

MEAN ANNUAL RUNOFF IN THE SAN FRANCISCO BAY REGION, CALIFORNIA, 1931-70

By S. E. Rantz

INTRODUCTION

Regional water-resources studies require a knowledge of the areal distribution of mean annual runoff. No such data are available for the San Francisco Bay region in the detail required for practical use. In an earlier report, Rantz (1968) presented a map of mean annual runoff for California coastal basins between the Oregon border and the north shore of San Francisco Bay. That map, however, includes only the northwest part, or about one-fifth, of the present report area. Furthermore, the small scale of the map and large interval used between lines of equal runoff severely restrict practical use of the data in the 1968 report. The purpose of this study, therefore, was to produce a map of larger scale showing the areal distribution of mean annual runoff in the San Francisco Bay region. The report area includes the nine counties that are collectively referred to as the San Francisco Bay region, and adjacent area. The nine counties have a total area of 7,416 mi² (19,207 km²). (Note.--1 mi² = 2.59 km².)

The values of mean annual runoff shown on the map in the present report (sheet 2) represent natural flow, or that part of the precipitation that would appear in water courses or stream channels where, or if, human activity had negligible effect on runoff. The 76 gaging-station records used in developing the runoff map were therefore those for streams that are either virtually undeveloped or, if developed, have records whose annual discharges can be adjusted for such manmade effects as diversion, storage, and import of water. For consistency, mean annual runoff figures for all gaging stations were adjusted to cover a common 40-year time base, 1931-70; the dearth of long-term runoff records made it impractical to use a base period longer than 40 years. Long-term precipitation records were examined to determine if mean values for the 40-year study period are representative of the long-term mean. The examination showed that the mean annual precipitation for the period 1931-70 is virtually identical with the long-term mean annual precipitation, thereby confirming the representativeness of the 40-year study period.

BASIC DATA USED

The locations of the 76 stream-gaging stations used in this study are shown with their identifying station numbers on sheet 1. Also shown on sheet 1 are the boundaries of the 76 hydrologic units and the sequential numbers, 1-76, that identify the units. (As used in this report, the term "hydrologic unit" refers to the basin upstream from a gaging station or to the area between gaging stations in the same basin.) The hydrologic units are identified in table 1, which also gives their drainage area and runoff, in both acre-feet and inches, for the period 1931-70. In adjusting runoff records to cover the 40-year base period, the records for short-term stations were correlated with those for nearby long-term stations.

Although this study is concerned primarily with mean annual runoff for the period 1931-70, runoff values, either observed or estimated by correlation, for individual years within that base period are useful in many water-resources studies. As an adjunct to the runoff map, therefore, table 2 is presented giving values of annual natural runoff for each of the 40 years at 70 of the 76 gaging stations. The 70 stations are those whose correlations were considered adequate for filling in each year of record that was missing from the 40-year array. Of the remaining six stations, two had extremely short records and four were partial-record stations (miscellaneous discharge measurements only). For those six stations the correlations were inadequate for obtaining annual runoff values, but the linear regression equations were considered adequate for computing mean annual discharge. Hence, those six stations appear in table 1, but have been omitted from table 2. As for table 2 itself, all estimated values of annual runoff listed there bear footnote symbols which give the source of the estimate or the regression equation used in computing the estimated values. The estimated values of runoff in table 2 are considerably less accurate than the observed values listed there, but for consistency the same degree of refinement, with respect to number of significant figures, was used in tabulating both estimated and observed values. Because the Russian River enters the study area as a large, partly regulated stream carrying appreciable quantities of water from an upstream transbasin diversion, runoff values are given in table 2 for the natural inflow between mainstem stations on the Russian River, rather than for the flow at the mainstem stations themselves.

The basic precipitation data for the study were provided by a detailed isohyetal map of the study area showing mean annual precipitation (Rantz, 1971). That map is virtually identical with one that had been prepared in 1957 by the U.S. Army, Corps of Engineers. The isohyets on the map represent mean annual precipitation for the 50-year period, 1907-56. However, the examination of long-term precipitation records showed that mean annual precipitation for the period 1907-56 is closely representative of the long-term mean annual precipitation.

PREPARATION OF THE MAP OF MEAN ANNUAL RUNOFF

Given the basic data described in the preceding paragraphs, the actual mechanics of producing the map of mean annual runoff were as follows. The boundaries of the 76 hydrologic units, as shown on sheet 1, were transferred to the isohyetal map of mean annual precipitation. By use of transparent grid overlays, precipitation values were obtained from the map for 60 to 80 grid intersections in most of the hydrologic units; fewer grid intersections were, of necessity, used for the smaller hydrologic units, and a greater number of grid intersections were used for the larger units. From those point-precipitation values, decile values of mean annual precipitation were determined for each hydrologic unit--that is, the point values were arrayed in order of magnitude and the mean precipitation value was determined for each one-tenth of the total number of points in the unit. That, in effect, gave the mean annual precipitation for each one-tenth of the area of each hydrologic unit. The mean annual basinwide precipitation for each unit was also computed; those values are shown in table 1.

Mean annual precipitation-runoff relations were next prepared. Four such relations were required, one for each of the following subregions: (1) North Bay and Sacramento Valley, (2) West Bay and South Coast, (3) East Bay, and (4) San Joaquin Valley. The four subregions are delineated on sheet 1. The precipitation-runoff relations were determined by cut-and-try procedures in which first-trial relations were obtained by plotting mean annual basinwide runoff, in inches, against mean annual basinwide precipitation. (Those data are given in table 1.) Runoff values from the trial relations were then applied to the decile values of mean annual precipitation for each basin to compute mean annual basinwide runoff. It was necessary to weight the runoff for each basin--that is, apply the relations to decile values of mean annual precipitation rather than to mean annual basinwide precipitation--because the precipitation-runoff relations are not linear. After trial values of weighted mean annual runoff were computed for the hydrologic units in a subregion, they were plotted on rectangular graph paper against the corresponding "true" values of mean annual basinwide runoff given in table 1. A random scatter of the plotted points about a 45-degree line through the origin of the graph would indicate that the trial precipitation-runoff relation used was satisfactory. If the plotted points did not scatter randomly about the 45-degree line, the trial relation was modified and the computations of mean annual basinwide runoff were repeated until random scatter was achieved. The above procedure was followed for each of the four subregions.

The precipitation-runoff relations finally used are shown in skeleton form in table 3. Intermediate values in the relations are obtained by linear interpolation between tabulated values. The standard deviations of percentage differences between computed and true values of mean annual basinwide runoff in the four subregions were as follows:

North Bay and Sacramento Valley	±22 percent
West Bay and South Coast	±17 percent
East Bay	±21 percent
San Joaquin Valley	±11 percent

Differences are to be expected between computed and true values of mean annual basinwide runoff because runoff is not related to precipitation alone. Runoff is also affected by the geologic, topographic, and vegetative characteristics of a basin. Furthermore, the errors inherent in any isohyetal map for mountainous areas introduce error into the values of runoff whose computation is based on data from the isohyetal map. However, the method used in the final step in constructing lines of equal mean annual runoff overcomes the discrepancies in computed runoff. In that step, the isohyetal map of mean annual precipitation on which the boundaries of the 76 gaged basins had been previously drawn, was used as an underlay for constructing the map of mean annual runoff. The isohyets provided the pattern to be followed by the lines of equal mean annual runoff, and the positioning of those lines was based on the generalized precipitation-runoff relations derived for the four subregions. At each of the 76 hydrologic units the value of mean annual basinwide runoff, as indicated by the lines of equal runoff (or by the computations described in the two preceding paragraphs), was compared with the true basinwide runoff value. Where discrepancies existed, the positioning of the lines of equal runoff was adjusted to give consistency with true basinwide runoff values.

REFERENCES CITED

- Rantz, S. E., 1968, Average annual precipitation and runoff in north coastal California: U.S. Geol. Survey Hydrol. Inv. Atlas HA-298.
_____, 1971, Mean annual precipitation and depth-duration-frequency data for the San Francisco Bay region, California: U.S. Geol. Survey open-file rept., 23 p.

