------	------
Tahquitz Creek near Palm Springs	-------	1,530	------	----	8	------	------	------
Palm Canyon Creek near Palm Springs	94.0	245	2.61	-95	20	3,670	1,000	4,840
Andreas Creek near Palm Springs	8.78	1,350	154	----	7	------	------	------
Coyote Creek near Borrego Springs	-------	1,690	------	----	5	------	------	------
Palm Canyon Creek near Borrego Springs	21.7	312	144	----	5	------	------	------
Mojave River basin:								
Deep Creek near Hesperia	137	16,260	119	-66	42	56,020	42,100	47,150
West Fork Mojave River near Hesperia	74.8	4,800	64.2	-82	43	32,330	21,000	26,330
Mojave River at lower narrows, near Victorville	530	22,520	42.5	-64	30	57,740	34,000	62,550
Mojave River at Barstow	-------	0	0	-100	25	22,300	190	29,550
Mojave River at Afton	-------	913	------	----	5	------	------	------
Antelope Valley:								
Rock Creek near Valyermo	23.0	5,940	258	-54	32	11,300	7,100	12,890
Little Rock Creek near Little Rock [g]	49.0	7,310	149	-49	23	13,010	7,500	14,340