CALIFORNIA.

Total population (average per square mile, 7.75)		1,208,130
Number of owners of farms (4.38 per cent of population)		52,894
Number of irrigators (25.96 per cent of farm owners, 1.14 per cent of population)		13,732
Area of state, land surface (155,980 square miles)	acres	99,827,200
Area irrigated in census year	do	1,001,233
Area of all farms, 57.01 per cent improved	do	21,427,293
Cereals raised in census year, including 661 acres in buckwheat and 27,413 acres in rye	do	3,812,754
Barley, average production, 21.51 bushels per acre	do	815,995
Corn, average production, 33.87 bushels per acre	do	70,303
Oats, average production, 25.41 bushels per acre	do	57,569
Wheat, average production, 11.39 bushels per acre	do	2,840,807
Alfalfa	do	245,915
Total value of all farms, including land, fences, and buildings		$997,116,630
Estimated total value of the farms irrigated in whole or in part		$150,635,000
Estimated value of all farm productions (sold, consumed, or on hand) for 1889		$87,033,290
Estimated value of productions, as above, from farms irrigated in whole or in part		$19,080,000
Average size of irrigated farms	acres	73
Average size of irrigated farms of 160 acres and upward	do	547
Per cent of acreage of irrigated farms of 160 acres and upward to total acreage irrigated		61.88
Average size of irrigated farms under 160 acres	acres	30
Average first cost of water right per acre		$12.95
Average annual cost of water per acre		$1.60
Average first cost per acre of preparation for cultivation		$17.48
Average value of irrigated land, including buildings, etc., in June, 1890, per acre		$150.00
Average annual value of products per acre, in 1889		$19.00

COMPARISONS WITH OTHER STATES.

Comparing California with the other 10 states and territories which go to make up the arid region as previously defined, it is seen that this state in area irrigated, number of irrigators, and average value of products per acre during the census year stood at the head, Colorado coming second in point of area, and Utah second in number of irrigators. In average size of irrigated area, 73 acres, California was number 5. When the area irrigated is considered in comparison with the size of the state, California stands second, since Colorado had 1.34 per cent of its entire land surface irrigated, and California 1.01 per cent. Taking the total number of farms in the state and placing against this the number irrigated, the relative importance of irrigation seems to fall in the scale; for California with only 25.96 per cent of all farms irrigated comes number 10 in the list, but this is somewhat compensated for by the large size of the farms irrigated, 17.86 per cent of land owned by irrigators being watered, the state standing seventh in this respect.

In average value on June 1, 1890, of farm land irrigated, $150 per acre, California leads the list, Utah coming second, with $84.25 per acre. This figure exhibits perhaps better than any other the extraordinary values of land in California arising from its utilization for orchards and vineyards. The value of these ranges from $300 to $500 and upward per acre, thus greatly raising the average value of irrigated land, which of course also includes great areas devoted to the raising of hay crops. The same fact is exhibited, though perhaps not as clearly, in the high average value of products per acre in 1889 and in the large average first cost of water rights, $12.95 per acre, and average value of these in 1890, $39.28 per acre, a high cost and value being justified by the enormous profits resulting from successful fruit culture. In short, it may be said that the conditions in California, although by no means perfect, have produced such results that they have served to stimulate development in all parts of western United States. Much is still to be accomplished by the subdivision of the great irrigated holdings, this state standing first in the aggregate area and average size of irrigated holdings of over 160 acres in area. These, although embracing 61.88 per cent of the total area irrigated, are not of as great relative importance as in Nevada and Wyoming, where the large farms are devoted mainly to the forage crops.

GENERAL DESCRIPTION.

California stands at the head of the states and territories not only in acreage of land irrigated and in value of the products, but in many other features it is unique and easily leads in its developments along this line of agricultural prosperity. The wonderful advantages of the state due to its peculiar topography and the resulting climatic conditions and water supply render it difficult to make general conclusions which can be applied with safety to the arid regions farther to the east. It is often the case that persons knowing of the results obtained in California have argued that benefits as far reaching must necessarily follow irrigation everywhere, and have been disappointed by not taking full cognizance of the many almost unparalleled features of this great sea coast state.

California as a whole can not be said to be arid; in fact the greater part of its broad valley lands possess a mean annual rainfall sufficient for maturing the small grains, but the necessity for irrigation lies mainly in the fact that the greater part of the rainfall occurs during winter and early spring and that for months during summer and autumn hardly a drop falls. This fact is brought out most clearly by the diagrams shown in preceding figures and by a subsequent table. In the really arid portions of the state, namely, those east of the Sierra Nevadas, irrigation has made relatively little progress, but its greatest development, excepting perhaps in Kern and Tulare counties, is to be found where wheat growing has been carried on successfully for years without the artificial application of water. The one factor which forces irrigation into such prominence in California is its vital importance to fruit growing in many sections. Were it not for this the subject of irrigation as adding immensely to the value of the lands of the state would receive comparatively little attention, for, next to the orchards and vineyards, the crop which depends most upon irrigation is alfalfa, ranking when compared with fruits far down in the scale of value. Taking away the fruit and alfalfa, irrigation would become of little moment, as the ordinary field crops are probably raised on the whole as profitably without as with this means of supplying moisture.

The most striking feature of the topography of California is the great valley between the Coast and Sierra Nevada ranges, opening near its center by a break in the first named mountains. The Sacramento river coming from the north meets here the San Joaquin from the south, and together their waters enter in succession a number of inland bays to mingle with those of the ocean. The Sierra Nevadas on the east, as a whole, dip gently toward this interior valley; the lower portions of the mountains being partially buried beneath its sediments, while they present abrupt faces to the country farther to the east, furnishing a small catchment area for the streams which escape in that direction. South of the great valley of California, and at some distance below its southern end, are chains of mountains near the coast, some of which, the San Bernardino in particular, rise to extraordinary heights above their bases. They inclose or bound valleys near the coast, and by the steepness of their slopes in part protect these valleys and aid in furnishing an unusually large supply of running water. In the same way in the northern part of the state are mountain masses of irregular outline which also serve, though to a less degree, in making valuable the lands around their feet.

IMPORTANCE OF IRRIGATION.

Irrigation is dependent upon the great topographical features above mentioned, since these have a determining effect upon the quantity and distribution of the moisture. There is no county in the state in which crops of some kind have not been raised, in some localities at least, without irrigation, and on the other hand, there are many counties, notably those along the northern coast, in which the artifical application of water is not employed except in rare instances. Thus, in discussing the importance and development of this method of agriculture it is necessary at all times to bear in mind the topography of each region as well as the resulting precipitation and water supply. Grouping the counties of the state as regards the necessity and advantages of irrigation, those in the southern end, forming what is popularly known as southern California, come first. Here, as a whole, the returns arising from the introduction of irrigation have been largest and the aggregate investment in irrigation works as regards the quantity of water handled has been the greatest, the systems for water storage and distribution being far in advance of those of any other part of the United States.

Next to the counties of southern California in the order of importance of irrigation come those in the southern or upper end of the San Joaquin valley, where the artificial application of water is essential in bringing about a higher state of development of agriculture. In these counties the production of the cereals and the raising of cattle and sheep were more or less successfully carried on before the construction of irrigating canals, so that in one sense this great valley was settled in a general way before irrigation was practiced to any considerable extent, but in order to support a dense population and to bring about a corresponding increase in value of lands great systems of water distribution were constructed, these being among the largest in the state and in the whole United States. The locality standing third as regards necessity of irrigation comprises counties in the Sacramento valley, where agriculture flourished and land values were comparatively high before the present ditch systems were built or used for agricultural purposes. Here mining and stock raising have always been of first importance, and it is only within the last decade that fruit growing has forced its way toward the front. The use of water in the Sacramento valley is mainly confined to the foothill region, where, at elevations above that of the

central valley, orchards and vineyards flourish and yield wonderful results. Water is obtained to a large extent from the flumes and ditches constructed for working the placers and other deposits in which the hill country abounds. On the passage of the law relative to hydraulic workings many of these ditches fell into disuse and would have become entirely abandoned had not the discovery been made that the climate and soil of adjacent localities were singularly favorable for the production of fruit. These old mining ditches have therefore been extended and others constructed to meet the constantly increasing needs.

The northern counties of California and those lying along the eastern front of the Sierra Nevadas rank fourth as regards the importance of irrigation. Artificial watering of the fields is practiced mainly for the purpose of raising forage crops on the broad meadow lands which occur in many of the basins within these counties. On account of the general lack of transportation facilities fruit growing has not reached a high degree of importance, and the irrigation works in use are of the simplest possible description. The coast and bay counties, as before mentioned, have little, if any, need for irrigation, and where this is practiced it is generally in a small way, a few acres of trees or alfalfa being watered. The annual rainfall is sufficient for all needs, but there is a time in summer during which water may be of benefit if applied judiciously. In many of the northern and coast counties irrigation is practiced not only to furnish the requisite moisture, but also to prevent the ravages of various small animals, and in particular to protect the fields of alfalfa. In many localities the so-called gophers are particularly destructive, breeding with incredible rapidity and ravaging the alfalfa fields, which they honeycomb with their burrows. A thorough flooding of the whole area must, of course, completely fill their holes, and as a result these little pests are drowned.

RAINFALL AND WATER SUPPLY.

The great fluctuation in rainfall month by month has been illustrated by diagrams in the preceding pages, where are shown the relatively heavy rainfall in the early part of the year and the almost complete lack of precipitation during August, September, and October. This same characteristic prevails throughout the state, whether the mean annual rainfall be large or small, and has perhaps more influence as regards the importance of irrigation even than has the total amount of the annual precipitation. (*a*) Though the annual rainfall may be as large as that in some of the eastern states, yet it is necessary to guard against the evil effects to orchards and vineyards of the long severe drought of summer and autumn by building expensive canal systems and providing other means of distributing the water.

The water supply of the state is far better than that of any of the arid states and territories to the east. The Sierra Nevadas and other ranges force the moisture laden winds coming from the ocean to drop a large part of this moisture in the form of snow or rain, giving rise to almost innumerable streams. These flow down to the valley lands, bringing sediment of considerable value to plant life. Many of the smaller streams at least sink into the ground at points near the edges of the valleys, and thus to obtain the largest and best use of their waters they must be diverted before they leave the canyons in the foothills. The total quantity of water in many of these streams has been measured from time to time and computations have been made of the discharges month by month for several years in succession, this work being carried on mainly under the direction of the state engineering department. The results of this work are given in the county descriptions.

a The subject is more fully treated in Irrigation and Water Storage in the Arid Regions, by General A. W. Greely, Chief Signal Officer, United States army. Fifty-first Congress, second session, House of Representatives, Executive Document No. 287, February 28, 1891.

MEAN MONTHLY AND ANNUAL RAINFALL AT STATIONS IN CALIFORNIA.

[T. indicates a trace of rain, less than 0.01 inch.]