TABLES

TABLE 1.--Mean annual basinwide precipitation and runoff for hydrologic units in or near the San Francisco Bay region, for the period 1931-70

Number on sheet	Basin upstream from indicated gaging station or area between indicated gaging stations (Number in parentheses is gaging station number)	Drainage area (mi ²)	Mean annual basinwide values		
			Precipitation (in)	Runoff	
				Thousands of acre-ft	Inches
North Bay and Sacramento Valley subregion					
	<u>Garcia River basin</u>				
1	Garcia River near Point Arena (11467600)	98.5	56	229.4	43.7
	<u>Gualala River basin</u>				
2	South Fork Gualala River near Annapolis (11467500)	161	51	273.9	31.9
	<u>Russian River basin</u>				
3	Russian River drainage between gages near Cloverdale (11463000) and near Healdsburg (11464000), but excluding gaged areas of Big Sulphur Creek (11463200), Maacama Creek (11463900), and Franz Creek (11463940)	148.6	40	121.6	15.3
4	Russian River drainage between gages near Healdsburg (11464000) and near Guerneville (11467000), but excluding gaged areas of Dry Creek (11465200), Mill Creek (11465300), and Santa Rosa Creek (11465800)	361.0	35	346.9	18.0
a5	Cummisky Creek near Cloverdale (11462900)	13.4	39	15.90	22.2
6	Big Sulphur Creek near Cloverdale (11463200)	82.3	48	132.23	30.1
7	Maacama Creek near Kellogg (11463900)	43.4	58	54.80	23.7
8	Franz Creek near Kellogg (11463940)	15.7	40	15.85	18.9
9	Dry Creek near Cloverdale (11464500)	87.8	47	113.07	24.1
a10	Warm Spring Creek at Skaggs Springs (11464880)	32.7	50	53.16	30.5
11	Dry Creek drainage between gages near Cloverdale (11464500) and near Geyserville (11465200), but excluding gaged area of Warm Spring Creek (11464880)	41.5	46	51.77	23.4
a12	Mill Creek near Healdsburg (11465300)	11.5	50	16.30	26.6
13	Santa Rosa Creek near Santa Rosa (11465800)	12.5	36	12.48	18.7
a14	Big Austin Creek at Cazadero (1146705000)	26.6	65	67.85	47.8
15	Austin Creek near Cazadero (11467200), but excluding gaged area of Big Austin Creek (11467050)	36.5	59	62.25	32.0
	<u>Salmon Creek basin</u>				
16	Salmon Creek at Bodega (11460920)	15.7	44	13.51	16.1
	<u>Walker Creek basin</u>				
17	Walker Creek near Tomales (11460800)	37.1	27	29.10	14.7
	<u>Lagunitas Creek basin</u>				
18	Nicasio Creek near Point Reyes (11460500)	36.6	33	28.70	14.7
	<u>Pine Creek basin</u>				
b19	Pine Creek at Bolinas (11460170)	7.83	36	6.80	16.3
	<u>Arroyo Corte Madera del Presidio basin</u>				
b20	Arroyo Corte Madera del Presidio at Mill Valley (11460100)	4.69	35	4.11	16.4

- a. Partial-record station; runoff values for individual years not shown in table 2.
b. Short record; runoff values for individual years not shown in table 2.

TABLE 1.--Mean annual basinwide precipitation and runoff for hydrologic units in or near the San Francisco Bay region, for the period 1931-70--Continued

Number on sheet 1	Basin upstream from indicated gaging station or area between indicated gaging stations (Number in parentheses is gaging station number)	Drainage area (mi ²)	Mean annual basinwide values		
			Precipitation (in)	Runoff	
				Thousands of acre-ft	Inches
North Bay and Sacramento Valley subregion--Continued					
	<u>Corte Madera Creek basin</u>				
21	Corte Madera Creek at Ross (11460000)	18.1	41	17.88	18.6
	<u>Novato Creek basin</u>				
22	Novato Creek at Novato (11459500)	17.6	27	8.84	9.42
	<u>Petaluma River basin</u>				
23	Petaluma River at Petaluma (11459000)	30.9	25	11.77	7.14
	<u>Sonoma Creek basin</u>				
24	Sonoma Creek at Agua Caliente (11458500)	58.4	35	45.48	14.6
	<u>Napa River basin</u>				
25	Napa River near St. Helena (11456000)	81.4	39	65.97	15.2
26	Conn Creek near St. Helena (11456500)	52.1	31	25.55	9.20
27	Dry Creek near Napa (11457000)	17.4	37	13.38	14.4
28	Napa River drainage between gages near St. Helena (11456000) and near Napa (11458000), but excluding gaged areas of Conn Creek (11456500) and Dry Creek (11457000)	67.1	31	30.90	8.63
29	Redwood Creek near Napa (11458200)	9.79	36	7.28	13.9
	<u>Sacramento River basin</u>				
30	Adobe Creek near Kelseyville (11448500)	6.36	36	8.00	23.6
31	Highland Creek above Highland Creek Dam (11448900)	11.9	34	13.35	21.0
32	Copsey Creek near Lower Lake (11449450)	13.2	30	9.30	13.2
33	Kelsey Creek near Kelseyville (11449500)	36.6	46	52.63	27.0
34	Dry Creek near Middletown (11453200)	8.35	72	19.95	44.8
35	Putah Creek near Guenoc (11453500), but excluding gaged area of Dry Creek (11453200)	104.6	47	128.15	23.0
36	Pope Creek near Pope Valley (11453600)	78.3	33	58.09	13.9
37	Putah Creek drainage between gages near Guenoc (11453500) and near Winters (11454000), but excluding gaged area of Pope Creek (11453600)	382.7	27	168.81	8.27
38	Pleasants Creek near Winters (11454100)	15.9	26	6.64	7.83
39	Morrison Creek near Sacramento (11336580)	48.6	19	11.11	4.29
40	Arcade Creek near Del Paso Heights (11447360)	31.5	21	9.01	5.36
West Bay and South Coast subregion					
	<u>Coyote Creek basin</u>				
41	Coyote Creek near Gilroy (11169800)	109	22	31.52	5.42
	<u>Guadalupe River basin</u>				
42	Saratoga Creek at Saratoga (11169500)	9.22	45	6.92	14.1
	<u>Matadero Creek basin</u>				
43	Matadero Creek at Palo Alto (11166000)	7.24	17	1.05	2.72

TABLE 1.--Mean annual basinwide precipitation and runoff for hydrologic units in or near the San Francisco Bay region, for the period 1931-70--Continued

Number on sheet 1	Basin upstream from indicated gaging station or area between indicated gaging stations (Number in parentheses is gaging station number)	Drainage area (mi ²)	Mean annual basinwide values		
			Precipitation (in)	Runoff	
				Thousands of acre-ft	Inches
West Bay and South Coast subregion--Continued					
	<u>Redwood Creek basin</u>				
44	Redwood Creek at Redwood City (11162800)	1.82	24	0.70	7.21
	<u>Colma Creek basin</u>				
45	Colma Creek at South San Francisco (11162720)	10.8	23	4.10	7.12
	<u>Purisima Creek basin</u>				
46	Purisima Creek near Half Moon Bay (11162600)	4.83	37	2.57	9.98
	<u>Pescadero Creek basin</u>				
47	Pescadero Creek near Pescadero (11162500)	45.9	41	28.48	11.6
48	Butano Creek near Pescadero (11162540)	18.3	37	13.82	14.2
	<u>Scott Creek basin</u>				
49	Scott Creek above Little Creek, near Davenport (11161900)	25.1	45	23.19	17.3
	<u>San Lorenzo River basin</u>				
50	Zayante Creek at Zayante (11160300)	11.1	45	8.13	13.7
51	San Lorenzo River at Big Trees (11160500), but excluding gaged area of Zayante Creek (11160300)	99.9	50	87.64	16.4
52	Branciforte Creek at Santa Cruz (11161500)	17.3	39	13.50	14.6
	<u>Soquel Creek basin</u>				
53	West Branch Soquel Creek near Soquel (11159800)	12.2	44	10.08	15.5
54	Soquel Creek at Soquel (11160000), but excluding gaged area of West Branch Soquel Creek (11159800)	28.0	40	19.95	13.4
	<u>Aptos Creek basin</u>				
55	Aptos Creek at Aptos (11159700)	12.2	36	6.15	9.45
	<u>Pajaro River basin</u>				
56	Corralitos Creek near Corralitos (11159150)	10.6	38	7.97	14.1
57	Uvas Creek near Morgan Hill (11154000)	30.4	36	26.00	16.0
58	Bodfish Creek near Gilroy (11154100)	7.40	27	2.50	6.33
59	Cedar Creek near Bell Station (11152900)	12.8	20	2.69	3.94
East Bay subregion					
	<u>Pacheco Creek basin</u>				
60	San Ramon Creek at San Ramon (11182500)	5.89	25	2.06	6.56
61	San Ramon Creek at Walnut Creek (11183000), but excluding area upstream from station 11182500	44.9	22	8.95	3.73
62	Walnut Creek at Walnut Creek (11183500), but excluding gaged area of San Ramon Creek (11183000)	28.4	25	11.69	7.72
63	Grayson Creek near Hookston (11185000)	1.95	21	.32	3.08

TABLE 1.--Mean annual basinwide precipitation and runoff for hydrologic units in or near the San Francisco Bay region, for the period 1931-70--Continued

Number on sheet 1	Basin upstream from indicated gaging station or area between indicated gaging stations (Number in parentheses is gaging station number)	Drainage area (mi ²)	Mean annual basinwide values		
			Precipitation (in)	Runoff	
				Thousands of acre-ft	Inches
East Bay subregion--Continued					
	<u>Arroyo del Hambre basin</u>				
64	Arroyo del Hambre at Martinez (11182400)	15.1	20	2.27	2.82
	<u>Pinole Creek basin</u>				
65	Pinole Creek at Pinole (11182100)	10.0	22	2.56	4.80
	<u>San Lorenzo Creek basin</u>				
66	San Lorenzo Creek at Hayward (11181000)	37.5	24	9.94	4.97
	<u>Alameda Creek basin</u>				
67	Alameda Creek near Sunol (11173000)	37.5	28	13.14	6.57
68	San Antonio Creek near Sunol (11174000)	37.0	24	6.92	3.51
69	Arroyo Mocho near Livermore (11176000)	38.2	17	2.70	1.32
70	Arroyo Valle near Livermore (11176500)	147	20	20.27	2.58
71	Arroyo de la Laguna near Pleasanton (11177000), but excluding gaged areas of Arroyo Mocho (11176000) and Arroyo Valle (11176500)	220	16	5.02	.43
72	Dry Creek at Union City (11180500)	9.41	21	1.42	2.83
San Joaquin Valley subregion					
	<u>San Joaquin River basin</u>				
73	Marsh Creek near Byron (11337500)	42.6	17	6.06	2.67
74	Del Puerto Creek near Patterson (11274630)	72.6	13	3.20	.83
75	Orestimba Creek near Newman (11274500)	134	14	11.01	1.54
76	San Luis Creek near Los Banos (11263000)	84.6	13	4.92	1.09

Note.--Metric equivalents of English units used in table are:

$$1 \text{ mi}^2 = 2.59 \text{ km}^2$$

$$1 \text{ in} = 25.4 \text{ mm}$$

$$1,000 \text{ acre-ft} = 1.233 \text{ hm}^3$$

TABLE 2.--Annual runoff, in thousands of acre-feet, for gaging stations in or near the San Francisco Bay region, for period 1931-70

Gaging station (number and name)	11152900	11154000	11154100	11159150	11159700	11159800
	Cedar Creek near Bell Station	Uvas Creek Near Morgan Hill	Bodfish Creek near Gilroy	Corralitos Creek near Corralitos (f)	Aptos Creek at Aptos	West Branch Soquel Creek near Soquel
Drainage area (mi ²)	12.8	30.4	7.40	10.6	12.2	12.2
Water year						
1931	a0.01	1.97	a0.05	g1.46	h0.70	a1.00
1932	b3.42	32.70	e3.07	g9.86	h7.74	i12.77
1933	b.17	5.58	e.36	g2.96	h1.44	12.38
1934	b.71	10.10	e.81	g4.43	h3.01	14.97
1935	bl.36	15.52	e1.35	g5.94	h4.12	16.80
1936	b2.54	25.30	e2.33	g8.28	h6.20	i10.23
1937	b3.27	31.44	e2.94	g9.60	h6.52	i10.76
1938	b7.66	68.03	e6.60	g16.22	h13.87	i22.89
1939	b.05	4.60	e.26	g2.60	h1.26	12.08
1940	b4.84	44.48	e4.25	g12.15	h10.70	i17.66
1941	b6.40	57.50	e5.55	g14.47	h15.11	i24.93
1942	b4.16	38.80	e3.68	g11.07	h9.56	i15.77
1943	b2.84	27.80	e2.58	g8.83	h7.02	i11.58
1944	bl.57	17.28	e1.53	g6.39	h3.58	15.91
1945	b2.49	24.95	e2.30	g8.20	h5.70	19.40
1946	b1.32	15.19	e1.32	g5.85	h3.80	16.27
1947	b.69	9.95	e.80	g4.39	h2.10	13.47
1948	b.22	6.02	e.40	g3.12	h1.70	12.80
1949	bl.16	13.84	e1.18	g5.49	h3.56	15.87
1950	b.80	10.80	e.88	g4.64	h3.03	15.00
1951	b4.29	39.92	e3.79	g11.29	h8.88	i14.65
1952	b6.09	54.88	e5.29	g14.01	h12.99	i21.43
1953	bl.89	19.92	e1.79	g7.04	h5.20	18.58
1954	bl.14	13.66	e1.17	g5.44	h3.34	15.51
1955	b.66	9.70	e.77	g4.31	h2.78	14.59
1956	b6.29	56.56	e5.46	g14.31	h12.60	i20.79
1957	b.78	c10.70	e.87	g4.61	h2.60	14.29
1958	b7.40	c65.80	e6.38	16.34	h14.26	i23.53
1959	bl.22	c14.30	e1.23	5.74	3.86	7.10
1960	b.30	c6.70	1.64	5.20	3.16	3.69
1961	b.04	c4.50	.22	2.40	.99	1.65
1962	2.78	d24.20	1.61	7.30	4.13	7.22
1963	5.39	d51.80	5.31	15.00	14.54	22.94
1964	.46	d9.00	.95	3.92	2.64	3.60
1965	2.54	d30.60	4.20	9.90	6.72	11.35
1966	1.10	d8.40	.70	3.20	1.53	3.27
1967	6.34	d61.40	6.07	14.20	10.30	17.89
1968	.09	d9.50	.82	3.82	2.61	5.18
1969	9.76	d55.50	5.47	13.60	12.60	20.30
1970	3.45	d30.90	3.87	11.40	9.53	13.06
Mean	2.69	26.00	2.50	7.97	6.15	10.08

See footnotes at end of table.

TABLE 2.--Annual runoff, in thousands of acre-feet, for gaging stations in or near the San Francisco Bay region, for period 1931-70--Continued

Gaging station (number and name)	11160000	11160300	11160500	11161500	11161900	11162500
	Soquel Creek at Soquel	Zayante Creek at Zayante	San Lorenzo River at Big Trees	Branciforte Creek at Santa Cruz	Scott Creek above Little Creek, near Davenport	Pescadero Creek near Pescadero
Drainage area (mi ²)	40.2	11.1	111	17.3	25.1	45.9
Water year						
1931	j2.06	k0.41	L15.00	n2.58	a3.00	p2.46
1932	j38.08	k10.56	L123.00	n17.00	o29.52	p36.14
1933	j6.28	k1.35	L25.00	n3.91	o6.00	p5.98
1934	j14.21	k4.45	L58.00	n8.32	o13.92	p15.72
1935	j19.81	k5.86	L73.00	n10.32	o17.52	p21.10
1936	j30.30	k8.59	L102.00	n14.19	o24.48	p25.74
1937	j31.93	k7.32	88.47	n12.38	o21.23	p28.16
1938	j69.04	k16.30	184.00	n25.13	o44.16	p60.12
1939	j5.36	k1.16	22.99	n3.64	o5.52	p5.62
1940	j53.04	k15.27	173.10	n23.67	o41.54	p53.18
1941	j75.28	k23.90	264.90	37.46	o63.58	p78.28
1942	j47.26	k13.86	158.10	21.19	o37.94	p48.50
1943	j34.43	k10.17	118.80	17.59	o28.51	p32.09
1944	j17.08	k3.57	48.62	n7.06	o11.67	p12.90
1945	j27.76	k7.20	87.24	n12.22	o20.94	p22.82
1946	j18.19	k4.97	63.50	n9.05	o15.24	p19.58
1947	j9.62	k1.74	29.17	n4.46	o7.00	p7.28
1948	j7.57	k1.99	31.83	n4.82	o7.64	p8.04
1949	j16.96	k4.75	61.14	n8.74	o14.67	p17.16
1950	j14.30	k4.25	55.90	n8.04	o13.42	p11.92
1951	j43.83	k11.40	131.90	n18.18	o31.66	p35.92
1952	67.70	k18.42	206.60	n28.14	o49.58	66.92
1953	27.17	k7.50	90.44	11.76	o21.71	31.90
1954	18.66	k4.18	55.06	6.01	o13.21	16.52
1955	15.04	k3.88	51.96	7.50	o12.47	15.66
1956	71.58	k16.62	187.50	26.39	o45.00	66.97
1957	13.61	k3.00	42.50	4.72	o10.20	13.09
1958	63.75	17.74	205.40	28.32	o49.30	74.79
1959	19.69	5.68	61.61	11.49	11.00	11.98
1960	12.41	2.80	34.89	8.11	9.20	7.41
1961	3.28	.83	m19.42	3.36	4.05	3.96
1962	22.74	5.31	m68.03	12.12	16.58	16.59
1963	62.79	13.70	m141.60	19.95	37.19	47.78
1964	10.05	2.26	m36.05	4.90	8.39	7.49
1965	36.82	8.64	m118.90	13.82	34.91	37.70
1966	9.13	2.30	m45.08	5.31	9.38	13.01
1967	54.24	16.55	m168.11	23.54	39.50	50.37
1968	12.03	3.83	m53.89	6.77	13.05	15.87
1969	53.70	21.86	m204.69	n30.34	53.03	62.04
1970	44.52	11.00	m123.35	n17.31	30.73	30.42
Mean	30.03	8.13	95.77	13.50	23.19	28.48

See footnotes at end of table.