LOCALITIES.	Altitude.	Length of record.		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Alameda county:	*Feet.*	*Yrs.*	*Mos.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Livermore	485	a20	4	2.63	2.34	2.04	1.30	0.45	0.15	0.02	T.	0.14	0.71	1.64	2.98	14.40
Niles	87	a19	5	3.16	2.90	2.43	1.53	0.60	0.23	.....	T.	0.12	0.71	2.28	3.66	17.62
Amador county:																
Sutter Creek	.....	15	4	6.22	4.34	4.68	4.24	1.33	0.37	0.02	0.02	0.28	1.94	3.64	4.70	31.78
Butte county:																
Cherokee	.....	12	4	13.35	9.96	11.70	3.78	2.06	0.73	0.30	0.24	0.54	4.08	7.80	5.77	60.31
Chico	193	a19	5	3.86	3.29	2.73	1.62	0.84	0.37	0.03	0.01	0.27	1.45	2.40	4.04	20.91
Calaveras county:																
Valley Springs	.....	a2	10	4.17	1.66	3.82	1.83	1.79	.....	.....	.....	0.16	1.41	2.50	5.11	22.45
Colusa county:																
Orland	254	11	11	2.12	1.85	2.37	1.52	0.77	0.37	.....	.....	0.18	1.20	2.12	3.55	16.05
Princeton	57	a12	4	2.98	2.21	1.67	1.54	0.55	0.49	0.10	0.12	0.24	1.10	1.64	2.60	15.24
Contra Costa county:																
Brentwood	80	a10	5	2.32	1.53	2.01	1.36	0.36	0.20	.....	.....	0.14	0.75	1.66	2.69	13.02
Del Norte county:																
Fort Ter Wah	150	a2	3	9.97	8.78	8.50	6.07	3.63	0.17	0.66	0.71	3.81	5.64	12.71	11.52	72.17
Eldorado county:																
Georgetown	2,433	a17	8	11.08	7.81	9.15	6.44	2.51	0.75	0.05	T.	0.43	3.47	5.56	10.42	57.67
Shingle Springs	1,427	a21	11	7.72	4.09	5.34	3.20	1.40	0.18	0.20	.....	0.23	1.11	4.26	7.53	35.26
Fresno county:																
Firebaugh	150	13	7	1.78	1.14	1.34	0.98	0.16	0.18	.....	.....	0.07	0.31	1.52	1.28	8.76
Fresno	328	a13	6	1.32	1.17	1.32	1.34	0.36	0.10	T.	T.	0.10	0.57	1.24	1.50	9.02
Humboldt county:																
Fort Gaston	397	a28	1	10.84	7.97	7.55	4.69	1.87	0.82	0.14	0.11	0.85	2.90	7.33	10.37	55.46
Humboldt Light	8	a12	7	5.79	5.62	5.30	2.82	1.24	0.47	0.16	0.06	0.55	1.08	3.79	7.14	34.61
Inyo county:																
Fort Independence	4,598	a12	4	1.22	0.56	0.52	0.21	0.27	0.04	0.11	0.22	0.07	0.32	0.21	2.26	6.01
Kern county:																
Mojave	2,751	13	0	0.73	1.14	0.74	0.23	0.01	0.08	0.06	0.08	0.04	0.24	0.31	1.59	5.25
Sumner	422	a13	10	0.94	0.85	0.58	0.89	0.30	0.09	.....	.....	.....	1.50	3.37	3.98	12.50
Tehachapi	3,964	a13	5	1.40	3.17	1.66	1.62	0.40	0.11	0.01	0.15	0.02	0.53	0.62	1.79	11.68
Lake county:																
Kono Tayee	1,350	a10	9	5.13	3.78	4.17	1.09	0.52	0.52	.....	0.01	0.17	1.03	3.19	1.71	21.32
Lassen county:																
Susanville	4,195	a3	0	4.34	2.95	4.04	1.28	3.02	0.97	0.31	0.15	.....	1.50	3.37	3.98	25.91
Los Angeles county:																
Los Angeles	330	a18	5	4.08	3.74	2.27	1.29	0.31	0.09	0.02	0.10	0.04	0.82	1.71	3.84	18.31
San Fernando	1,066	a12	2	2.11	3.16	3.01	1.75	0.36	0.17	0.02	.....	0.03	0.80	1.54	3.48	16.43
Marin county:																
San Rafael	25	a12	3	9.40	5.37	5.45	3.94	1.19	0.40	T.	.....	0.34	2.30	4.69	6.32	39.40
Mendocino county:																
Camp Wright	1,800	a10	6	8.02	6.50	5.22	1.96	0.64	0.24	0.01	0.02	0.40	1.23	6.83	11.42	43.39
Point Arena	156	14	4	6.30	4.61	5.02	2.87	1.05	0.37	0.03	T.	0.31	1.78	3.20	5.23	30.77
Merced county:																
Merced	171	a18	5	2.19	1.22	1.33	1.22	0.43	0.17	0.01	T.	0.12	0.44	1.40	1.77	10.30
Modoc county:																
Fort Bidwell	4,640	a24	2	4.24	2.52	2.60	1.65	1.42	1.00	0.28	0.19	0.37	1.02	2.16	3.39	20.84
Monterey county:																
Monterey	42	27	0	3.03	2.55	2.80	1.53	0.33	0.15	0.04	0.02	0.08	0.66	1.55	3.54	16.28
Soledad	188	a16	6	2.10	1.61	1.04	0.65	0.25	0.10	T.	T.	0.03	0.41	1.04	1.59	9.42
Napa county:																
Calistoga	331	a17	11	6.76	4.52	4.74	2.68	0.89	0.30	0.01	T.	0.25	2.28	3.48	6.16	32.07
Nevada county:																
Boca	5,531	a19	10	4.25	3.10	2.61	1.28	0.54	0.14	0.18	0.02	0.03	0.52	1.06	3.19	16.92
Nevada city	2,500	22	10	10.93	7.68	8.57	5.15	2.06	0.60	0.04	0.04	0.54	2.25	6.77	12.09	60.72
Placer county:																
Auburn	1,360	a20	11	6.03	4.85	4.81	3.40	1.32	0.42	0.02	0.01	0.33	1.59	3.59	6.18	32.55
Summit	7,017	a20	6	7.77	7.27	7.47	4.84	1.84	0.73	0.39	0.02	0.21	2.23	3.37	7.51	43.65
Plumas county:																
Mumford Hill	4,900	5	8	13.08	12.33	10.71	7.56	2.96	0.56	0.14	0.32	0.69	2.23	4.10	11.12	65.80
Sacramento county:																
Folsom	182	a19	6	4.33	3.43	3.30	2.33	0.99	0.25	0.02	T.	0.25	1.23	2.58	4.62	23.33
Sacramento	64	a41	0	3.78	2.80	2.73	1.85	0.74	0.12	0.02	.....	0.12	0.79	2.14	4.71	19.80
San Benito county:																
Hollister	284	a16	10	2.54	1.74	1.86	1.13	0.41	0.16	0.02	T.	0.09	0.66	1.42	1.87	11.90
San Bernardino county:																
Riverside	850	a9	10	1.62	1.94	2.14	1.07	0.31	0.07	.....	0.33	0.02	0.37	0.83	2.04	10.74
San Bernardino	950	19	8	3.52	3.11	2.51	1.66	0.49	0.07	0.03	0.10	0.05	0.52	1.70	3.38	17.16
San Diego county:																
Fort Yuma	276	a26	7	0.31	0.39	0.14	0.07	.....	.....	0.33	0.66	0.58	0.09	0.30	0.29	3.16
Indio	20	a12	8	0.65	0.46	0.18	0.06	0.04	.....	.....	0.08	T	0.07	0.27	0.74	2.55
San Diego	93	a40	11	1.66	2.00	1.29	0.72	0.33	0.07	0.06	0.14	0.07	0.34	1.05	2.13	9.86
San Francisco county:																
San Francisco	60	41	0	5.10	3.60	3.26	1.93	0.67	0.15	0.02	0.02	0.16	0.98	2.87	5.32	24.08
San Joaquin county:																
Lathrop	25	a13	0	2.07	1.68	1.61	1.51	0.57	0.11	.....	.....	0.13	0.52	1.40	2.28	11.88
Stockton	20	a23	11	2.46	2.26	1.85	1.38	0.56	0.12	0.01	.....	0.07	0.48	1.25	2.74	13.18
San Luis Obispo county:																
San Luis Obispo	270	a20	4	4.64	3.78	3.02	1.97	0.32	0.12	T.	.....	0.12	1.05	2.01	4.50	21.53
San Mateo county:																
Pilarcitos	620	20	0	11.02	8.77	7.86	4.03	1.79	0.49	0.03	T.	0.39	2.01	6.09	12.35	54.83
San Mateo	30	a16	10	4.14	2.80	2.99	1.91	0.52	0.20	T.	T.	0.17	1.16	2.18	3.60	19.67
Santa Barbara county:																
Santa Barbara	20	a23	1	3.90	3.62	2.18	1.44	0.33	0.11	T.	T.	0.04	0.80	1.75	4.02	18.19
Santa Clara county:																
Mount Hamilton	4,440	a9	7	4.48	4.50	5.38	3.93	1.74	0.66	T.	0.02	0.24	1.75	1.92	9.80	34.42
San Jose	94	a16	6	2.75	2.25	2.61	1.43	0.47	0.18	T.	.....	0.13	0.86	1.42	2.42	14.52
Santa Cruz county:																
Santa Cruz	25	a16	5	5.37	2.88	3.58	2.49	0.67	0.30	0.01	0.01	0.32	1.95	3.20	5.03	25.81
Shasta county:																
Fort Crook	3,300	a10	3	3.16	3.78	4.00	1.60	1.25	0.72	0.24	0.01	0.53	1.00	2.82	5.39	24.50
Redding	556	a15	7	6.34	4.29	4.82	3.35	1.62	0.54	0.04	0.06	0.33	2.60	3.68	6.93	34.60
Siskiyon county:																
Scott Valley	2,570	30	7	5.37	3.14	2.58	1.84	1.13	0.57	0.51	0.17	0.40	1.26	3.07	5.14	25.18
Yreka	2,635	18	7	3.25	2.16	1.44	1.08	1.09	0.58	0.46	0.12	0.31	1.30	1.86	2.09	16.34
Solano county:																
Benicia Barracks	64	a35	6	3.26	2.28	2.48	1.47	0.53	0.11	0.01	0.01	0.09	0.72	1.87	3.44	16.27
Vacaville	175	a11	10	5.31	3.32	3.94	2.79	1.56	0.19	.....	.....	0.24	1.63	3.26	7.40	29.04
Sonoma county:																
Petaluma	10	a18	0	5.10	3.57	3.19	2.02	0.75	0.30	T.	T.	0.19	1.42	2.50	4.65	23.75

a Record broken.

MEAN MONTHLY AND ANNUAL RAINFALL AT STATIONS IN CALIFORNIA—Continued.

LOCALITIES.	Altitude.	Length of record.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Stanislaus county:	*Feet.*	*Yrs. Mos.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
La Grange	250	a20 11	2.79	2.63	2.56	1.55	0.60	0.05	T.	T.	0.28	0.88	2.28	2.99	16.61
Turlock	106	11 5	1.40	1.17	1.28	1.42	0.47	0.17	T.	.....	0.19	0.63	1.80	1.75	10.28
Sutter county:															
Nicolaus	42	a11 8	3.36	2.44	2.62	2.76	0.54	0.40	T.	T.	0.26	0.75	2.00	3.42	18.55
Tehama county:															
Red Bluff	342	18 6	4.37	3.41	2.93	1.98	0.94	0.45	0.11	0.04	0.40	1.58	3.13	4.45	23.79
Tehama	220	a18 7	2.75	2.10	2.31	1.24	0.56	0.26	0.05	0.04	0.15	1.24	1.87	3.23	15.80
Trinity county:															
Weaverville	2,162	12 8	7.64	6.01	3.83	3.01	1.44	0.70	0.10	0.45	0.49	2.13	6.14	6.37	38.31
Tulare county:															
Goshen	286	a13 6	1.12	1.18	1.12	1.13	0.32	0.07	.....	.....	0.10	0.63	0.80	1.50	7.97
Tulare	289	16 3	1.48	1.07	0.96	0.96	0.38	0.08	0.05	.....	0.02	0.40	0.52	1.08	7.00
Ventura county:															
San Buena Ventura	50	a11 0	3.65	2.83	1.98	1.61	0.15	0.03	0.17	0.01	0.13	0.31	3.28	3.72	17.87
Yolo county:															
Davisville	51	a18 10	3.30	2.17	2.21	1.58	0.58	0.14	0.01	T.	0.12	0.87	1.78	3.98	16.74
Knight Landing	35	a12 10	2.84	2.35	2.52	2.09	0.80	0.30	T.	T.	0.19	0.82	1.99	3.30	17.20
Yuba county:															
Marysville	67	a19 4	3.40	2.45	2.40	1.55	0.75	0.31	0.01	T.	0.18	1.16	1.99	3.89	18.09
Smartville	800	a9 9	7.11	5.70	4.48	2.85	0.79	0.40	0.04	.....	0.10	1.35	3.35	4.51	30.68

a Record broken.

STATE INVESTIGATIONS.

A careful examination of the water supply in the Sacramento and San Joaquin basins was begun in June, 1878, by the state engineering department of California. Surveys were made for the purpose of obtaining facts bearing upon the solution of problems relating to drainage, river improvement, mining detritus, and irrigation, this work being carried on through a number of years. The state engineer published a number of annual reports, giving in detail the operations of his department, and also a preliminary volume of results. (*a*) In the following pages reference will be made frequently to this collection of statistics. He also prepared two volumes, one entitled "Irrigation Development" (*b*), the other "Irrigation in Southern California".

As one of the results of the work of the state engineering department there are now available computations of the monthly discharge of many of the more important rivers and creeks whose waters are employed in irrigation, these data covering the period from November, 1878, to October, 1884. Since that time few, if any, measurements have been made other than observations of the height of water from day to day on the railroad bridges of the Southern Pacific railway.

IRRIGATION DISTRICTS.

The early growth and development of irrigation in California have been similar to that in other parts of the arid region in the general lack of system or broad plans. Small ditches have been built by farmers, acting singly or in concert, and these have been enlarged and extended from year to year. Corporations and wealthy land owners also have sought to increase the value of vast estates by constructing canals, and, in short, each owner or group of owners has consulted only the immediate advantages to be obtained. Added to the complications which have necessarily arisen has been the question of riparian rights, especially troublesome and vexatious as the use of water became more and more valuable. Relief was sought by the passage, in 1887, of what was known as the District law, creating irrigation districts, these being corporations of a public character, possessing powers sufficient to overcome the obstacles interposed by conflicting interests, and empowered each within its own borders to construct the best possible system for conserving and distributing the waters. The irrigation district is in some respects similar to a municipal organization, but it has a single aim, that of delivering water in sufficient quantities to all of the lands embraced within its borders, and for this ultimate end all of its resources and the efforts of its officers are to be bent.

The law provides for the creation of districts by petition addressed to the board of supervisors of the county and by ballot of the electors of the district sought to be established. The board of supervisors is compelled to set a day for the hearing of the petition upon notice given, and if the petition establishes the allegations the election is ordered. Provision is made for the defining of boundaries, election of officers, and other requisites. After a feasible system has been determined upon by a competent engineer the board of directors may submit to the people of the district the question as to whether all of the lands within the district shall be bonded in order to raise funds to construct the proposed works, purchase rights of way, or other property necessary for the completion of the required system of irrigation. If bonds are voted these are to be disposed of at not less than 90 per cent of their face value. The district officers are given powers sufficient to push forward the work of construction and to pay

a Physical Data and Statistics of California. Tables and memoranda of data collected and compiled by the state engineering department of California. William Ham. Hall, state engineer. Sacramento. 1880.

b Giving the history, customs, laws, and administrative systems relating to irrigation, water courses, and waters in France, Italy, and Spain.

for it from time to time by the sale of the requisite number of bonds, safeguards being provided for the protection of the district against loss or misappropriation of its funds.

To aid in the sale of district bonds a somewhat novel provision of law has been put into successful operation. The superior courts of each county are empowered to examine into the legality and technical completeness of the acts of the district officers as far as these concern the bonds, and to issue a decree confirming all proceedings leading up to the organization of the district and the issuance of its bonds. This act of confirmation is intended as a safeguard, and one which shall act as an inducement to investors to purchase this class of securities. The only question which should then arise in the mind of the possible purchaser should be as to whether the real estate offered as security was of sufficient value.