TABLE 2.--Annual runoff, in thousands of acre-feet, for gaging stations in or near the San Francisco Bay region, for period 1931-70--Continued

Gaging station (number and name)	11162540	11162600	11162720	11162800	11166000	11169500
	Butano Creek near Pescadero	Purisima Creek near Half Moon Bay	Colma Creek at South San Francisco	Redwood Creek at Redwood City	Matadero Creek at Palo Alto	Saratoga Creek at Saratoga (v)
Drainage area (mi ²)	18.3	4.83	10.8	1.82	7.24	9.22
Water year						
1931	q1.83	r0.29	s0.54	t0.04	u0.02	w0.53
1932	q17.32	r3.24	s4.31	t.87	u1.19	w8.73
1933	q3.45	r.64	s1.18	t.14	u.10	w1.49
1934	q7.93	r1.44	s2.02	t.36	u.37	3.72
1935	q10.41	r1.98	s4.07	t.52	u.59	5.21
1936	q12.54	r1.98	s4.16	t.52	u.59	5.21
1937	q13.65	r2.80	s4.38	t.74	u.97	7.51
1938	q28.36	r5.80	s7.82	t1.60	u2.72	15.84
1939	q3.29	r.63	s.92	t.14	u.10	1.47
1940	q25.16	r4.87	s7.05	t1.33	u2.12	13.24
1941	q36.71	r6.74	s8.38	t1.86	u3.35	18.45
1942	q23.01	r4.46	s6.78	t1.21	u1.87	12.10
1943	q15.46	r2.63	s4.52	t.70	u.89	7.04
1944	q6.63	r1.20	s2.44	t.30	u.28	3.06
1945	q11.20	r1.87	s3.34	t.48	u.54	4.93
1946	q9.71	r1.98	s3.15	t.52	u.59	5.21
1947	q4.05	r.75	s1.42	t.18	u.14	1.81
1948	q4.40	r.81	s.83	t.19	u.15	1.97
1949	q8.59	r1.61	s2.42	t.42	u.43	4.19
1950	q6.18	r.82	s2.98	t.20	u.16	1.99
1951	q17.22	r2.95	s6.18	t.78	u1.04	7.91
1952	q31.48	r5.45	s8.12	t1.50	u2.49	14.87
1953	q15.37	r2.36	s4.64	t.64	.84	6.29
1954	q8.30	r1.54	s2.09	t.26	.04	4.00
1955	q7.90	r1.25	s2.02	t.30	.25	3.19
1956	q31.51	r5.67	s8.10	t1.58	2.74	15.48
1957	q6.72	r1.13	s1.96	t.20	.06	2.85
1958	q35.10	r6.42	s9.34	t1.92	3.87	17.56
1959	q6.21	.90	s2.18	t.36	.33	3.82
1960	q4.11	.95	s1.86	.35	.25	1.78
1961	q2.52	.63	s.90	.07	.07	1.19
1962	q8.33	1.43	s3.46	.60	.62	5.52
1963	20.00	4.20	s7.00	1.14	1.11	12.14
1964	4.25	1.12	1.69	.18	.23	1.80
1965	19.15	3.95	4.05	.80	.96	10.64
1966	6.62	1.49	3.36	.42	.72	3.10
1967	24.04	4.94	7.22	1.51	2.64	13.13
1968	10.07	1.46	3.80	.54	.96	3.48
1969	28.51	5.52	7.71	1.69	3.98	17.00
1970	15.40	r2.72	5.75	.95	1.55	7.28
Mean	13.82	2.57	4.10	0.70	1.05	6.92

See footnotes at end of table.

TABLE 2.--Annual runoff, in thousands of acre-feet, for gaging stations in or near the San Francisco Bay region, for period 1931-70--Continued

Gaging station (number and name)	11169800	11173000	11174000	11176000	11176500	11177000
	Coyote Creek near Gilroy	Alameda Creek near Sunol	San Antonio Creek near Sunol	Arroyo Mocho near Livermore	Arroyo Valle near Livermore	Arroyo de la Laguna near Pleasanton
Drainage area (mi ²)	109	37.5	37.0	38.2	147	405
Water year						
1931	a0.50	y2.17	z0.61	aa0.11	ab0.62	ad0.23
1932	x40.78	y13.56	z6.86	aa2.38	ab16.91	ad18.22
1933	x2.81	y4.00	z1.37	aa.30	ab1.87	ad1.00
1934	x9.14	y6.73	z2.73	aa.73	ab4.78	ad3.44
1935	x16.73	y12.85	z6.39	aa2.18	ab15.35	ad16.04
1936	x30.42	y13.14	z6.58	aa2.26	ab15.97	ad16.90
1937	x39.02	y13.74	z6.98	aa2.44	ab17.33	ad18.82
1938	x90.24	y24.61	z15.04	aa6.52	ab49.59	ad75.41
1939	x1.44	y3.49	z1.15	aa.24	ab1.46	ad.72
1940	x57.27	y21.97	z12.95	aa5.38	ab40.41	ad57.55
1941	x75.50	y26.99	z16.99	aa7.62	ab58.61	ad94.02
1942	x49.32	y14.64	z7.58	aa2.71	19.42	ad21.88
1943	x33.92	y2.48	z.73	aa.14	.79	ad.32
1944	x19.19	y11.22	z5.34	aa1.73	12.01	ad11.60
1945	x29.93	y18.05	z10.00	aa3.86	28.35	ad36.05
1946	x16.27	y9.58	z4.34	aa1.33	9.03	ad7.96
1947	x8.93	y6.32	z2.51	aa.66	4.26	ad2.95
1948	x3.43	y5.26	z1.97	aa.48	3.06	ad1.91
1949	x14.38	y8.96	z3.97	1.07	8.00	3.18
1950	x10.12	y8.44	z3.67	.65	7.18	4.42
1951	x50.89	y22.08	z13.03	aa5.43	40.77	ad58.23
1952	x71.83	y26.82	z16.84	aa7.53	57.93	98.03
1953	x22.89	y14.00	z7.15	aa2.52	ab17.91	ad19.66
1954	x14.12	y6.46	z2.58	aa.68	ab4.43	ad3.11
1955	x8.58	y7.07	z2.91	aa.80	ab5.22	ad3.86
1956	x74.18	y26.01	z16.18	aa7.15	ab54.81	ad86.06
1957	x9.98	y6.46	z2.58	aa.68	ab4.43	ad3.11
1958	x87.12	y32.24	z21.47	aa10.28	80.78	ad143.59
1959	x15.02	y12.98	z6.47	aa2.22	15.63	ad16.42
1960	x4.38	y8.63	z3.78	aa1.11	7.48	ad6.21
1961	1.15	y2.52	.48	aa.14	.81	ad.33
1962	27.97	y15.54	4.25	aa3.00	21.63	ad25.22
1963	53.72	y16.99	7.19	aa3.49	25.41	ad31.20
1964	7.55	y5.59	1.84	.40	3.42	ad2.21
1965	47.75	y17.44	z9.56	2.69	26.65	ad33.22
1966	11.22	y7.07	z2.91	.58	5.22	ad3.86
1967	69.27	y23.35	z14.04	5.90	45.13	ad66.59
1968	3.30	y5.18	z1.93	.72	2.98	ad1.84
1969	94.62	y26.35	z16.46	7.80	ac56.12	ad88.78
1970	35.74	y14.55	z7.53	2.06	ac19.22	35.39
Mean	31.52	13.14	6.92	2.70	20.27	27.99

See footnotes at end of table.

TABLE 2.--Annual runoff, in thousands of acre-feet, for gaging stations in or near the San Francisco Bay region, for period 1931-70--Continued

Gaging station (number and name)	11180500	11181000	11182100	11182400	11182500	11183000
	Dry Creek at Union City	San Lorenzo Creek at Hayward	Pinole Creek at Pinole	Arroyo del Hambre at Martinez	San Ramon Creek at San Ramon	San Ramon Creek at Walnut Creek
Drainage area (mi ²)	9.41	37.5	10.0	15.1	5.89	50.8
Water year						
1931	ae0	a0.30	a0.03	ah0	ai0.06	a0.10
1932	ae1.16	af8.13	ag2.32	ah2.03	ai1.71	aj9.06
1933	ae.04	a.90	a.20	ah0	ai.19	aj.38
1934	ae.26	af2.30	ag.55	ah.33	ai.48	aj2.04
1935	ae1.04	af7.38	ag2.08	ah1.80	ai1.55	aj8.15
1936	ae1.09	af7.68	ag2.16	ah1.87	ai1.61	aj8.49
1937	ae1.19	af8.33	ag2.39	ah2.09	ai1.75	aj9.29
1938	ae3.60	af23.84	ag6.60	ah6.14	ai5.01	aj27.91
1939	ae.01	a.70	a.10	ah0	ai.15	aj.16
1940	ae2.91	19.43	5.57	ah5.15	ai4.08	aj22.60
1941	ae4.27	af28.18	7.12	ah6.64	ai5.92	aj33.10
1942	ae2.73	af18.28	5.16	ah4.75	ai3.84	aj21.23
1943	ae1.23	af8.56	2.59	ah2.29	ai1.80	aj9.58
1944	ae.33	af2.76	.89	ah.65	ai.58	aj2.61
1945	ae.68	af5.06	1.50	ah1.24	ai1.06	aj5.35
1946	ae.85	af6.12	.96	ah.72	ai1.29	aj 6.67
1947	ae.05	.96	.38	ah.16	ai.20	aj.44
1948	ae.03	.81	.04	ah0	ai.17	aj.27
1949	ae.48	3.77	.61	ah.39	ai.79	aj3.81
1950	ae.91	6.54	.68	ah.45	ai1.37	aj7.12
1951	ae3.35	22.27	2.86	ah2.55	ai4.68	aj26.02
1952	ae4.38	28.90	6.21	ah5.76	ai6.07	aj33.96
1953	ae1.23	8.61	2.83	ah2.52	1.95	7.94
1954	ae.23	2.13	.67	ah.44	.70	1.65
1955	ae.29	2.51	.50	ah.28	.48	1.13
1956	ae3.98	26.35	6.77	ah6.30	4.94	23.99
1957	ae.23	2.13	.53	ah.31	.66	1.60
1958	ae5.22	34.34	8.61	ah8.07	6.64	38.76
1959	ae.25	2.29	.72	ah.49	.39	1.79
1960	.46	2.35	.38	ah.16	.59	2.86
1961	.01	.81	.07	ah0	.10	.69
1962	1.06	6.14	1.39	ah1.13	1.39	6.65
1963	1.97	19.61	5.41	ah4.99	4.52	23.29
1964	.22	2.69	.66	ah.43	.54	3.62
1965	1.81	12.76	2.61	2.38	3.44	16.23
1966	.32	3.37	1.36	1.15	.77	4.58
1967	2.93	19.74	5.80	6.17	4.01	25.55
1968	.61	3.81	1.57	1.14	.77	4.33
1969	3.58	17.59	6.45	5.83	3.29	20.22
1970	1.68	13.98	5.21	3.94	2.79	17.37
Mean	1.42	9.94	2.56	2.27	2.06	11.01

See footnotes at end of table.

TABLE 2.--Annual runoff, in thousands of acre-feet, for gaging stations in or near the San Francisco Bay region, for period 1931-70--Continued

Gaging station (number and name)	11183500 Walnut Creek at Walnut Creek	11185000 Grayson Creek near Hookston	11263000 San Luis Creek near Los Banos	11274500 Orestimba Creek near Newman	11274630 Del Puerto Creek near Patterson	113365.80 Morrison Creek near Sacramento (ap)
Drainage area (mi ²)	79.2	1.95	84.6	134	72.6	48.6
Water year						
1931	ak1.70	am0	an0	0	ao0	aq0.84
1932	ak19.26	am.28	an5.85	13.00	ao4.21	aq6.70
1933	ak2.24	am.01	an.15	.33	ao.26	aq2.80
1934	ak5.50	am.05	an.48	1.06	ao.63	aq3.37
1935	ak17.47	am.25	an1.72	3.82	ao1.66	aq10.77
1936	ak18.14	am.26	an4.19	9.31	ao3.27	aq11.33
1937	ak19.71	am.29	an6.25	13.89	ao4.43	aq9.05
1938	ak56.20	am.84	an20.17	44.82	ao10.80	aq22.78
1939	ak1.81	am0	an.12	.27	ao.22	aq1.09
1940	ak45.80	am.70	an8.21	18.24	ao5.45	aq18.25
1941	ak66.38	am.91	an27.02	60.04	ao13.48	aq25.52
1942	ak43.11	am.65	an7.38	16.39	ao5.03	aq19.62
1943	ak20.28	am.32	an7.72	17.16	ao5.20	aq10.21
1944	ak6.62	am.10	an3.22	7.15	ao2.68	aq5.05
1945	ak11.99	am.18	an4.12	9.16	ao3.23	aq6.86
1946	ak14.57	am.10	an.99	2.19	ao1.09	aq8.43
1947	ak2.36	am.03	an0	0	ao0	aq3.67
1948	ak2.03	am0	an0	0	ao0	aq4.78
1949	ak8.97	am.06	an.32	.72	ao.47	aq6.08
1950	ak15.46	am.07	0	.65	ao.43	aq7.12
1951	ak52.50	am.35	5.49	9.69	ao3.37	aq13.40
1952	ak68.06	am.79	11.55	26.34	ao7.20	aq18.29
1952	14.59	am.35	1.51	1.50	ao.82	aq13.79
1954	4.81	am.07	.43	0	ao0	aq10.32
1955	3.33	.03	.44	.04	ao.05	aq3.01
1956	50.59	.87	13.80	22.43	ao6.38	aq28.49
1957	4.90	.05	.16	1.90	ao.98	aq5.19
1958	70.39	1.12	16.74	41.49	ao10.18	aq23.76
1959	4.80	.07	1.89	9.98	ao3.45	aq4.02
1960	7.53	.04	1.07	1.71	ao.90	4.78
1961	3.62	am0	.09	0	ao0	5.07
1962	15.24	am.16	2.25	10.70	ao3.63	12.19
1963	40.62	am.68	an7.05	15.67	ao4.86	17.28
1964	7.61	am.07	an.12	.27	ao.22	6.40
1965	30.27	am.32	an2.86	6.35	ao2.44	14.76
1966	11.75	am.16	an.59	1.32	.70	7.13
1967	45.83	am.73	an9.40	20.89	5.78	20.91
1968	11.92	am.18	an0	0	.43	6.62
1969	aL42.19	am.82	an19.26	42.80	10.83	29.87
1970	aL38.04	am.66	an4.17	9.26	2.92	14.63
Mean	22.70	0.32	4.92	11.01	3.20	11.11

See footnotes at end of table.

TABLE 2.--Annual runoff, in thousands of acre-feet, for gaging stations in or near the San Francisco Bay region, for period 1931-70--Continued

Gaging station (number and name)	11337500 Marsh Creek near Byron	11447360 Arcade Creek near Del Paso Heights (ap)	11448500 Adobe Creek near Kelseyville	11448900 Highland Creek above Highland Creek Dam	11449450 Copsey Creek near Lower Lake	11449500 Kelsey Creek near Kelseyville
Drainage area (mi ²)	42.6	31.5	6.36	11.9	13.2	36.6
Water year						
1931	ar0	as0	at1.45	au2.43	av0.04	aw12.52
1932	ar4.78	as5.03	at4.58	au7.66	av4.46	aw31.59
1933	ar0	as1.52	at2.94	au4.91	av2.15	aw21.58
1934	ar.62	as2.03	at4.34	au7.26	av4.12	aw30.15
1935	ar4.24	as8.69	at7.65	au12.78	av8.79	aw50.28
1936	ar4.44	as 9.20	at8.51	au14.22	av10.00	aw55.53
1937	ar4.92	as7.14	at5.98	au9.99	av6.43	aw40.10
1938	ar15.93	as19.50	at17.95	au29.99	av23.31	aw113.10
1939	ar0	as0	at1.61	au2.69	av.27	aw13.45
1940	ar12.79	as15.42	at12.96	au21.65	av16.27	aw82.66
1941	ar19.01	as21.97	at17.06	au28.51	av22.05	aw107.69
1942	ar11.98	as16.66	at13.95	au23.31	av17.67	aw88.71
1943	ar5.08	as8.19	at7.14	au11.94	av8.07	aw47.21
1944	ar.96	as3.54	at4.49	au7.50	av4.33	aw31.02
1945	ar2.58	as5.17	at5.22	au8.72	av5.36	aw35.49
1946	ar3.36	as6.59	at6.35	au10.61	av6.95	aw42.38
1947	ar0	as2.30	at3.27	au5.46	av2.61	23.58
1948	ar0	as3.30	at4.02	au6.72	av3.67	28.16
1949	ar1.67	as4.47	at4.66	au7.79	av4.57	32.09
1950	ar3.63	as5.41	at4.17	au6.98	av3.88	29.11
1951	ar14.82	as11.06	at8.16	au13.64	av9.51	53.43
1952	ar19.52	as15.46	at11.12	au18.59	av13.68	71.48
1953	ar5.59	as11.41	at9.45	au15.79	av11.32	61.28
1954	.52	as8.29	at7.72	au12.91	av8.89	50.75
1955	1.00	as1.71	4.04	7.02	av3.70	26.74
1956	15.90	as24.64	16.95	28.25	av21.90	119.00
1957	.99	as3.67	5.57	9.55	av5.85	41.55
1958	20.56	as20.38	16.96	31.47	av21.91	112.60
1959	1.21	as2.62	4.56	9.33	av4.43	32.60
1960	1.38	as3.30	4.38	7.75	av4.18	32.88
1961	0	as3.56	5.55	8.98	4.21	32.96
1962	2.84	as9.97	7.38	13.97	8.54	45.78
1963	11.94	as14.55	12.17	16.71	14.10	70.59
1964	.96	5.10	2.91	4.63	2.14	25.55
1965	10.52	12.84	12.10	18.80	12.42	81.40
1966	1.24	5.02	7.64	12.14	10.32	45.94
1967	13.34	18.72	12.79	17.02	18.84	79.37
1968	.98	4.52	6.46	11.53	8.47	42.60
1969	14.18	26.86	13.26	23.69	av16.70	81.96
1970	8.90	10.70	12.64	21.26	av15.82	80.34
Mean	6.06	9.01	8.00	13.35	9.30	52.63

See footnotes at end of table.