In the five years following the passage of this act upward of 40 irrigation districts have been formed or seriously proposed, and the greater number of these have completed their organization and offered bonds for sale. There has been considerable difficulty in disposing of these bonds for cash for various reasons, many of these growing out of the novelty of the matter. At first there was a long struggle in the court before the constitutionality of the act and its amendments was settled beyond question. The main point being triumphantly carried, there have been many details requiring exact interpretation and definition by legal decision. Meanwhile, in the practical operations of many of the districts, troubles and unforeseen contingencies have arisen which have tended to render capitalists unusually cautious and even timid. The management of affairs of this kind, although in theory not novel, has in operation developed peculiar features. Apparently in each community it should be easy to select men of intelligence to conduct the affairs of a municipal corporation, from which in many respects the irrigation district differs little, but unfortunately the election of district officials has not in many cases brought the best men to the front, and the consequence of intrusting large affairs in the hands of unskilled men has been too apparent.

One feature of the typical irrigation district in which it differs most widely from other public associations is the fact that it starts at once by attempting to raise an enormous sum of money and to expend it toward the completion of a gigantic project. Little opportunity is given for preliminary work and the acquisition of experience so necessary in all lines of business; in other words, there is not the slow growth often essential for the success of great enterprises. Men are suddenly called upon to supervise the disbursement of hundreds of thousands or even millions of dollars and to take in charge the business of a great corporation, their only preparation being that of a small farmer or professional man in a country town. There are none of the minor rules or precedents so essential to the conduct of the innumerable details of a great business, and the personal judgment of each officer must be constantly exercised. It has thus resulted that boards of directors have been accused of extravagance, incompetence, and failure to select the best projects, and as a result investors have feared to purchase bonds of certain districts through doubts as to whether the money would be applied in such manner as to increase the value of the land. It is of course assumed that the land and property of the district in its original condition is ample security for the bonds, but as a matter of fact the argument is constantly used that the money obtained through sale of the bonds will be used in such manner as to increase this security. (*a*)

a The accompanying table gives in alphabetical order the names of the irrigation districts whose organization has been completed in whole or in part, together with a few of the principal facts concerning their area and the amount of bonds voted and sold:

IRRIGATION DISTRICTS, AREA, AND BONDS VOTED AND SOLD.*

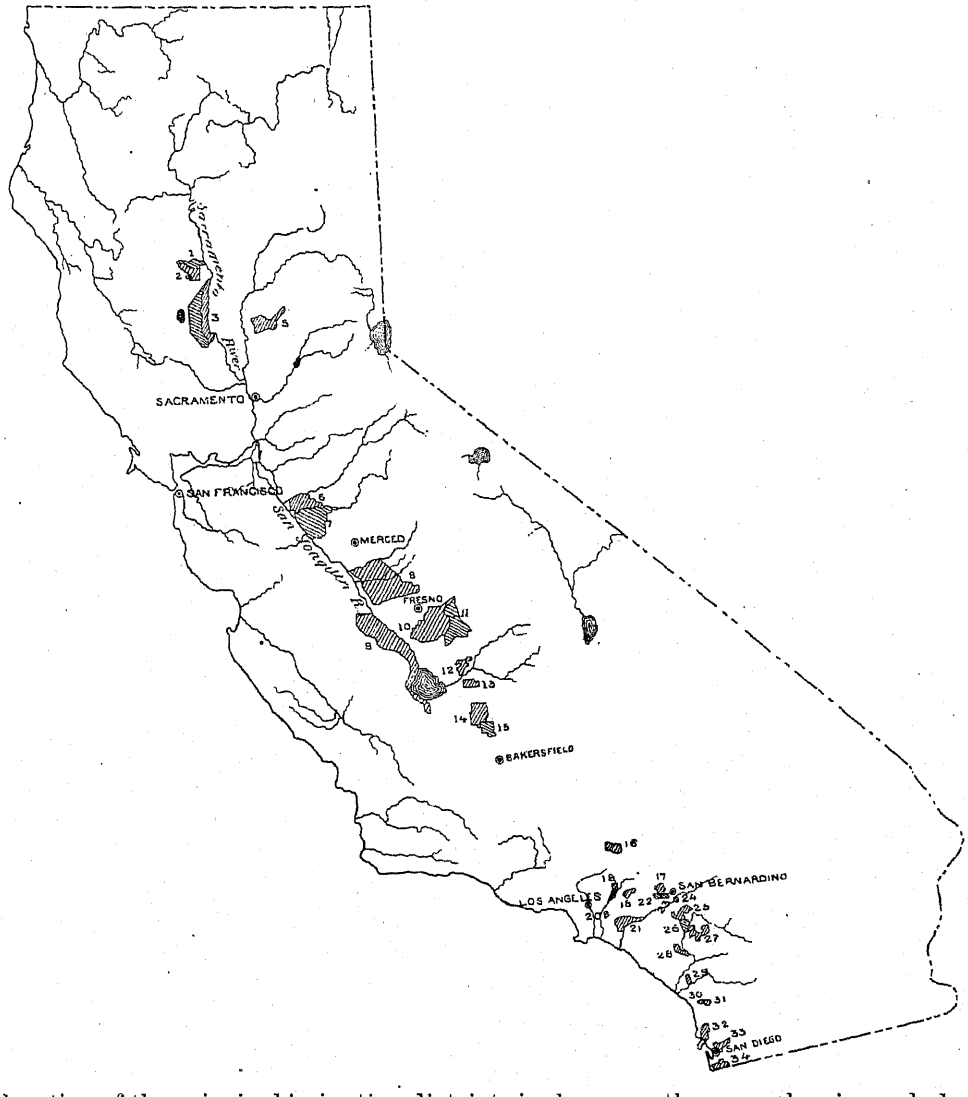
IRRIGATION DISTRICTS.	County.	Area in acres.	Bonds voted.	Bonds disposed of.	IRRIGATION DISTRICTS.	County.	Area in acres.	Bonds voted.	Bonds disposed of.
Alessandro	San Bernardino	25,500	$765,000	$765,000	Murrieta	San Diego	15,600	.....	.....
Alta	Fresno and Tulare	129,927	675,000	528,000	Olive	San Bernardino	1,280	.....	.....
Anaheim	Orange	32,500	600,000	300,000	Orland South Side	Glenn	26,000	$100,000	.....
Big Rock Creek	Los Angeles	30,000	400,000	150,000	Otay	San Diego	50,000	.....	.....
Brown Valley	Yuba	44,000	140,000	140,000	Palmdale	Los Angeles	50,000	175,000	.....
Central	Glenn and Colusa	156,550	750,000	574,000	Perris	San Diego	13,422	442,000	$314,500
Citrus Belt	San Bernardino	12,000	800,000	.....	Pomona Orange Belt	Los Angeles	4,000	200,000	.....
Colusa	Glenn and Colusa	100,000	600,000	.....	Poso	Kern	40,000	500,000	.....
Dehesia	Los Angeles	.....	.....	.....	Rialto	San Bernardino	7,200	500,000	500,000
East Riverside	San Bernardino	3,600	250,000	100,000	Riverside Heights	do	3,500	.....	.....
Elsinore	San Diego	11,300	452,000	.....	San Diego	San Diego	.....	.....	.....
Escondido	do	12,814	450,000	.....	San Jacinto and Pleasant Valley	do	18,000	350,000	350,000
Fallbrook	do	12,000	400,000	.....	San Marcos	do	10,000	.....	.....
Glendora	Los Angeles	3,000	170,000	.....	Santa Fe	Los Angeles	.....	.....	.....
Grapeland	San Bernardino	10,787	200,000	35,700	Santa Gertrudes	do	2,600	.....	.....
Happy Valley	Shasta	.....	.....	.....	Selma	Fresno and Tulare	271,000	.....	.....
Huron	Fresno	24,320	.....	.....	Spring Valley	San Diego	22,000	.....	.....
Jamacha	San Diego	22,000	700,000	165,000	Sunset	Fresno and Tulare	308,000	2,000,000	320,000
Kern and Tulare	Kern and Tulare	84,335	700,000	.....	Tipton	Tulare	17,040	50,000	.....
Kraft	Tehama and Glenn	13,500	80,000	.....	Tulare	do	40,520	500,000	469,000
Linda Vista	San Diego	42,000	1,000,000	160,000	Tule River	do	20,000	90,000	.....
Little Rock Creek	Los Angeles	2,000	.....	.....	Turlock	Stanislaus and Merced	176,210	1,200,000	430,000
Los Angeles	do	.....	.....	.....	Vineland	Los Angeles	4,000	62,000	54,000
Madera	Fresno	330,000	850,000	.....	White River	Tulare	.....	.....	.....
Manzana	Los Angeles	2,400	.....	.....					
Modesto	Stanislaus	80,564	800,000	370,000					

* This table has been revised according to reports from irrigation districts published in "The Orange Belt", January, 1893, page 81.

In the five years following the passage of the District act it appears from the statements of district officials that only 2 districts have actually constructed and completed works for irrigation, and these 2 have been among those voting and selling the smallest amount of bonds. These are Brown Valley district, in Yuba county, and Vineland district, in Los Angeles county. The other districts which in this time have obtained water for irrigation, although not completing the works, are Alessandro, Alta, Citrus Belt, Perris, Rialto, and Tulare. Some of these, notably Alta district, have, however, purchased canals and means of supply already constructed. (*a*)

Several proposed districts have given up their organization or the acts of the directors have been declared illegal by court decision; in others projects have been attempted apparently too great for successful completion; but as a rule the districts have been as well managed as other corporations conducted by untried officials. Among the charges brought against district directors has been that of evading the spirit of that section of the law preventing the disposal of bonds at less than 90 per cent of their face value. It is asserted that in certain districts the evasion has been accomplished by trading bonds for water rights or work to which fictitious value has been given, two or three times the actual value of a canal or water right being paid in this manner. Such matters, however, are mostly of local concern and can be guarded against by the public interest and resulting criticism.

MAP SHOWING THE RELATIVE LOCATION OF IRRIGATION DISTRICTS OF CALIFORNIA.



The relative location of the principal irrigation districts is shown on the map, the size and shape of each district

a Mr. L. M. Holt, secretary of the convention of irrigation districts held in Sacramento January 6, 1893, stated publicly that out of 38 irrigation districts then in existence 19 reported having voted bonds to the extent of $11,834,000. Out of this, bonds amounting to $2,622,000 had been sold for cash and $2,995,200 had been traded for water rights, making in all $5,617,200 of bonds disposed of, a little less than one-half the amount voted by the 19 districts. Thirteen other districts had voted bonds amounting to $4,942,000, none of these being sold. These 32 districts which had voted bonds contained 1,830,769 acres, and the bonds averaged $9.16 per acre. The 38 districts then in existence contained 2,149.069 acres. Out of this number 28 districts, containing 1,515,594 acres, had an assessed valuation of $39,982,849, the assessed valuation being thus $26.38 per acre.

being indicated by the cross hatched areas. Opposite each of these is a number which refers to the following list, giving the name of the district, the county in which it is located, and the area in acres:

IRRIGATION DISTRICTS.	Counties.	Area in acres.	IRRIGATION DISTRICTS.	Counties.	Area in acres.
1. Kraft	Tehama and Glenn(a)	13,500	18. Pomona Orange Belt	Los Angeles	4,000
2. Orland South Side	Glenn	26,000	19. Vineland	do	4,000
3. Colusa	Glenn and Colusa	100,000	20. Santa Gertrudes	do	2,600
4. Central	do	156,550	21. Anaheim	Orange	32,500
5. Brown Valley	Yuba	44,000	22. Citrus Belt	San Bernardino	12,000
6. Modesto	Stanislaus	80,564	23. Rialto	do	7,200
7. Turlock	Stanislaus and Merced	176,210	24. East Riverside	do	3,600
8. Madera	Fresno	330,000	25. Alessandro	do	25,500
9. Sunset	Fresno and Tulare	308,000	26. Perris	San Diego	13,422
10. Selma	do	271,000	27. San Jacinto and Pleasant Valley	do	18,000
11. Alta	do	129,927	28. Elsinore	do	11,300
12. Tulare	Tulare	40,520	29. Fallbrook	do	12,000
13. Tipton	do	17,040	30. San Marcos	do	10,000
14. Kern and Tulare	Kern and Tulare	84,335	31. Escondido	do	12,814
15. Poso	Kern	40,000	32. Linda Vista	do	42,000
16. Big Rock Creek	Los Angeles	30,000	33. Jamacha	do	22,000
17. Grapeland	San Bernardino	10,787	34. Otay	do	50,000

a Glenn county created since 1890, taken from the northern part of Colusa county.

FRUIT CULTURE.

The wonderful success attained by the cultivation of fruit trees and vines by means of irrigation upon lands otherwise valueless and the great results from the reclamation of such lands, increasing them in value a hundred fold or more, have drawn public attention to irrigation more forcibly than any other results. It must not be supposed that horticulture in California by any means depends upon irrigation, for in many of the counties widely known for the production of excellent fruit the artificial application of water is almost unknown, but on the other hand there are counties now wealthy and prosperous in which the destruction of the canal systems and other means of distributing water would bring about ruin and desolation. It is from a consideration of these localities that the general impression is sometimes given that the fruit producing districts of the state, outside of the orchards and vineyards, are arid and forbidding.

Local details are given under the county descriptions on the following pages. As regards acreage of trees or vines, raisins lead, followed at a considerable distance by the acreage of orange trees, peaches, and prunes. Experiment and intelligent observation in each county, aided by discussions at horticultural conventions, are rapidly bringing to light the varieties best suited for the different climates and soils and the best methods of cultivation and protection from insect and other pests. To the majority of orchardists the subject of irrigation, although as fundamental as that of supplying water to their families, is a matter of little concern in comparison with that of protecting their trees and vines from blight and disease, but it is generally recognized that the extension of area of productive lands will come largely through this means.

CONDITION OF IRRIGATION IN EACH COUNTY.

In the table on the following page, which contains the name of each county in the state, are given the facts concerning the number of irrigators, the area irrigated, and the average size of irrigated farms in the census year. Among these 53 counties there are included 10 in which no irrigated farms were reported. These are Alameda, Contra Costa, Del Norte, Marin, Napa, San Luis Obispo, San Mateo, Solano, Sonoma, and Sutter, counties located mainly along the coast or adjoining the bay of San Francisco. As previously stated, irrigation has not been practiced to any notable extent in these 10 counties, because fruits and vegetables, as well as field crops, are grown successfully without the artificial application of water. There may be a few exceptional cases where small orchards and vineyards are occasionally watered by means of machinery, driven by windmills or other devices, but these can hardly be classed as irrigation.

NUMBER OF IRRIGATORS, AREA IRRIGATED, FARMS, AND CROPS, IN EACH COUNTY IN CALIFORNIA IN 1889.

COUNTIES.	Number of irrigators.	Area irrigated in acres.	Average size of irrigated farms in acres.	OWNERS OF FARMS. (a)		IRRIGATORS.		Area of county in acres.	FARM AREA.		Cereals. (Acres.)	Alfalfa. (Acres.)	AREA IRRIGATED.		
				Total number.	Per cent of population.	Per cent of farm owners.	Per cent of population.		Acres.	Per cent improved.			Per cent of area of county.	Per cent of total farm area.	Per cent of land owned by irrigators.
Total	13,732	1,004,233	73	52,894	4.38	25.96	1.14	99,827,200	21,427,293	57.04	3,812,751	245,915	1.01	4.69	17.86
Alameda				1,822	1.94			450,560	298,846	74.58	45,782	54			
Alpine	31	2,680	86	31	4.65	100.00	4.65	483,200	9,780	45.50	459	120	0.55	27.40	27.40
Amador	221	3,136	14	700	6.78	31.57	2.14	363,520	208,172	34.19	9,058	2,467	0.86	1.51	5.06
Butte	372	5,478	15	1,186	6.61	31.37	2.07	1,100,800	504,538	71.41	170,595	18,761	0.50	1.09	4.05
Calaveras	57	582	10	483	5.44	11.80	0.64	627,200	148,560	47.20	3,293	522	0.09	0.39	4.92
Colusa	93	7,525	81	1,028	7.02	9.05	0.64	1,568,000	947,582	81.51	274,040	3,854	0.48	0.79	7.41
Contra Costa				1,069	7.91			518,400	296,093	87.89	59,176	110			
Del Norte				112	4.32			960,000	33,491	45.04	579	2			
Eldorado	425	4,318	10	744	8.06	57.12	4.60	1,145,600	177,302	29.10	7,325	416	0.38	2.44	4.57
Fresno	1,400	105,665	75	2,350	7.34	59.57	4.37	5,126,400	1,373,339	69.28	492,933	17,401	2.06	7.69	15.48
Humboldt	18	83	5	1,232	5.25	1.46	0.08	2,284,800	547,792	69.49	10,097	626		0.02	0.46
Inyo	209	46,242	221	225	6.35	92.89	5.90	6,412,800	68,256	67.75	4,211	6,664	0.72	67.75	69.63
Kern	370	154,549	418	730	7.44	50.68	3.77	5,101,440	712,130	19.61	21,127	36,642	3.03	21.70	16.13
Lake	68	958	14	664	9.35	10.24	0.96	720,000	203,062	51.04	10,757	3,971	0.13	0.47	3.75
Lassen	293	55,819	190	507	11.96	57.79	6.91	3,129,600	242,361	41.65	9,828	2,214	1.78	23.03	28.81
Los Angeles	1,843	70,164	38	3,828	3.77	48.15	1.82	2,560,000	759,933	57.48	143,696	10,181	2.74	9.23	21.70
Marin				422	3.23			377,600	257,717	74.22	1,768				
Mariposa	90	730	8	384	10.14	23.44	2.38	1,004,800	144,889	25.55	3,309	3,045	0.07	0.50	3.28
Mendocino	19	77	4	932	5.29	2.04	0.11	2,364,160	572,875	27.81	11,089	1,042		0.01	0.66
Merced	231	32,309	140	798	9.87	28.95	2.86	1,452,800	878,958	71.29	294,357	8,124	2.22	3.68	13.38
Modoc	402	80,110	199.	613	12.29	65.58	8.06	2,686,720	251,909	62.46	7,627	1,080	2.98	31.80	45.07
Mono	94	43,523	463	103	5.14	91.26	4.70	2,165,760	79,523	64.10	229	1,695	2.01	54.73	54.74
Monterey	21	891	42	1,673	8.98	1.26	0.11	2,209,280	1,045,212	45.86	195,529	164	0.04	0.09	3.13
Napa				1,204	7.34			544,000	288,747	51.02	23,688	686			
Nevada	318	3,990	13	601	3.46	52.91	1.83	640,000	117,877	28.05	259	511	0.62	3.38	5.72
Orange	1,039	31,816	31	1,406	10.35	73.90	7.65	473,600	265,240	72.60	14,596	3,386	6.72	12.00	21.16
Placer	431	7,480	17	1,023	6.77	42.13	2.85	954,880	278,706	50.24	29,485	13,561	0.78	2.68	9.51
Plumas	186	34,196	184	210	4.26	88.57	3.77	1,740,800	125,957	83.21	4,589	377	1.96	27.15	29.37
Sacramento	146	1,718	12	1,285	3.19	11.36	0.36	646,400	439,450	77.73	114,130	8,787	0.27	0.39	6.22
San Benito	77	905	12	740	11.54	10.41	1.20	640,000	484,361	55.80	48,268	553	0.14	0.19	1.99
San Bernardino	1,521	37,907	25	1,924	7.55	79.05	5.97	13,440,000	307,845	41.09	21,838	6,555	0.28	12.31	17.65
San Diego	524	10,193	19	2,474	7.07	21.18	1.50	9,310,720	887,796	26.91	47,138	4,277	0.11	1.15	3.77
San Francisco	52	479	9	145	0.05	35.86	0.02	32,000	3,469	89.45	15	4	1.50	13.81	49.43
San Joaquin	84	2,254	27	1,380	4.82	6.09	0.29	883,200	571,271	97.99	306,567	4,097	0.26	0.39	4.61
San Luis Obispo				1,788	11.12			2,178,560	1,084,398	25.19	52,597	242			
San Mateo				602	5.97			294,400	168,033	69.97	5,299	34			
Santa Barbara	47	396	8	853	5.41	5.51	0.30	1,523,200	521,270	45.50	33,147	1,938	0.03	0.08	1.01
Santa Clara	184	6,686	36	2,177	4.53	8.45	0.38	883,200	445,535	63.15	48,228	429	0.76	1.50	21.82
Santa Cruz	23	374	16	916	4.75	2.51	0.12	272,000	126,021	60.41	12,521	1,221	0.14	0.30	7.71
Shasta	475	13,662	29	950	7.83	50.00	3.91	2,534,400	281,370	31.47	12,936	1,675	0.54	4.86	9.86
Sierra	86	14,499	169	107	2.12	80.37	1.70	576,000	44,595	49.43	3,115	141	2.52	32.51	37.14
Siskiyou	302	31,567	105	517	4.25	58.41	2.48	3,635,200	228,993	39.73	12,807	7,631	0.87	13.79	22.72
Solano				1,213	5.79			614,400	431,910	84.84	107,791	103			
Sonoma				2,886	8.82			990,720	707,053	43.57	28,806	2,827			
Stanislaus	42	3,370	80	713	7.10	5.89	0.42	951,040	741,468	88.21	344,803	3,408	0.35	0.45	8.64
Sutter				642	11.74			377,600	257,956	87.61	92,769	3,366			
Tehama	116	7,169	62	781	7.88	14.85	1.17	1,912,320	864,666	45.76	97,390	5,515	0.37	0.83	2.80
Trinity	140	3,186	23	220	5.92	63.64	3.76	1,920,000	67,757	18.63	1,286	735	0.17	4.70	11.87
Tulare	1,287	168,455	131	2,193	8.92	58.69	5.24	3,578,880	928,677	63.33	319,405	32,426	4.71	18.14	34.03
Tuolumne	100	1,285	13	219	3.60	45.66	1.64	1,310,720	68,128	34.48	3,154	16	0.10	1.89	4.52
Ventura	134	3,347	25	764	7.59	17.54	1.33	1,076,480	324,529	42.32	66,223	4,461	0.31	1.03	7.90
Yolo	30	1,062	41	866	6.83	4.50	0.31	622,080	375,664	82.23	144,499	12,553	0.26	0.43	11.39
Yuba	122	2,852	23	459	4.76	26.58	1.27	456,960	226,231	73.34	38,538	5,245	0.62	1.26	6.62

a Includes owned and hired farms, assuming one farmer to each.

ALAMEDA COUNTY includes a large part of the area immediately west of the bay of San Francisco, containing within its limits the city of Oakland. It is noted for the large quantities of fruit produced, many of its wheat fields having been cut up and planted in orchards and vineyards. Besides the arable areas along the shore, there are a number of inland valleys in which agriculture and fruit raising are carried on. Irrigation is not practiced to any considerable extent, and the few gardens or nurseries to which water is occasionally applied were not considered of sufficient area to justify enumeration. One irrigating ditch known as the Washington and Murray was constructed about 1875, taking water from the west side of Alameda creek and conducting it for 3 or 4 miles. The control of this ditch has been acquired by the Spring Valley Water Company of San Francisco. Some of the farmers under the ditch state that irrigation was of doubtful benefit, at least for the crops they were raising.

ALPINE COUNTY includes a portion of the mountain area south of Lake Tahoe and adjoining Douglas county, Nevada. Owing to the altitude and lack of communication the principal industry is stock raising. In some of the valleys dairy products assume importance, these being shipped by way of Carson, Nev. There are a number of small ditches taking water from the upper tributaries of the Carson river and carrying it to the meadow lands

of Hope, Faith, and Charity, Diamond, Hermit, and Pleasant valleys. There are numerous localities in this county where water could be held for use on the fertile lands of Nevada, and probably a number of these would be utilized for storage purposes were it not that the catchment basin of the Carson river lies in two states differing in laws and customs.

AMADOR COUNTY occupies a narrow belt of country west of Alpine county, extending from the summits of the Sierra Nevadas westward to the Sacramento valley, between the Mokelumne and the south fork of the Cosumnes. The eastern part of the county is exceedingly rugged, while the western portion contains a number of valleys in which agriculture is carried on. The principal industry is mining, and nearly all of the ditches have been built for use in connection with mines and mills, although some of the water is now employed for irrigation. The cereals are seldom watered, the farmers stating that crops are successful by dependence upon the rainfall, and that the extra labor and expense of applying water would hardly be justified by the probable increased returns. In fact, irrigation can not be considered as essential in this county, although there are localities where it is employed to profit, as shown by one statement that land planted in grain not irrigated would yield from $10 to $12 per acre, but when irrigated and covered with alfalfa would yield $30 per acre, or in fruits from $50 to $100 per acre.

The principal fruits raised are peaches, apricots, apples, prunes, and pears, mainly in Lone and Jackson valleys and adjacent localities. The orchards are cultivated largely without irrigation, although water is used where it can be obtained at reasonable cost. Water is usually sold by the miner's inch per day, the charge varying from 5 cents up to 25 cents per day. In the first instance it was considered that the irrigation season lasted for 130 days, so that the charge per miner's inch for the season was $6.50. In the other instance water was only used 4 days during the year. In all of these estimates of quantity the miner's inch is so variable that the quantity actually delivered may in one case be two or three times that in another.

BUTTE COUNTY is in the northern part of the Sacramento valley, being on the east of the river of that name and extending easterly up the slopes of the Sierras. The western part of the county includes a large portion of the broad valley land between the Feather and Sacramento rivers, this area being utilized largely for the production of cereals and other field crops. Near and among the foothills the soil and climate have been found to be exceptionally favorable for fruit culture, and much of the rolling land to which water can be conducted is being set out to orchards and vineyards. The principal locality in which irrigation is conducted is in the vicinity of Oroville, where a number of colonies depending almost entirely on fruit culture have been started. The water supply of the county as a whole is large, although during summer most of the smaller streams become dry. From about 1855 to 1860 and during later years large and expensive systems of ditches and flumes were constructed for the purpose of bringing water, mainly from the upper tributaries of Feather river, to the gravel or placer mines among the foothills. With the decline of hydraulic mining these ditches would have become almost useless were it not for the growth of the fruit industry.

Irrigation is not required for wheat and other of the cereals, excepting perhaps Indian corn, but in most localities it is indispensable for orchards, vineyards, and alfalfa. Some of the orchardists claim that fruit not grown by irrigation, but produced in localities where the soil is deep, somewhat moist and well cultivated, is better in that it shrinks less in drying and can be transported with less loss. Land among the foothills without water is worth from $10 or under up to $30 per acre, but with water is valued at $100 per acre and upward. Attempts have been made to obtain flowing wells, but with little success. At Oroville a well was drilled to the depth of 800 feet at a cost of $2,000 or over. It flows at the rate of only 4 gallons a minute. The water contains a perceptible amount of mineral matter commonly known as soda, and there is also a small quantity of gas issuing from the well. The owner states that if the well were properly cased the supply would probably be increased. About 4 miles north of Chico a well has been drilled to the depth of 686 feet without obtaining artesian water.