TABLE 2.--Annual runoff, in thousands of acre-feet, for gaging stations in or near the San Francisco Bay region, for period 1931-70--Continued

Gaging station (number and name)	11453200	11453500	11453600	11454000	11454100	11456000
	Dry Creek near Middletown	Putah Creek near Guenoc	Pope Creek near Pope Valley	Putah Creek near Winters	Pleasants Creek near Winters	Napa River near St. Helena
Drainage area (mi ²)	8.35	113	78.3	574	15.9	81.4
Water year						
1931	ax4.76	23.50	ay5.83	34.80	ba0	5.05
1932	ax12.00	83.10	ay29.02	201.00	ba2.26	40.10
1933	ax8.20	51.80	ay16.49	94.60	ba0	bb16.78
1934	ax11.46	78.60	ay27.18	145.00	a.10	bb20.20
1935	ax19.11	141.50	ay53.72	352.30	ba6.06	bb64.51
1936	ax21.10	157.90	ay60.90	346.50	ba6.58	bb67.84
1937	ax15.24	109.70	ay40.09	280.00	ba4.45	bb54.21
1938	ax42.98	337.80	ay144.26	853.40	ba17.28	bb136.42
1939	ax5.11	26.42	ay6.89	41.55	ba0	bb6.55
1940	ax31.41	242.70	ay99.26	674.70	ba13.05	109.30
1941	ax40.92	320.90	ay136.14	1,004.00	ba19.84	152.80
1942	ax33.71	261.60	ay108.05	715.20	ba14.33	117.50
1943	ax17.94	131.90	ay49.56	319.40	ba5.54	61.16
1944	ax11.79	81.32	ay28.29	178.20	ba.72	30.24
1945	ax13.49	95.29	ay34.05	206.50	ba2.41	41.06
1946	ax16.10	116.80	ay43.10	261.70	ba3.87	50.49
1947	ax8.96	79.14	ay27.40	129.40	a.40	21.98
1948	ax10.70	85.39	ay29.96	133.30	ba.46	28.60
1949	ax12.19	95.44	ay34.11	192.10	ba1.68	36.42
1950	ax11.06	85.60	ay30.04	182.10	ba2.65	42.62
1951	ax20.30	173.60	ay67.85	388.00	ba8.52	80.25
1952	ax27.16	222.00	ay89.72	588.00	ba13.08	109.50
1953	ax23.29	185.20	ay73.03	423.40	ba8.88	82.57
1954	ax19.29	134.40	ay50.64	284.20	ba5.64	61.82
1955	ax10.16	60.52	ay19.92	92.79	ba0	18.01
1956	ax45.22	304.00	ay128.06	860.70	ba22.61	170.60
1957	ax15.79	90.49	ay32.06	az153.50	ba.85	31.09
1958	ax42.79	296.90	ay124.69	az855.40	ba18.19	142.30
1959	ax12.39	79.92	ay27.72	az202.10	a.70	24.10
1960	18.22	113.40	ay41.66	az248.80	2.08	42.98
1961	13.82	81.31	ay28.28	az167.40	.52	27.25
1962	15.91	121.60	50.50	az311.00	4.84	49.55
1963	27.82	213.80	94.14	az627.10	12.15	98.25
1964	8.76	54.07	16.73	az144.60	1.92	20.57
1965	28.00	212.60	85.48	az561.50	9.19	98.66
1966	15.80	128.50	40.68	az304.10	3.45	53.17
1967	27.73	240.00	88.97	az710.70	16.38	119.80
1968	13.32	108.20	35.99	az271.90	1.52	46.90
1969	31.14	245.80	110.70	az717.10	ba23.90	126.40
1970	33.03	251.10	112.40	az743.20	ba9.66	131.30
Mean	19.95	148.10	58.09	375.0	6.64	65.97

See footnotes at end of table.

TABLE 2.--Annual runoff, in thousands of acre-feet, for gaging stations in or near the San Francisco Bay region, for period 1931-70--Continued

Gaging station (number and name)	11456500	11457000	11458000	11458200	11458500	11459000
	Conn Creek near St. Helena	Dry Creek near Napa	Napa River near Napa	Redwood Creek near Napa	Sonoma Creek at Agua Caliente	Petaluma River at Petaluma
Drainage area (mi ²)	52.1	17.4	218	9.79	58.4	30.9
Water year						
1931	1.09	be1.01	7.65	bg0.46	bh3.48	a0.20
1932	15.50	be8.02	90.90	bg4.15	bh27.67	bi6.26
1933	4.38	be3.36	bf31.72	bg1.65	bh11.58	bi1.46
1934	5.52	be4.04	bf38.50	bg2.01	bh13.94	bi2.16
1935	23.39	be12.90	bf129.42	bg6.88	bh44.51	bi11.29
1936	24.83	be13.57	bf136.42	bg7.25	bh46.81	bi11.98
1937	18.84	be10.84	bf107.90	bg5.72	bh37.40	bi9.17
1938	59.37	be27.28	bf283.31	bg15.21	bh94.13	bi26.10
1939	1.36	be1.31	bf11.90	bg.61	bh4.52	a.30
1940	45.02	be21.86	bf224.66	bg12.02	bh75.42	bi20.52
1941	75.37	be30.56	bf319.02	bg17.15	bh105.43	bi29.48
1942	53.48	be23.50	bf242.32	bg12.98	bh81.08	bi22.20
1943	23.06	be12.23	bf122.40	bg6.50	bh42.20	bi10.60
1944	10.42	be6.05	bf58.66	bg3.08	bh20.87	bi4.23
1945	14.99	be8.21	bf80.72	bg4.26	bh28.33	bi6.46
1946	bc12.80	be10.10	bf100.18	bg5.30	bh34.84	bi8.40
1947	bc5.52	be4.40	bf42.04	bg2.20	bh15.17	bi2.53
1948	bc7.02	be5.72	bf55.34	bg2.90	bh19.73	bi3.89
1949	bc11.56	be7.28	bf71.22	bg3.75	bh25.13	5.17
1950	bc13.52	be8.52	bf83.92	bg4.43	bh29.41	8.40
1951	bc32.26	be16.05	bf162.61	bg8.67	bh55.37	19.52
1952	bc43.70	25.94	bf225.08	bg12.05	bh75.56	23.94
1953	bc27.52	16.73	bf167.53	bg8.93	bh56.97	14.87
1954	bc18.52	12.44	bf123.78	bg6.57	bh42.66	7.32
1955	bc4.76	4.18	bf34.16	bg1.78	bh12.43	3.76
1956	bc75.79	35.08	bf358.04	bg19.27	113.80	32.80
1957	bc8.20	5.71	bf60.38	bg3.17	19.45	1.60
1958	bc61.28	32.80	bf296.11	bg15.90	105.30	31.81
1959	bc11.39	5.61	bf46.28	2.46	19.17	5.30
1960	bd14.12	6.97	bc81.35	3.61	32.54	3.50
1961	bd8.13	4.44	bc45.24	2.23	18.89	3.71
1962	bd16.77	12.25	bc118.79	6.17	41.56	9.26
1963	bd38.46	20.39	bc221.98	12.31	62.63	13.81
1964	bd5.78	3.93	bc37.67	2.94	13.15	bi2.24
1965	bd38.65	17.36	bc185.57	8.92	56.91	bi18.32
1966	bd18.27	9.55	bc111.15	5.66	43.73	bi8.95
1967	bd48.90	be23.96	bc269.30	15.62	91.43	bi22.68
1968	bd15.69	be9.38	bc108.68	4.18	33.46	bi7.66
1969	bd52.19	be25.28	bc278.81	15.70	86.50	bi24.04
1970	bd54.65	be26.26	bc260.86	16.53	76.17	bi25.05
Mean	25.55	13.38	135.8	7.28	45.48	11.77

See footnotes at end of table.