The Thermalito canal has resulted from the utilization of four ditches formerly used for mining purposes, and known as the West, or Powers, Flea Valley, Miocene, and Mineral Slide, or Snow, ditches. It obtains water from the west branch of the north fork of Feather river, carrying it out on the west side to the vicinity of Oroville. The principal head dam is about 25 miles north of Oroville, this being designed for permanent use. The total length of the main ditch is 33 miles, the average width from 5 to 8 feet, and the original cost was over $500,000. The earliest of the ditches was begun in 1852. There are on the line of the canal 800 feet of tunnel, 4 miles of wooden flumes, and 3 miles of 22-inch iron pipe. Water is sold usually under annual contracts at $2.50 per acre for orchards and $5 per acre for alfalfa and vegetables. It is computed that the water duty is at the rate of 1 miner's inch for 5 acres of orchard or 2.5 acres of alfalfa.

The canal of the Palermo Land and Water Company takes water from the south branch of Feather river, the head being about 1.5 miles above the town of Enterprise. The canal is located on the south side of Feather river, and continues in a southwesterly direction for 22 miles from the head to Oroville, then turning southerly toward Palermo. The total length of the main ditch is about 25 miles, the average width 9 feet, and the total cost was $200,000. Along the line of the canal are nearly 4 miles of flumes, 72 inches wide and 24 inches high. There are five branch ditches, with a capacity, respectively, of 12, 8, 4, 5, and 6 second-feet. Water is measured under a 6-inch pressure, and sold at the rate of 10 cents per miner's inch for 24 hours, or $5 per second-foot for the same time.

The ditch owned by the South Feather Water and Union Mining Company takes water from Lost creek, a branch of the south fork of Feather river, the head being about 2 miles west of the town of Strawberry Valley. The ditch is built on the south side of the river, the water flowing in a general westerly direction. The total length of the main ditch is 25 miles and the average width 8 feet. From the head down to Forbestown, a distance of 18 miles, the ditch, 10 feet wide on top and 6 feet wide on bottom, is built along the steep mountain side through a very rough country. There are nearly 3 miles of flumes and 2 tunnels. Water, as in the case of many of the other companies, is sold at the rate of 10 cents per miner's inch per 24 hours, and is used mainly for fruit and vegetables. This ditch system was originally built for mining, but since the exhaustion of the shallow deposits among the foothills and the suppression of the large hydraulic mines the water has gradually been utilized for irrigation. The irrigating season extends usually from about the middle of May to the middle of September.

The Cherokee ditch, belonging to the Spring Valley Gold Company, takes water from Butte creek near the northern edge of the county. The total length of the ditch is about 40 miles, the average width 5.5 feet on bottom and 8 feet on top, and the cost was about $200,000. In the course of the ditch there are about 2 miles of flume and 2.5 miles of 36-inch iron pipe, the latter carrying water across the west branch of Feather river under a nearly vertical pressure of about 1,000 feet. This ditch has been used exclusively for hydraulic mining, but this being stopped by the operations of law it is proposed to utilize the water for irrigation.

CALAVERAS COUNTY is south of Amador, and, like it, extends from the summits of the Sierra Nevadas down the slopes to the San Joaquin valley. Mining has always been the principal industry, and upon this agriculture has been dependent largely for its markets. Nearly all the farmers are interested to a greater or less extent in stock raising, and many of the cereals are produced for hay. Irrigation, although not essential, is practiced to a notable extent, mainly for fruit trees. The miners have constructed elaborate systems of ditches, and from these water can be obtained in many localities at rates of from 10 to 15 cents per miner's inch for 24 hours. In one case at least it is stated that during the season 8 miner's inches flowing for 24 hours furnished sufficient water for each acre, the water, of course, being applied at different times. At 15 cents per miner's inch this would make the annual charge only $1.20 per acre. The water supply is large, as can be seen by examining the tables of discharge of the Calaveras and other rivers, as given in descriptions of San Joaquin county.

COLUSA COUNTY (*a*) includes a large part of the valley west of the Sacramento river. It thus consists mainly of a broad plain sloping gently toward the south. Besides the general fall along the valley there is also a gentle slope from the foothills toward the river, and also, as is sometimes found in great valleys, a slight rise to the river banks, so that the lowest ground is parallel to the stream and at a distance of some miles from it. In other words, this river has built up for itself a broad, low ridge, upon the top of which is the main channel. This feature renders the diversion of water for irrigation comparatively easy, since, aided by the general fall toward the south, canals can be made to conduct the water far away from the river across the plains to points near the foot of the bounding hills.

The county as a whole has the reputation of being one of the greatest wheat producing areas of the world, the level surface and uniform richness of soil rendering possible farming operations by machinery and on an enormous scale. With the low price of wheat even this wholesale farming can hardly be said to be profitable at all times, and steps have been taken, as in the San Joaquin valley, to introduce irrigation in order to insure the profitable cultivation of fruit. For the ordinary field crops the artificial application of water is not essential, although often desirable, and some of the lands of the county in fact need drainage rather than irrigation. Where practiced, the application of water is generally by flooding, the water flowing from one check or levee to the next and covering the intervening ground.

The principal source of water supply of these counties is the Sacramento, the waters of which, owing to the peculiar topography, can be brought out to the base of the foothills, covering the entire plain. The small streams coming in from the west, although intermittent in character, also furnish some water, which, especially by storage, could be used in irrigation. Stony creek, which flows easterly near the north line of the county, has a relatively large catchment area and supplies a number of ditches among the foothills and also above Orland. The quantity of water in the Sacramento river at Sacramento, 30 miles below the southern line of the county, has been ascertained by the state engineering department of California, the results being published in the volume of physical data and statistics. From these figures estimates have been prepared of the probable quantity at the head of the main canal of the Central irrigation district, which is at the south line of Tehama county. The results obtained are given in the table on the following page.

a In 1891 this county was divided, the northern part being set off and given the name of Glenn. In this discussion the two counties are included, since the census statistics apply to the condition of things before the division.

DISCHARGE IN SECOND-FEET OF THE SACRAMENTO RIVER AT SACRAMENTO, CALIFORNIA. (a)

[For each month from 1879 to 1885, and at proposed head of Central District canal for each month when the flow was approximately less than 6,040 second-feet during the same period.]

MONTHS.	1879		1880		1881		1882		1883		1884		1885	
	At Sacramento.	At head of Central canal.	At Sacramento.	At head of Central canal.	At Sacramento.	At head of Central canal.	At Sacramento.	At head of Central canal.	At Sacramento.	At head of Central canal.	At Sacramento.	At head of Central canal.	At Sacramento.	At head of Central canal.
January	12,000	6,040	28,000	.....	95,000	.....	24,000	.....	12,000	6,040	12,000	6,040	90,000	.....
February	30,000	.....	21,000	.....	115,000	.....	22,000	.....	17,000	.....	24,000	.....	52,000	.....
March	110,000	.....	22,000	.....	77,000	.....	55,000	.....	21,000	.....	80,000	.....	30,000	.....
April	110,000	.....	95,000	.....	90,000	.....	90,000	.....	73,000	.....	105,000	.....	29,000	.....
May	75,000	.....	135,000	.....	70,000	.....	92,000	.....	80,000	.....	111,000	.....	23,000	.....
June	45,000	.....	110,000	.....	25,000	.....	74,000	.....	32,000	.....	90,000	.....	14,000	.....
July	16,000	.....	53,000	.....	14,000	.....	17,000	.....	12,000	6,040	31,000	.....	6,500	3,960
August	8,500	4,960	18,000	.....	8,000	4,740	8,000	4,740	7,000	4,240	12,000	6,040	5,500	3,340
September	6,500	3,960	9,000	5,160	6,500	3,960	6,500	3,960	6,500	3,960	7,500	4,500	5,200	3,070
October	8,000	4,740	7,500	4,500	7,000	4,240	10,000	5,500	7,000	4,240	8,000	4,740	5,200	3,070
November	7,500	4,500	7,000	4,200	8,200	4,780	14,000	.....	7,500	4,500	7,000	4,240	.....	.....
December	27,000	.....	20,000	.....	16,000	.....	11,000	5,790	7,400	4,475	31,000	.....	.....	.....

a During the months for which approximate figures are not given for the point "At head of Central canal" the discharge of the river there was manifestly so far in excess of the canal's utmost capacity that it were idle to make any comparison, and so reductions from the Sacramento station records were not attempted. (From report on the Central Irrigation district, California; its physical, engineering, and business problems and conditions. William Ham. Hall. San Francisco.)

The principal irrigation works in this county are those of the Central irrigation district, mentioned below. In addition to this large canal, which is not yet in practical operation, there are a number of ditches taking water from Stony creek and other streams, and also what are known as high water or overflow canals leading from the Sacramento to the lower grounds back from the river banks. These high water ditches, as their name implies, receive water only in times of flood. As an example of each of these classes of irrigation works the following descriptions may suffice. The Carver ditch takes water from the west side of Big Stony creek to irrigate lands south of the town of Elk Creek. The length is 1.3 miles, width 8 feet, and the cost was about $2,000. During the census year only about 20 acres were irrigated, 3 of these being in orchards, 8 in corn, and 9 in alfalfa.

The Cheney Slough Water and Irrigation ditch takes water from the west side of the Sacramento river, about 6 miles north of Colusa. The total length is about 10 miles, the width 40 feet, and the cost was approximately $10,000. The head gate consists of an iron pipe 4.5 feet in diameter and 50 feet in length, laid in masonry and placed 6 feet below the top of the river bank. For the canal itself an old slough was utilized, after having been scraped out and otherwise improved. There are about 20 distributaries of from 0.2 to 1 mile in length and from 4 to 6 feet in width. The works are owned by an association of land owners. Irrigation can be practiced only when the river is very high, as it is at times in the winter season, and thus it is rarely possible for the land to receive more than one thorough flooding during the year. At that time the ground is covered to the depth of from 1 foot to 1.5 feet. The principal crops raised are wheat, barley, and alfalfa. Along the river there are a number of similar devices for flooding the lowlands during the time of high water, and in addition to these are several pumping plants for the purpose of irrigating orchards and gardens during the long dry season. One instance is given of a 7-inch centrifugal pump run by a 40-horse power engine pumping from an 18-inch well 34 feet in depth. The delivery is estimated to be 120,000 gallons per hour, and with this quantity 10 acres are irrigated in 12 hours, the water being applied by means of furrows 16 inches wide, 6 inches deep, and 4 feet apart.

A number of irrigation districts have been formed in this county, mainly in the northern part. The most northerly of these is the Kraft irrigation district, lying on the north side of Stony creek. South of this is the Orland South Side Irrigation district, water for which is diverted from the south side of Stony creek, canals being projected to cover land west and south of Orland. Still farther south is the Central irrigation district, one of the largest in the state. East of this, and between it and the Sacramento river, is the Colusa district, a narrow body of land from 3 to 5 miles in width.

The Central irrigation district shown on the preceding map embraces 156,550 acres, or nearly 245 square miles. Of this amount over 140,000 acres have been cultivated for cereals. In general shape, the district is long and narrow, being 38 miles from north to south, and in general from 6 to 9 miles in width. Water for irrigation is to be obtained from the Sacramento, the diverting canal heading at the Tehama county line and continuing southerly and southwesterly to Willows, and thence southerly along the edge of the foothills. The capacity of the main canal as projected is about 750 second-feet. As planned, this main canal will be nearly 62 miles in length and 60 feet in bottom width near the head, narrowing to 50 and then to 25 feet. There will be upward of 200 miles of distributary canals and ditches, of from 8 to 20 feet bottom width. In order to build this system bonds to the amount of $750,000 have been voted. Great difficulty has been experienced in selling these bonds, and as a consequence construction has not been pushed forward as rapidly as it otherwise would have been.

The district was formed in the fall of 1887, and from its inception has been bitterly fought by many of the land owners within its area. Many statements have been received from farmers to the effect that irrigation is not needed and that they are in danger of ruin from the results of the excessive taxation incident upon the district organization and work. In carrying out its plans also the district has encountered many unforeseen obstacles in obtaining rights of way, the condemnation proceedings being slow and expensive. It has been estimated by persons familiar with the conditions that the opposition alone has resulted in an unforeseen expenditure of at least $200,000.

The Kraft irrigation district as organized includes 13,500 acres, on which bonds to the amount of $80,000 were voted. So far as has been ascertained none of these have as yet been sold. The district extends along the north side of Stony creek, being thus partly in Tehama county. It averages 2 miles in width and is approximately 10 miles long. Water is to be obtained from Stony creek, which, however, is dry in its lower parts at least by June of each year. The Orland South Side Irrigation district comprises 26,000 acres. Bonds were voted, but by decision of court were declared void on account of irregularities. Persistent attempts have been made by many of the farmers in the district to put an end to the whole matter, and as a result, little, if anything, has been accomplished. The Colusa district, lying along the west side of the Sacramento, includes 100,000 acres, on which bonds to the amount of $600,000 were voted, but none were sold. No work has been done, and apparently all plans of irrigation have been abandoned.

CONTRA COSTA COUNTY lies directly north of Alameda county, being between it and Suisun and San Pablo bays. On the east the county includes a large part of the tule or swamp lands at the mouth of the San Joaquin river, some of which have been reclaimed, forming farms of great value. Irrigation is not practiced, there being ample rainfall even among the valleys at the foot of Mount Diablo. As in the other bay counties, fruit culture is of great importance, large areas being planted in vines as well as in trees. The principal fruits are apricots, cherries, peaches, prunes, pears, and the so-called small fruits. Owing to its proximity to the city of San Francisco considerable areas on the lowlands are devoted to market gardening, but for this no irrigation is required as the soils are naturally moist.

DEL NORTE COUNTY is in the extreme northwestern corner of the state, extending from the Oregon line southerly along the coast to Klamath river and including nearly the entire catchment basin of Smith river, which drains a portion of the coast range. The greater part of the area is mountainous and heavily timbered, the valleys being narrow and containing little agricultural land. The rainfall is heavy and there is no need of irrigation, except perhaps for fruit trees during the summer drought. There is an area of farming lands near the coast in the vicinity of Crescent city, but here it may be said that drainage is more important than irrigation. Also in Smith River valley are a few farms, as well as in small valleys similar to the one at Gasquet. Here the only crops are hay and vegetables, together with a few acres of grapevines and fruit trees.

ELDORADO COUNTY, lying north of Amador, extends from Lake Tahoe and the Nevada state line westerly down the slopes of the Sierra Nevadas to the plains in the vicinity of Sacramento, the state capital. It includes a large portion of the catchment basin of the American river and of the Cosumnes, the next important river on the south. Mining has been the principal industry, this portion of the state having become famous for the rich discoveries and heavy output of gold. Following the miners came the cattlemen, who found excellent grazing on the wild grasses covering the valleys and hill slopes. General agriculture has also been practiced to a considerable extent, and irrigation, although not strictly essential, has come to be of considerable importance. Some of the ditch systems built by the large mining companies rival in extent those of counties farther to the south. The more important of these are the works of the California Water and Mining Company, whose ditches cover Georgetown divide; the Eldorado Water and Deep Gravel Mining Company, and the Park Canal and Mining Company, covering portions of the county southerly from Georgetown. The amount charged for the use of water from these mining ditches varies considerably, but compared with the rest of the state seems high. The rates given are in different instances 12.5 cents per miner's inch for 12 hours, or from 20 cents up to 35 cents per miner's inch for 24 hours. There is general complaint that these prices are too high, and that if water could be obtained at lower rates it would be more generally used. By thorough cultivation excellent fruits, such as peaches, prunes, and cherries, are raised without irrigation, although it is probable that in many instances a larger yield could be obtained by proper application of water. Grain and the forage crops are seldom if ever watered, on account of the expense involved.

FRESNO COUNTY is situated midway of the length of San Joaquin valley, and includes within its boundaries a greater portion of this valley than any of the neighboring counties. It extends from the summits of the Sierra Nevadas southwesterly down the slope of the range to and across the lowlands up to the hills on the west, and thus on the east embraces the catchment area of the head waters of the San Joaquin and Kings rivers. The broad valley lands of the southwestern half of the county have been found to have a soil and climate particularly adapted to the raisin grape and to the so-called deciduous fruits, rendering the production of these the chief industry of this great region.

The rivers on leaving the foothills spread out over the broad valley and, as is the case with most rivers in this part of the state, lose their waters in innumerable sloughs or in the pervious beds. The San Joaquin river, in the center of the county, may be considered as a notable exception, for this, by its strong perennial discharge, has cut for itself a more decided channel, in which it continues throughout its course in the county. The smaller streams, draining relatively a few square miles of mountain area, generally disappear altogether on reaching the lower ground, their waters passing by seepage down along the valley and giving rise to conditions favorable for artesian wells. There is one peculiarity of the soil of the San Joaquin valley, which is perhaps as well marked in the vicinity of Fresno as at any other point, and that is the power of receiving and transmitting water laterally for long distances. After a large area has been thoroughly saturated it is not necessary to apply water again to the surface, but the orchards and vineyards receive a sufficient amount of moisture through the percolation from canals at some distance away. The mechanical structure favorable for this transmission of water is not possessed by all the soils, but is peculiar to most of the good raisin land. The fact that the land does not require direct irrigation does not relieve the owner from the necessity of paying his annual dues of $1 or more per acre, for although he does not draw the water, the canals in the vicinity must be maintained and kept full.

In this county, as a rule, the cereals are not irrigated, and between the San Joaquin and Kings rivers there are probably 75,000 acres of land not needing irrigation. For the best development of the fruits, however, artificial application of water is essential. Some of the land otherwise good is worthless from the presence of an excess of alkali, and other lands are doubtless being injured by the accumulation of earthy salts, due to lack of suitable drainage. Irrigation must be accompanied by drainage in order to accomplish the best results. The development of the county has been greatly retarded by litigation over questions of riparian rights, land owners along the lower course of Kings river having secured injunctions against the largest irrigating canals. During the census year water was run in these canals in spite of the injunctions, public sentiment being so strong in condemnation of the decisions that the injunctions could not be enforced. The returns from land irrigated and set to raisin grapes are stated to be from $50 to $250 per acre, while those from land unirrigated and devoted to grain may be $5 an acre or less. The colony lots of from 10 to 20 acres, when covered with bearing vines, are considered to be amply sufficient for the support of a family. The great returns in the grape and fruit business and the large amount of labor involved have led to the cutting up of large ranches and the formation of colonies.

The water supply is derived mainly from Kings river, on the southern border of the county, and from the San Joaquin, which flows about through the center. Besides these are a number of smaller rivers or creeks, the most important being Fresno river and Chowchilla creek, both north of San Joaquin river. Chowchilla creek, which forms a portion of the northern boundary of the county, was measured by the state engineering department at a point near Buchanan, where a record of the height of water was kept at intervals. This stream is characterized by short, sudden freshets, making it exceedingly difficult to estimate the discharge. The monthly averages, as computed, are given in a short table in the description of Merced county.

Fresno creek, or river as it is sometimes called, was measured at the head of the Fresno River Canal and Irrigation Company's canal, about 3 miles above the railroad crossing near Minturn. The mean monthly discharge is shown in the following table:

DISCHARGE IN SECOND-FEET OF FRESNO CREEK AT BASE OF FOOTHILLS, CALIFORNIA.

(Drainage area, 272 square miles.)

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1879	27	80	118	156	79	15	0	0	0	0	0	109	49
1880	5	150	16	1,088	54	27	0	0	0	0	0	218	130
1881	544	544	272	109	54	.....	0	0	0	0	0	27	129
1882	54	163	1,088	272	54	0	0	0	0	27	54	27	138
1883	82	54	272	136	109	0	0	0	0	0	0	0	54
1884	27	1,360	1,632	1,088	816	816	272	27	0	0	0	0	.....

The San Joaquin river where it enters the valley from the mountain region on the northeast is among the largest of the streams crossing the broad plains. Observations were made at a number of points, mainly at Hamptonville, at the edge of the valley, and at the railroad crossing near Herndon, formerly Sycamore. At that time little or no water was diverted at points above the railroad. The mean discharges as computed by the state engineer are given in the table on the following page.

DISCHARGE IN SECOND-FEET OF SAN JOAQUIN RIVER AT HAMPTONVILLE, CALIFORNIA.

(Drainage area, 1,637 square miles.)

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1879	609	1,276	1,953	3,849	5,302	6,379	2,303	786	381	373	411	1,140	2,064
1880	825	942	1,229	4,846	13,170	18,120	8,010	1,730	734	422	380	2,001	4,367
1881	3,856	6,340	2,855	8,008	9,095	5,948	3,064	1,260	584	463	461	632	3,547
1882	303	330	1,522	3,409	8,850	7,867	2,918	591	240	564	490	320	2,292
1883	320	320	1,150	2,130	7,370	6,220	1,470	490	410	330	250	250	1,726
1884	410	2,460	4,090	3,270	8,190	16,400	13,100	3,270	980	820	.....	.....	.....

Kings river is one of the most important streams of this part of the state, since it receives a large and stant supply of water from its elevated catchment area. The gaugings made by the state engineer were at ılities between Slate point, where the river leaves the mountains, and Tulare lake. The record of the height the stream was kept at the railroad bridge near Kingsburg, and from these observations the discharge was ıputed, due allowance being made for the amount of water diverted by canals heading higher up stream. The ults are shown in part in the following table.

DISCHARGE IN SECOND-FEET OF KINGS RIVER AT SLATE POINT, CALIFORNIA.

(Drainage area, 1,742 square miles.)

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1879	370	870	1,970	4,750	5,090	3,760	1,650	380	270	280	400	1,440	1,770
1880	720	1,040	1,120	5,230	7,120	9,540	4,800	1,150	370	220	220	510	2,670
1881	870	2,430	1,900	5,800	8,220	5,010	4,790	650	340	250	230	260	2,563
1882	380	440	1,250	3,170	9,190	6,410	2,020	620	390	610	470	340	2,108
1883	320	340	1,050	2,220	6,700	6,730	1,460	600	480	420	260	260	1,737
1884	430	2,620	3,610	3,370	9,210	17,630	13,210	3,570	880	900	.....	.....	.....

There are a number of flowing wells on the low grounds near the lower end of Chowchilla creek and in Fresno ugh. The total number enumerated upon farms in 1890 was 47, the depth ranging from 72 to 1,200 feet, the ɔrage being 562 feet. As a rule, little if any of the water is used for irrigation. At Kingsburg, east of the artesian a, a well was bored to the depth of 600 feet, but without success. Also at Madera, 20 miles northwesterly from ɔsno, a well was put down to the depth of 1,200 feet, but the water does not rise to the surface. It is necessary employ windmills in this vicinity in order to raise water for stock.

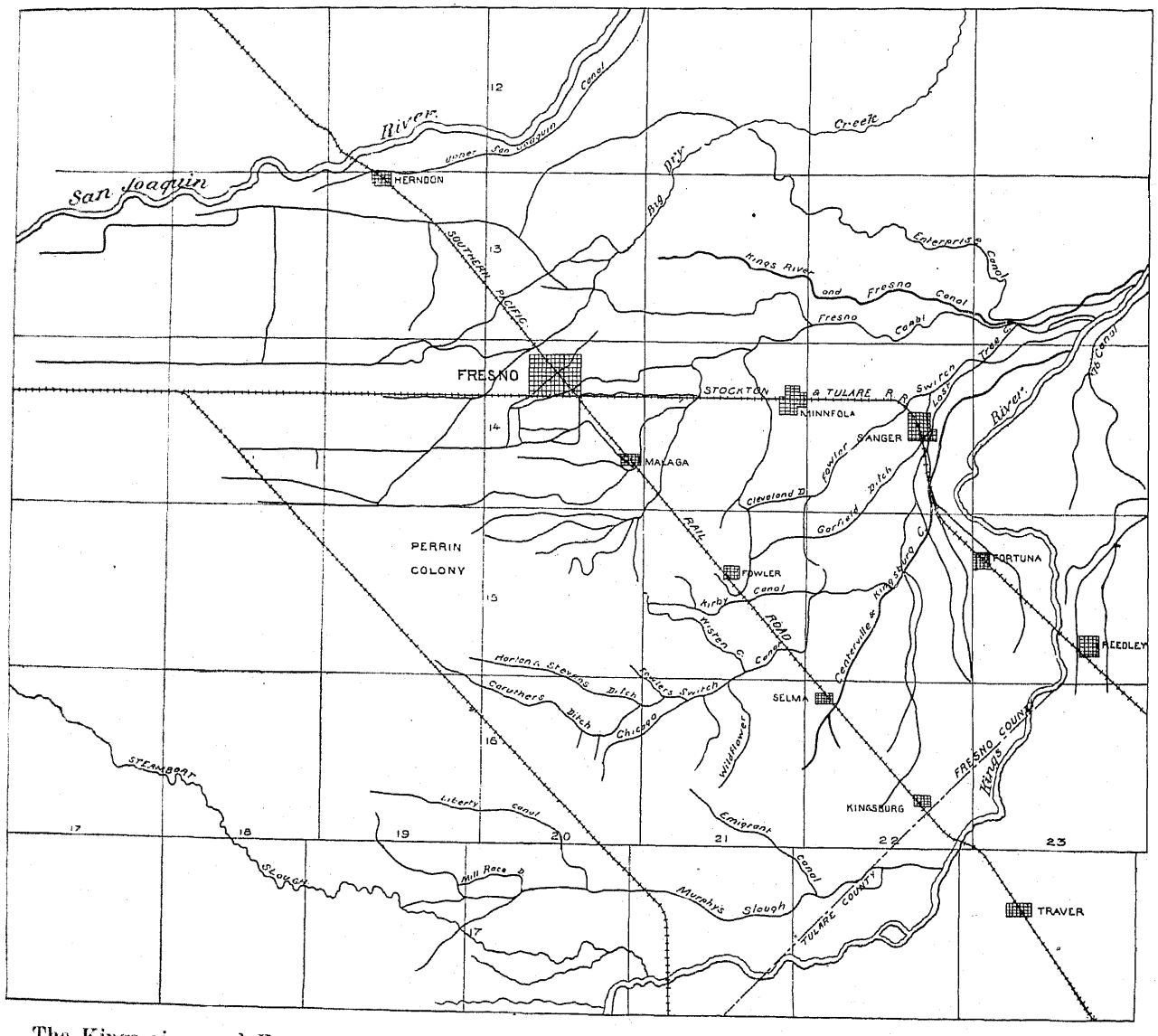
There are at least 16 important irrigation systems taking water from Kings, San Joaquin, Fresno, and other ers and covering over a half million acres of land. The total length of the principal canals is stated to be ward of 750 miles, and there are doubtless over a thousand miles of distributing ditches. There are stated to be dams across the rivers, as well as other works for diverting the water. The total cost of all these systems has ɔn placed at about $2,000,000. The farming land under these canals has an assessed value of from $25 to $40 ɔ acre, and sells readily at from $50 to $100 per acre. The unirrigated lands are assessed at from $5 to $10 per ɔe, and sell probably at from $10 to $20 per acre. Of the land irrigated, it is estimated that from 1 to 2 per cent ɔn fruit, 15 to 20 per cent in grapes, about 10 per cent in alfalfa, and the balance in cereals, the value of the it and grape product being far greater than that of all other crops put together. While not attempting to give a ɔailed description of each irrigating system, it may not be out of place to mention a few of the typical canals.