TABLE 2.--Annual runoff, in thousands of acre-feet, for gaging stations in or near the San Francisco Bay region, for period 1931-70--Continued

Gaging station (number and name)	11459500	11460000	11460500	11460800	11460920
	Novato Creek at Novato	Corte Madera Creek at Ross	Nicasio Creek near Point Reyes	Walker Creek near Tomales	Salmon Creek at Bodega
Drainage area (mi ²)	17.6	18.1	36.6	37.1	15.7
Water year					
1931	bj0.67	bL1.94	bm2.58	bn3.80	bo1.38
1932	bj5.29	bL11.71	bm18.00	bn20.00	bo8.83
1933	bj2.21	bL5.48	bm7.92	bn9.91	bo4.02
1934	bj2.67	bL6.46	bm9.46	bn11.54	bo4.76
1935	bj8.52	bL17.73	bm28.17	bn29.34	bo13.58
1936	bj8.95	bL18.51	bm29.51	bn30.52	bo14.22
1937	bj7.16	bL15.24	bm23.92	bn25.51	bo11.60
1938	bj18.01	bL34.01	bm56.93	bn53.55	bo26.90
1939	bj.86	bL2.41	bm3.26	bn4.64	bo1.74
1940	bj14.43	bL28.05	bm46.23	bn44.81	bo21.96
1941	bj20.17	bL37.53	bm63.33	bn58.66	bo29.84
1942	bj15.51	bL29.87	bm49.47	bn47.49	bo23.46
1943	bj8.07	bL16.92	bm26.77	bn28.08	bo12.94
1944	bj3.99	bL9.17	bm13.81	bn15.94	bo6.84
1945	bj5.42	bL11.96	bm18.41	bn20.39	bo9.02
1946	bj6.66	bL14.31	bm22.35	bn24.07	bo10.88
1947	1.89	bL4.78	bm6.84	bn8.74	bo5.14
1948	1.04	bL2.85	bm3.90	bn5.41	bo6.50
1949	7.43	bL15.74	bm24.77	bn26.28	bo8.10
1950	5.73	bL12.56	bm19.40	bn21.32	bo9.33
1951	12.79	bL25.25	bm41.27	bn40.67	bo16.57
1952	bk15.32	34.94	bm48.90	bn47.02	bo22.00
1953	bk11.66	20.49	bm37.83	bn37.75	bo17.00
1954	bk5.15	14.36	25.35	bn19.57	bo13.08
1955	bk4.08	9.53	14.02	bn16.23	bo4.30
1956	bk22.16	37.45	65.61	bn63.27	bo32.00
1957	bk3.95	7.46	10.38	bn15.81	bo6.42
1958	bk21.17	45.84	64.73	bn60.98	bo29.80
1959	bk3.81	8.44	13.11	bn15.36	bo6.34
1960	bk3.80	10.64	12.63	12.90	bo10.22
1961	bk1.95	5.75	bm7.04	13.24	bo6.26
1962	bk7.79	15.59	bm25.90	23.38	bo12.77
1963	bk10.81	24.13	bm35.24	37.97	16.01
1964	bk3.68	5.77	bm12.80	10.15	4.90
1965	bk10.53	19.99	bm34.38	38.02	16.37
1966	bk7.46	15.60	bm24.86	26.83	13.39
1967	bk18.95	31.66	bm59.72	55.10	20.47
1968	bk6.13	15.09	bm20.67	23.00	11.27
1969	bk19.15	36.29	bm60.32	60.92	25.12
1970	bk18.48	33.79	bm58.33	55.64	25.25
Mean	8.84	17.88	28.70	29.10	13.51

See footnotes at end of table.

TABLE 2.--Annual runoff, in thousands of acre-feet, for gaging stations in or near the San Francisco Bay region, for period 1931-70--Continued

Gaging station (number and name)	Inflow between Russian River mainstem stations		11463200	11463900	11463940	11464500
	Cloverdale (11463000) to Healdsburg (11464000)	Healdsburg (11464000) to Guerneville (11467000)	Big Sulphur Creek near Cloverdale	Maacama Creek near Kellogg	Franz Creek near Kellogg	Dry Creek near Cloverdale
Drainage area (mi ²)	290	547	82.3	43.4	15.7	87.8
Water year						
1931	bp73.3	bq130.6	bs30.05	a6.00	bu1.73	bv25.82
1932	bp191.9	bq341.9	bs78.68	bt38.95	bu11.26	bv67.57
1933	bp152.0	bq270.8	bs62.32	bt20.04	bu5.79	bv53.52
1934	bp133.9	bq238.6	bs54.90	bt23.09	bu6.67	bv47.16
1935	bp267.8	bq477.2	bs109.80	bt55.99	bu16.18	bv94.30
1936	bp337.5	bq601.3	bs138.38	bt58.18	bu16.81	bv118.83
1937	bp178.7	bq318.3	bs73.27	bt49.03	bu14.17	bv62.91
1938	bp699.4	bq1,246.2	bs286.75	bt99.14	bu28.65	bv246.28
1939	bp107.5	bq191.6	bs44.08	a8.00	bu2.31	bv37.86
1940	bp469.8	781.0	bs192.62	bt83.72	bu24.20	bv165.43
1941	bp580.6	1,367.0	bs238.05	bt108.10	bu31.24	bv204.43
1942	bp531.6	865.0	bs217.96	bt88.47	bu25.57	187.20
1943	bp299.3	504.2	bs122.71	bt53.76	bu15.54	105.40
1944	bp142.9	275.2	bs58.59	bt31.41	bu9.08	50.33
1945	bp206.5	376.2	bs84.66	bt39.66	bu11.46	72.71
1946	bp315.8	523.2	bs129.48	bt46.44	bu13.42	111.20
1947	bp123.1	197.6	bs50.47	bt24.62	bu7.12	43.35
1948	bp217.7	324.4	bs89.26	bt30.10	bu8.70	76.64
1949	bp250.7	365.7	bs102.79	bt36.20	bu10.46	88.26
1950	bp163.4	348.3	bs66.99	bt40.80	bu11.79	57.55
1951	bp378.0	651.0	bs154.98	bt66.14	bu19.11	133.10
1952	548.6	903.0	bs224.93	bt83.84	bu24.23	167.80
1953	449.2	597.0	bs184.17	bt67.59	bu19.53	134.40
1954	341.8	482.0	bs140.14	bt54.20	bu15.66	131.40
1955	164.7	244.9	bs67.53	bt21.25	bu6.11	57.41
1956	699.0	1,300.0	bs286.59	bt117.59	bu33.98	214.20
1957	223.3	305.3	bs91.55	bt32.08	bu9.27	70.29
1958	717.0	1,385.0	272.00	bt102.39	bu29.59	259.00
1959	194.4	br351.3	79.58	bt26.41	bu7.63	84.09
1960	207.7	br400.9	84.48	bt41.07	bu11.87	92.03
1961	232.3	br408.0	93.76	bt29.01	bu8.38	106.90
1962	294.5	br560.1	110.40	47.88	bu13.84	109.50
1963	402.9	br884.3	175.50	74.69	bu21.59	121.50
1964	107.6	br274.4	55.22	23.53	5.93	41.93
1965	393.6	br833.7	194.20	85.09	22.45	172.50
1966	287.1	br662.6	118.50	50.45	15.79	107.20
1967	504.8	br915.2	188.60	91.11	27.22	137.40
1968	275.0	br426.8	97.66	41.77	13.62	77.47
1969	531.0	br1,203.5	215.20	96.03	bu27.75	190.20
1970	583.0	br1,213.7	222.40	98.16	bu28.37	197.70
Mean	324.5	593.7	132.23	54.80	15.85	113.07

See footnotes at end of table.

TABLE 2.--Annual runoff, in thousands of acre-feet, for gaging stations in or near the San Francisco Bay region, for period 1931-70--Continued

Gaging station (number and name)	11465200	11465800	11467200	11467500	11467600
	Dry Creek near Geyserville	Santa Rosa Creek near Santa Rosa	Austin Creek near Cazadero	South Fork Gualala River near Annapolis	Garcia River near Point Arena
Drainage area (mi ²)	162	12.5	63.1	161	98.5
Water year					
1931	bw49.6	bx0.96	by30.30	bz63.8	ca53.2
1932	bw129.7	bx7.62	by79.28	bz166.9	ca139.2
1933	bw102.8	bx3.19	by62.80	bz132.2	ca110.3
1934	bw90.5	bx3.84	by55.34	bz116.5	ca97.2
1935	bw181.1	bx12.26	by110.63	bz232.9	ca194.2
1936	bw228.2	bx12.89	by139.41	bz293.5	ca244.8
1937	bw120.8	bx10.30	by73.82	bz155.4	ca129.6
1938	bw472.9	bx25.92	by288.94	bz608.3	ca507.3
1939	bw72.7	bx1.24	by44.41	bz93.5	ca78.0
1940	bw317.6	bx20.77	by194.08	bz408.6	ca340.8
1941	bw392.5	bx29.03	by239.83	bz504.9	ca421.1
1942	bw359.4	bx22.32	by219.64	bz462.4	ca385.6
1943	bw202.4	bx11.62	by123.64	bz260.3	ca217.1
1944	bw96.6	bx5.75	by59.04	bz124.3	ca103.7
1945	bw139.6	bx7.80	by85.31	bz179.6	ca149.8
1946	bw213.5	bx9.59	by130.48	bz274.7	ca229.1
1947	bw83.2	bx4.18	by50.87	bz107.1	ca89.3
1948	bw147.1	bx5.43	by89.92	bz189.3	ca157.9
1949	bw169.5	bx6.92	by103.55	bz218.0	ca181.8
1950	bw110.5	bx8.10	by67.50	bz142.1	ca118.5
1951	bw255.6	bx15.25	by162.16	341.4	ca284.7
1952	bw322.2	bx20.80	by206.20	434.1	ca362.0
1953	bw258.0	bx15.69	by162.69	342.5	ca285.6
1954	bw252.3	bx11.75	by162.16	341.4	ca284.7
1955	bw110.2	bx3.42	by81.51	171.6	ca143.1
1956	bw411.3	bx32.41	by220.68	464.6	ca387.5
1957	bw135.0	bx5.91	by105.64	222.4	ca185.5
1958	bw497.3	bx27.04	by266.14	560.3	ca467.3
1959	bw161.5	bx4.58	by84.79	178.5	ca148.9
1960	145.9	11.46	111.40	224.2	ca187.0
1961	156.6	5.77	119.70	270.9	ca225.9
1962	199.3	9.49	127.90	266.1	ca221.9
1963	279.4	17.46	149.70	307.1	252.1
1964	94.0	4.37	61.84	138.0	117.2
1965	316.0	19.08	160.40	361.5	316.9
1966	212.1	8.34	125.30	234.5	218.2
1967	294.2	22.15	170.52	359.0	321.5
1968	159.0	7.80	92.96	195.7	149.6
1969	393.3	22.67	190.00	400.0	351.8
1970	386.9	23.96	193.61	407.6	314.2
Mean	218.0	12.48	130.10	273.9	229.4