Among the canals taking water from Kings river in this county are the Enterprise, Kings River and Fresno, ɛsno, Fowler Switch, Centerville and Kingsburg, Emigrant, and Liberty. From the San Joaquin are the ɔper San Joaquin and other canals heading in the foothills, and lower down is the San Joaquin and Kings ver canal, taking water out on the west side of the valley in the vicinity and north of Firebaugh and extending and beyond Los Banos in Merced county, as shown on the map of the vicinity of Merced. Also on the east e of the river are the Chowchilla and other canals covering the lowlands. Other canals, as, for example, ıdera and Fresno River, head along Fresno river and Dry and Chowchilla creeks in the northern part of the ınty.

The Enterprise canal takes water from the west side of Kings river and carries it out in a northwesterly ırse along the upper edge of the valley land toward the point where the San Joaquin river leaves the ıuntains. The total length is about 30 miles, the average width 20 feet, and the cost was approximately $40,000. ork on the canal was begun in 1885 and water was first used in 1886. From the river water is diverted by means a wing dam made of cobblestones, replaced whenever the river falls and fails to supply the canal. Lands can brought under irrigation within 4 miles of the headworks. There are few deep cuttings along the line and only

5 flumes. The canal is owned by a corporation, 6 shares in which entitle the holder to 1 second-foot of water, an amount considered sufficient to irrigate 160 acres. The cost of the water right was about $5 per acre, and the annual assessment is about 65 cents per acre. Water is used mainly for irrigating vineyards, which are moistened two or three times during the year, beginning in March and ending in July.

MAP OF IRRIGATING CANALS IN THE VICINITY OF FRESNO, FRESNO COUNTY, CALIFORNIA.



The Kings river and Fresno canal, sometimes known as the Gould canal, is the next in order below the Enterprise, and carries water to lands north and east of Fresno. The total length of the main ditch is 22 miles, the average width 24 feet, and the capacity is estimated to be from 250 to 300 second-feet when full. The cost is stated to have been $100,000. The canal was begun in 1871, used in the following year, and enlarged in 1881. Under this canal, as in the case of that described above, 1 second-foot is supposed to irrigate 160 acres. The amount of water flowing in a box 18 inches wide and having a depth of 4 inches, without head or back pressure, is supposed to be 1 second-foot, although as a matter of fact the quantity must vary greatly. Also the quantity of water flowing through an opening 1 inch in height and 50 inches in width under a 4-inch pressure has been defined as being a second-foot. Shares are valued at $100, each entitling the holder to one-fourth of a second-foot of water, and the annual assessment is about 50 cents per acre.

The irrigating system belonging to the Fresno Canal and Irrigation Company, commonly known as the Church or Perrin canal, takes water from the west side of Kings river, the head works being about 20 miles east of Fresno. The total length of the main ditches is about 200 miles, the width being from 100 feet down to 10. The ordinary discharge of the main canal is estimated to be about 1,000 second-feet. The total cost of the canal and system of ditches was probably $1,000,000. The canal was begun in 1868 and the distributaries are still being extended. Water is diverted by means of a small stone dam, and there are no works of engineering importance, such as

flumes or deep excavations, along its line. Besides the main ditches, there are several hundred miles of distributaries, covering an area 40 miles in length from east to west and about 15 miles in width. It is customary to estimate that 1 second-foot will irrigate a quarter section, or 160 acres. No attempt is made to measure the exact quantity, but persons owning water rights in general use as much water as they desire.

This canal system is owned by a corporation, but the shares do not entitle the holder to the use of water, the water rights being sold entirely independent of ownership in the canal. The cost of water right per acre is stated to be $6.25, or $1,000 per quarter section. The annual assessment is 62.5 cents per acre. The most important product is raisin grapes. Second in value to these are the grapes raised for wine, the fruits, vegetables, and alfalfa. In this vicinity, as in many localities in the state, it has been found that the amount of water required for irrigating an acre depends upon the length of time during which the land has been under irrigation. When water is first applied it is necessary to use from 2 to 3 second-feet for each quarter section, but in the course of a few years the land becomes saturated, or, as it is commonly called, "subirrigated", requiring far less water. Many of the older irrigators do not use water directly, but depend entirely upon subirrigation. When irrigation was first introduced it is stated that in many localities water could be found only at depths of 100 feet. In the same localities at the present time water can be found at depths of from 5 to 15 feet. Improved lands under irrigation now yield products valued at from $50 to $200 per acre, while the unimproved land is worth from $75 to $100 per acre.

The Fowler Switch canal is below that of the Fresno Canal and Irrigation Company and covers land in the vicinity of Fowler, 8 miles southwesterly from Fresno. The total length of the main canal is about 30 miles, width 40 feet, and the cost was in round numbers $300,000. It was begun in 1882 and used in 1884. The canal was owned by a corporation, 300 shares at $1,000 each being issued. The water has been rented at $32 per share. This canal as well as others has suffered from the enforcement of the so-called riparian laws. In the case of this irrigating system and others adjoining some water is supplied to canal companies or associations owning the branch lines.

The Centerville and Kingsburg canal also takes water from the west side of the Kings river, but for a large portion of its course follows along within only 2 miles of the river. The total length of the main ditch is about 22 miles, the average width 30 feet, and the cost was approximately $100,000. The canal was begun probably in 1877. There are 3 main branches each about 20 feet in width, as well as a large number of smaller ditches.

The Madera canal takes water from Fresno river, carrying it out on the south side in a southwesterly direction. The total length of the main canal is 40 miles, the average width 15 feet, and the total cost was $160,000. Water rights have been sold at $5 per acre, the annual assessment being $1 per acre. Water is used mainly for raisin grapes, fruit, alfalfa, and some small grain. No attempt is made to measure the water, but the annual charges are made according to the acreage. There is great variation in the land, some being heavy and not requiring one-half as much water as do the adjoining tracts of light sandy soil.

HUMBOLDT COUNTY is one of the northern coast counties, lying in a relatively narrow strip along the Pacific ocean and separated from Oregon by Del Norte county. The greater part of the area is mountainous and heavily timbered, and the larger rivers flow through deep, narrow valleys. The rainfall is heavy and is sufficient for the needs of agriculture, irrigation being exceptional. The few irrigated areas reported consist mainly of orchards, vegetable gardens, and fields of alfalfa, to which water has been brought for use during the late summer droughts. The ditches are small, costing probably not more than $50 or $100, and taking water from some spring or rivulet to cultivated patches near by. In this part of the state several deep borings have been made for the purpose of obtaining water supply. One of these was near the town of Eureka, while other attempts to strike flowing water have been made in the reclaimed salt marshes near Ferndale.

INYO COUNTY lies on the eastern side of the Sierra Nevada range and adjoins Esmeralda and Nye counties, Nevada, to which it is similar in climate and topography, being within the great interior basin. On the extreme western edge of the county are the high peaks of the Sierras, rising to altitudes of 14,000 feet and upward and covered throughout the year with snow. From these come numerous streams, which, descending rapidly, unite to form Owens river, flowing southerly along the base of the range to Owens lake. Along each side of Owens river is a strip of agricultural land, but upon which crops can be raised only by irrigation. To the east of this is a succession of ranges and deep valleys of what is known as the Great Basin type, similar to those in southern Nevada. In these valleys the water supply is so limited that agriculture is impossible, except at a few restricted localities in the vicinity of springs or of the small perennial streams. The most noted among these lowlands between the mountains is Death valley, the bottom of which is reported to be upward of 350 feet below sea level. Borax and similar substances are obtained in these depressions, but beyond these products the desert area has little present value.

The streams which enter Owens valley from the west are diverted by numerous ditches, and there are also several canals already in use or under construction deriving their supply from Owens river and covering both sides of the valley. The principal among these is the Inyo canal, heading about 6 miles above Independence and carrying water out on the east side of the valley as far south as Owens lake. This ditch is reported to be 50 feet in width near the head, 30 miles in length, and to have a capacity of 300 second-feet. Besides this ditch there are

on the east side of the river the McNally, Zeiger, and Collins, in the northern end of the valley, and on the west side the Stevens ditch, heading near Independence. A large irrigating system known as the Owens river canal has been projected to cover the entire west side of the valley, the head being 10 miles west of Bishop station, and the main canal extending down to and even beyond Owens lake.

The Bishop creek ditch heads on the south side of Owens river, about 6 miles west of Bishop station. It is 14 miles long, from 16 to 20 feet in width, and has cost over $15,000. It is owned by a corporation composed of farmers, each share in the ditch entitling the owner to 0.5 second-foot of water. Each share cost from $250 to $500. There is apparently an ample water supply for the land now under irrigation, but it is probable that it will be necessary to resort to water storage in the future at localities known to be favorable.

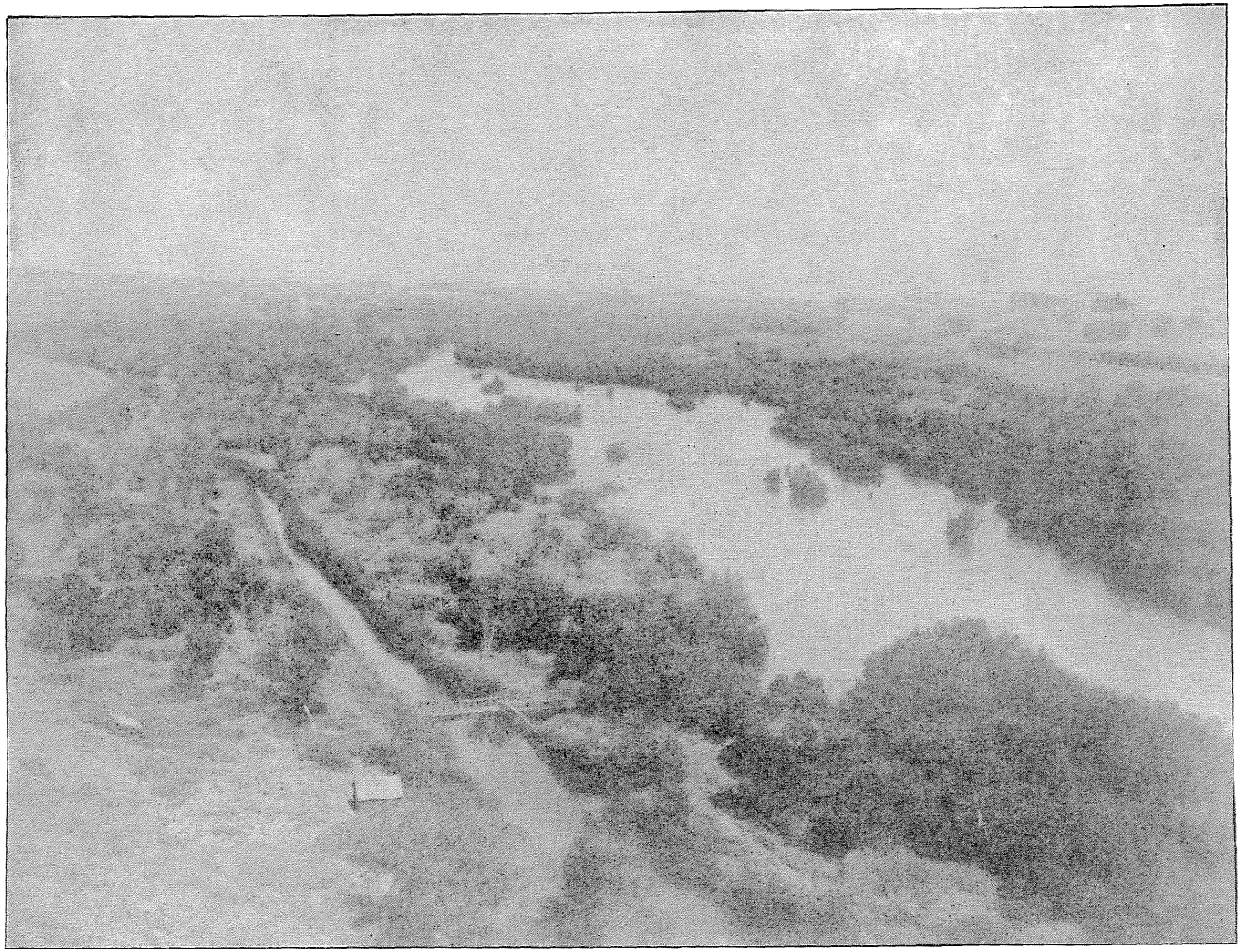
KERN COUNTY is in the extreme southern end of San Joaquin valley, extending from the coast range easterly across the end of the valley to and beyond the Sierra Nevada mountains, and including in its southeastern corner a portion of the Mohave desert, a part of the great interior basin of western United States. The most valuable lands of the county are those which lie within the San Joaquin basin between the lowest ground and the foothills of the Sierra Nevadas. The rivers which come from the high mountains forming the southern end of the Sierra Nevadas discharge their waters out upon the nearly level plain at the southern end of the San Joaquin valley, the fall near the center being so slight that the channels are not well defined, and the water for a great part of the year flows sluggishly through what are known as sloughs and forms in places large marshes or open lakes. There were formerly two lakes of considerable size in this county, Buena Vista and Kern, the river discharging into Kern lake, then westerly into Buena Vista, the excess water of which flowed out northerly into the sloughs extending to Tulare lake. Works of river reclamation and improvement have, however, changed the condition of things so that Kern lake has disappeared and Buena Vista, confined within narrower limits, serves as a reservoir for lands to the north.

The greater part of the agricultural lands of this county are under the control of two large corporations or associations of capitalists. The first of these, the Kern County Land Company, owns the lands formerly known as the Haggin and Carr property, while the second, the San Joaquin and Kings River Canal and Irrigation Company, or Miller and Lux, controls the lands northerly from Buena Vista reservoir. There has been a long legal warfare between these companies over the use of the water of Kern river, the matter being finally settled by agreement, all parties joining in works of river improvement and water storage in Buena Vista lake. Until within a few years nearly all of the lands held by these great owners were utilized, if at all, for pasturage and for raising forage crops and the cereals, tracts of several thousand acres being flooded in a wholesale manner by means of checks or low levees a few inches in height constructed on contours. In the latter part of the last decade the owners began to see the advantages of cutting up these great holdings into small lots and selling these to colonists who would set them out in fruit, it being found that the climate was favorable for the profitable production of all the fruits for which California is famous.