See footnotes at end of table.

TABLE 2.--Annual runoff, in thousands of acre-feet, for gaging stations in or near the San Francisco Bay region, for period 1931-70--Continued

NOTE.--Equations shown below were used to estimate annual runoff for years without discharge records during the period 1931-70. In all equations runoff is expressed in thousands of acre-feet (1,000 acre-ft = 1.233 hm³).

- a. Subjective estimate
- b = 0.12(Uvas Creek near Morgan Hill) - 0.5
- c = 3.75(Saratoga Creek at Saratoga)
- d = 1.45(Uvas Creek above Uvas Reservoir)
- e = 0.1(Uvas Creek near Morgan Hill) - 0.2
- f. Runoff figures include estimate of municipal diversion to Watsonville
- g = 0.92(Uvas Creek near Morgan Hill)^{0.68}
- h = 0.12(Uvas Creek near Morgan Hill) + 0.031(San Lorenzo River at Big Trees)
- i = 1.65(Aptos Creek at Aptos)
- j = 3.06(West Branch Soquel Creek near Soquel) - 1.0
- k = 0.094(San Lorenzo River at Big Trees) - 1.0
- L = 0.415(Arroyo Seco near Soledad) + 1.805(Uvas Creek near Morgan Hill) + 7.0
- m. Adjusted for reservoir storage and municipal diversion to Santa Cruz
- n = 0.07(San Lorenzo River at Big Trees) + 0.675(Zayante Creek at Zayante) + 1.25
- o = 0.24(San Lorenzo River at Big Trees)
- p = 0.16(San Lorenzo River at Big Trees) + 2.0(Saratoga Creek at Saratoga) - 1.0
- q = 0.46(Pescadero Creek near Pescadero) + 0.7
- r = 0.36(Saratoga Creek at Saratoga) + 0.1
- s = 1.29(Pinole Creek at Pinole)^{0.585} + 0.71(San Lorenzo Creek at Hayward)^{0.54}
- t = 0.058(Saratoga Creek at Saratoga)^{0.97} + 0.345(Matadero Creek at Palo Alto)^{0.78}
- u = 0.06(Saratoga Creek at Saratoga)^{1.38}
- v. Runoff figures include municipal diversion to San Jose
- w = 0.267(Uvas Creek near Morgan Hill)
- x = 1.4(Uvas Creek near Morgan Hill) - 5.0
- y = 2.83(Arroyo Valle near Livermore)^{0.554}
- z = 0.87(Arroyo Valle near Livermore)^{0.73}
- aa = 0.17(Arroyo Valle near Livermore)^{0.934}
- ab = 2.08(San Lorenzo Creek at Hayward)
- ac = 1.02(Arroyo Valle above Lang Canyon)
- ad = 0.436(Arroyo Valle near Livermore)^{1.32}
- ae = 0.155(San Lorenzo Creek at Hayward) - 0.1
- af = 0.09(Napa River near St. Helena) + 0.36(Saratoga Creek at Saratoga)^{1.3} - 1.5
- ag = 0.026(Napa River near St. Helena) + 0.25(Saratoga Creek at Saratoga) - 0.9
- ah = 0.96(Pinole Creek at Pinole) - 0.2
- ai = 0.21(San Lorenzo Creek at Hayward)
- aj = 5.71(San Ramon Creek at San Ramon) - 0.7
- ak = 1.96(San Ramon Creek at Walnut Creek) + 1.5
- aL = 0.93(Walnut Creek at Concord)

TABLE 2.--Annual runoff, in thousands of acre-feet, for gaging stations in or near the San Francisco Bay region, for period 1931-70--Continued

am = 0.13(Pinole Creek at Pinole) - 0.02
 an = 0.45(Orestimba Creek near Newman)
 ao = 0.6(Orestimba Creek near Newman)^{0.76}
 ap. Runoff figures do not include 500 acre-feet per year of waste-water discharge
 aq = 0.167(Napa River near St. Helena)
 ar = 3.38(San Ramon Creek near San Ramon) - 1.0
 as = 0.9(Morrison Creek near Sacramento) - 1.0
 at = 0.164(Kelsey Creek near Kelseyville) - 0.6
 au = 0.274(Kelsey Creek near Kelseyville) - 1.0
 av = 1.41(Adobe Creek near Kelseyville) - 2.0
 aw = 0.32(Putah Creek near Guenoc) + 5.0
 ax = 0.38(Kelsey Creek near Kelseyville)
 ay = 0.208(Putah Creek near Guenoc) + 0.062(Putah Creek near Guenoc)^{1.22} - 2.0
 az. Adjusted for storage in Lake Berryessa
 ba = 0.934(Morrison Creek near Sacramento) - 4.0
 bb = 5.116(Conn Creek near St. Helena)^{0.804}
 bc. Adjusted for reservoir storage and municipal diversion to Napa
 bd = 0.148(Napa River near St. Helena)^{1.212}
 be = 0.20(Napa River near St. Helena)
 bf = 0.995(Napa River near St. Helena) + 0.695(Napa River near St. Helena)^{1.09}
 bg = 0.083(Napa River near St. Helena)^{1.06}
 bh = 0.69(Napa River near St. Helena)
 bi = 0.206(Napa River near St. Helena) - 2.0
 bj = 0.132(Napa River near St. Helena)
 bk. Adjusted for reservoir storage and municipal diversion to Novato
 bl = 2.75(Novato Creek at Novato)^{0.87}
 bm = 3.76(Novato Creek at Novato)^{0.94}
 bn = 5.24(Novato Creek at Novato)^{0.804}
 bo = 0.15(Sonoma Creek at Agua Caliente) + 0.308(Sonoma Creek at Agua Caliente)^{0.82}
 bp = 2.84(Dry Creek near Cloverdale)
 bq = 5.06(Dry Creek near Cloverdale)
 br. Adjusted for diversion by Sonoma County Water Agency
 bs = 0.41(Russian River inflow between Cloverdale and Healdsburg)
 bt = 2.33(Napa River near St. Helena)^{0.763}
 bu = 0.289(Maacama Creek near Kellogg)
 bv = 0.233(Eel River at Van Arsdale Dam (adjusted))
 bw = 1.92(Dry Creek near Cloverdale)
 bx = 0.19(Napa River near St. Helena)
 by = 0.475(South Fork Gualala River near Annapolis)
 bz = 2.47(Dry Creek near Cloverdale)
 ca = 0.834(South Fork Gualala River near Annapolis)

TABLE 3.--*Skeleton relations of mean annual precipitation and runoff*

[Use linear interpolation for intermediate values]

North Bay and Sacramento Valley (hydrologic units 1-40)		West Bay and South Coast (hydrologic units 41-59)		East Bay (hydrologic units 60-72)		San Joaquin Valley (hydrologic units 73-76)	
precipitation (in)	Runoff (in)	Precipitation (in)	Runoff (in)	Precipitation (in)	Runoff (in)	Precipitation (in)	Runoff (in)
14	1.6	12	0.2	13	0	10	0
17	3.4	16	2.6	14	.1	11	.1
26	7.9	19	4.1	15	.2	12	.4
28	9.1	35	10.5	16	.5	13	.8
29	9.8	42	14.0	17	.9	17	2.8
31	11.4	44	15.2	18	1.4	35	10.0
35	15.0	46	16.6	24	5.0	37	11.0
80	60.0	48	18.2	30	8.0	44	15.2
		50	20.0	35	10.0	46	16.6
		60	30.0	37	11.0	48	18.2
				44	15.2	50	20.0
				46	16.6		
				48	18.2		
				50	20.0		

Note.--1 in = 25.4 mm