A number of colonies have been started in the vicinity of Bakersfield and at other points, mainly on the eastern side of the valley, and lands which formerly yielded under irrigation only forage and grain are now set out to the most expensive orchards and vineyards. Much of this land requires but little water, one good wetting a year being sufficient. In some cases no direct irrigation is practiced, but the seepage from canals at a distance suffices to keep the ground sufficiently moist. In wet years the small grains can be raised usually without any application of water even on lands above the canals. Although large areas have been subdivided, there still remain a number of great ranches, devoted mainly to the raising of horses and cattle.

This county is noted for the number of artesian wells and the large quantity of water discharged by them. The principal wells, as shown on the map, are found in the region of country lying from 10 to 20 miles west of the Southern Pacific railroad and between it and that part of Kern river known as Buena Vista slough and Goose Lake slough, being in the vicinity of the Smyrna, Miramonte, and other colonies. They are thus located mainly within townships 25, 26, and 27 south, ranges 22, 23, and 24 east, Mount Diablo meridian. There are also many flowing wells in the lower part of what is known as the Kern delta, south and west of Bakersfield. It is claimed that the largest wells are in township 23 east, range 27 south, this being about 40 miles southerly from Tulare lake. In this township the Kern County Land Company had in the census year 24 artesian wells, of from 300 to 1,100 feet in depth, and also 4 wells not flowing, of from 400 to 1,000 feet in depth. The discharge ranged from 40 to 420 gallons per minute, or from 0.1 to 1 second-foot. A few wells were reported as discharging as high as 4 second-feet, or approximately 2,500,000 gallons per day. Comparatively little of this water has yet been used for irrigation, but it is probable that it will be more fully utilized as the colonies increase. The cost of these wells varied from $2 to $3 per foot in depth.

As an example of the largest wells may be given one in section 17, township 26 south, range 23 east. This is 635 feet deep, 8 inches in diameter, and cost $1,875. It discharges at the rate of 3.7 second-feet, and has irrigated 320 acres. This area was covered by young orchards of plum and fig trees, by raisin vines, grain for hay, alfalfa, corn, sorghum, vegetables, and shade trees. Taking Kern county as a whole, the average depth of the wells is 551 feet, diameter 8 inches, and cost $1,489. The discharge is 1,072 gallons per minute, and the average area irrigated by each well used for that purpose was 125 acres.



VIEW OF KERN RIVER AND CANAL ON SOUTH SIDE ABOVE BAKERSFIELD, KERN COUNTY, CALIFORNIA.

The larger canals of the county depend upon the Kern river, which, rising in the lofty Sierra Nevadas, flows southerly and then southeasterly into the head of the San Joaquin valley. To the south and north of this are other streams having a less area of mountain catchment and a far smaller discharge. The quantity of water flowing in these streams was measured by the state engineering department of California and the results were published in the "Physical Data and Statistics of California", already cited. The Kern river was gauged chiefly at the Rio Bravo Ranch station, a point below the mountain canyon and above all canals of diversion in the valley. Readings of the height of water were kept from 1878 to 1883, these data forming the basis for computing the discharge.

DISCHARGE IN SECOND-FEET OF KERN RIVER AT RIO BRAVO RANCH, CALIFORNIA.

(Drainage area, 2,345 square miles.)

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1879	462	591	552	764	927	971	535	266	171	182	261	356	503
1880	354	370	389	1,557	2,659	3,317	2,196	1,060	767	758	767	1,063	1,280
1881	1,078	1,773	1,570	2,288	2,362	1,890	1,126	627	361	333	337	350	1,183
1882	335	395	600	1,174	1,670	1,306	726	330	330	330	280	280	646
1883	280	350	700	1,170	1,410	1,170	940	470	350	280	200	200	627
1884	350	470	940	1,980	5,860	9,380	5,860	2,350	940	470	.....	.....	.....

The mean discharge of Caliente creek, lying to the south of Kern river, has been computed by the state engineer of California from considerations of the rainfall and of the probable drainage per square mile. The results are considered as approximate only, but as such have their value, and are therefore given in the following table:

DISCHARGE IN SECOND-FEET OF CALIENTE CREEK AT BASE OF FOOTHILLS, CALIFORNIA.

(Drainage area, 423 square miles.)

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1879	34	59	30	106	76	25	0	0	0	0	110	212	54
1880	508	973	1,100	1,227	846	212	21	0	0	0	85	212	432
1881	212	423	423	423	423	212	0	0	0	0	0	51	181
1882	51	63	212	212	42	0	0	0	0	0	63	63	59
1883	63	63	338	212	169	0	0	0	0	42	42	63	83
1884	212	1,269	1,269	846	169	212	0	0	0	0	.....	.....	.....

Poso creek drains the area to the north of Kern river, entering the valley east of Goose lake. Here, as in the case of Caliente creek, the computations of discharge have been based upon considerations of rainfall and drainage. The following table gives therefore the best information available:

DISCHARGE IN SECOND-FEET OF POSO CREEK AT BASE OF FOOTHILLS, CALIFORNIA.

(Drainage area, 289 square miles.)

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1879	23	40	20	72	52	17	0	0	0	0	75	145	37
1880	347	665	751	838	578	145	14	0	0	0	58	145	295
1881	145	289	289	289	289	145	0	0	0	0	0	35	123
1882	35	43	145	145	29	0	0	0	0	0	43	14	38
1883	43	43	231	145	119	0	0	0	0	29	29	43	57
1884	145	867	867	578	119	145	0	0	0	0	.....	.....	.....

Measurements of the amount of evaporation from exposed surface of water were made at various points in Kern county and also at Kingsburg, in Tulare county, by the state engineering department of California in 1879 and later years. Those in Kern county were commenced in June, 1879, and were carried on during July, August, and September, the hottest months of the year, being supplemented by observations made into December at Rio Bravo ranch, about 10 miles east of Bakersfield. The Kern county measurements were made from pans of galvanized iron 2 feet square and 1 foot deep, some of these being floated in large bodies of water, and in other cases the pans were set in open ground.

The following statement shows the average evaporation in inches per 24 hours, as obtained at the different localities:

	INCHES.
Reeder lake, a narrow body of water 12 to 15 feet deep, surrounded by large cottonwood trees and willows. Pan placed in a shallow arm of the lake, fully exposed to the sun, but protected from the wind. June 25 to July 8	0.24
Panama slough. Pan placed in running water 10 feet deep, having lower temperature than Reeder lake; fully exposed to sun, but protected from the wind. July 9 to August 20	0.14
Kern lake, about 2 miles from shore. Pan in 5 feet of water. September 5 to 29	0.22
Kern lake, near shore. Pan in 2 feet of water. August 30 to September 29	0.32
Kern river, at Rio Bravo ranch, 3 miles below the mouth of Kern river canyon. Pan freely exposed to sun and wind, but immersed in water to within 2 inches of its top:	
October 11 to 25	0.11
November 1 to 29	0.09
December 6 to 20	0.05

At the same time a pan was kept on top of the ground, free to the action of the weather, resulting in greater evaporation. The results of all of these measurements are shown in a different form in the following table, the mean daily evaporation in each case being multiplied by the number of days in each month. In doing this a number of assumptions are made, some of which may be questionable, but the results obtained afford a basis for judging of the possible monthly evaporation. At the bottom of the table are given figures showing in inches the computed evaporation at Fresno, in Fresno county, these representing possibilities of evaporation rather than actual loss. Below these are given the percentages showing the relative evaporation in each month of the year.

COMPUTED DEPTH OF EVAPORATION, MONTHLY.

STATIONS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total for year.
Reeder lake						7.5							
Panama slough							4.4	4.5					
Kern lake, center									6.5				
Kern lake, northeast shore									9.5				
Kern river										3.5	2.0		
Rio Bravo ranch (ground)										7.6	3.7	1.6	
Fresno (a) ..... inches..	1.8	2.8	3.0	5.6	6.6	7.0	9.1	10.2	7.6	6.7	3.8	2.2	65.8
Fresno ..... per cent..	2.7	4.3	4.6	8.5	9.1	10.6	13.9	15.5	11.5	10.2	5.8	3.3	100.0

a Depth of evaporation in the United States. T. Russell. (Extract from Monthly Weather Review, September, 1888.)

The principal canals of the county are owned or controlled by the Kern County Canal and Water Company, which is under the same management as the Kern County Land Company, the property being known as the Haggin and Carr lands. A general description of their works, as given by Walter James, chief engineer, is as follows:

All of the canals take their water from Kern river, the discharge of which has been discussed on a previous page. The average flow of the river during June and July is assumed to be about 3,500 second-feet. In 1884 and 1890 it was probably about 7,000 second-feet, these being regarded, however, as exceptional years. From August 1 until November 1, during which period but little water is needed for irrigation, the discharge may be as low as 300 second-feet, the average being about 500 second-feet. During the time of winter rains, that is, from November to March, the discharge is about 1,000 second-feet.

During periods of high water the excess over the amount required by the various canals flows down the channel southwesterly from Bakersfield to a point north of Buena Vista lake and is there deflected by dikes southerly through the inlet canal, which is 400 feet in width, into the lake, as shown on the map. This lake, which has been converted by means of levees into a reservoir, thus holds the flood waters, which are used later in the season upon the lands to the northward extending to Tulare lake, these lands having a less altitude. The total area of this reservoir is about 25,000 acres. The evaporation from its surface has been discussed in part on a preceding page.

CANALS ON NORTH SIDE OF KERN RIVER.

NAMES OF CANALS.	Located—	Length in miles.	APPROPRIATION.		Bottom width in feet.	Slope of banks.	Depth of water in feet.	Fall in feet per mile.	CAPACITY IN SECOND-FEET BY KUTTER'S FORMULA. VALUES OF N.		
			Miner's inches.	Second-feet.					0.025	0.030	0.035
Beardsley (*a*)	Dec. 2, 1873	8.0	47,230	938	40	3 to 1	4.0	1.0	371	307	263
McCord	Mar. 20, 1875	14.5	5,000	100	30	3 to 1	3.0	1.5	207	171	146
Calloway (*a*)	May 4, 1875	32.0	74,000	1,476	80	3 to 1	5.0	0.8	921	776	656
McCaffrey	Oct. 31, 1874	3.0	1,296	26	10	1 to 1	2.0	1.5	30	24	20
Emery	Dec. 2, 1876	3.0	2,000	40	6	3 to 1	2.0	1.5	27	22	18
Jones and Tuckey	June 24, 1876	4.0	1,000	20	4	3 to 1	2.0	1.5	21	17	14
Railroad	July 24, 1874	0.6	31,075	620	40	3 to 1	3.0	2.0	309	256	216
Wible	May 1, 1875	0.2	5,040	100	40	3 to 1	3.0	2.0	309	256	216
Goose Lake (*a*)	July 13, 1875	4.5	90,060	1,795	140	3 to 1	3.0	2.0	1,024	850	727
Pioneer	Apr. 26, 1873	11.5	20,074	400	40	3 to 1	3.0	2.0	309	256	216
Edwards	Dec. 21, 1874	2.0	1,440	29	6	1 to 1	1.0	1.5	7	6	5
James and Dixon (*a*)	Apr. 29, 1873	3.0	14,000	279	40	3 to 1	3.0	2.0	309	256	216
Johnson	June 12, 1873	4.0	8,640	172	30	3 to 1	3.0	1.5	207	171	146
Ashe (*b*)		1.0	1,200	24							
May (*b*)	Nov. 29, 1873	2.0	4,000	80							
Joice (*a*)	June 2, 1873	4.0	6,250	125	10	3 to 1	2.0	2.0	44	36	31

CANALS ON SOUTH SIDE OF KERN RIVER.

Kern Island (*a*)	1870	30.0	20,000	400	40	3 to 1	4.0	2.0	503	427	372
Old South Fork		3.0	3,800	75	20	1 to 1	2.0	5.0	112	92	78
Farmers	Apr. 20, 1873	19.7	14,400	287	30	2 to 1	3.0	2.0	233	193	164
Castro		5.0	1,000	20	16	1 to 1	1.5	2.0	35	28	24
Stine (*a*)	Dec. 12, 1872	47.5	55,980	1,117	30	3 to 1	3.0	2.0	241	198	169
Anderson (*a*)	Oct. 9, 1872	4.0	5,057	101	20	1 to 1	2.0	1.5	61	50	42
Gates (*a*)	Oct. 7, 1878	2.5	5,057	101	12	3 to 1	2.0	1.5	44	36	30
Buena Vista (*a*)	July 15, 1870	13.2	14,000	279	30	3 to 1	3.0	2.0	241	198	169
James (*a*)	Oct. 15, 1871	17.2	19,730	394	40	3 to 1	3.0	2.0	309	256	216
Plunket (*a*)	Dec. 31, 1872	3.7	5,057	101	12	3 to 1	2.0	1.5	44	36	30
Meacham (*a*)	Apr. 15, 1873	4.0	1,500	30	12	3 to 1	2.0	1.5	44	36	30
Wilson	Aug. 15, 1874	2.5	500	10	4	3 to 1	2.0	1.5	21	17	14
Henley (*b*)	Jan. 29, 1874	2.5	2,880	57							
Frazer (*b*)	Apr. 15, 1873	2.2	2,600	52							
Kern Valley Water Company (*a*)	Apr. 7, 1877	40.0	130,000	2,594	125	3 to 1	10.0	0.9	5,626	4,238	3,722

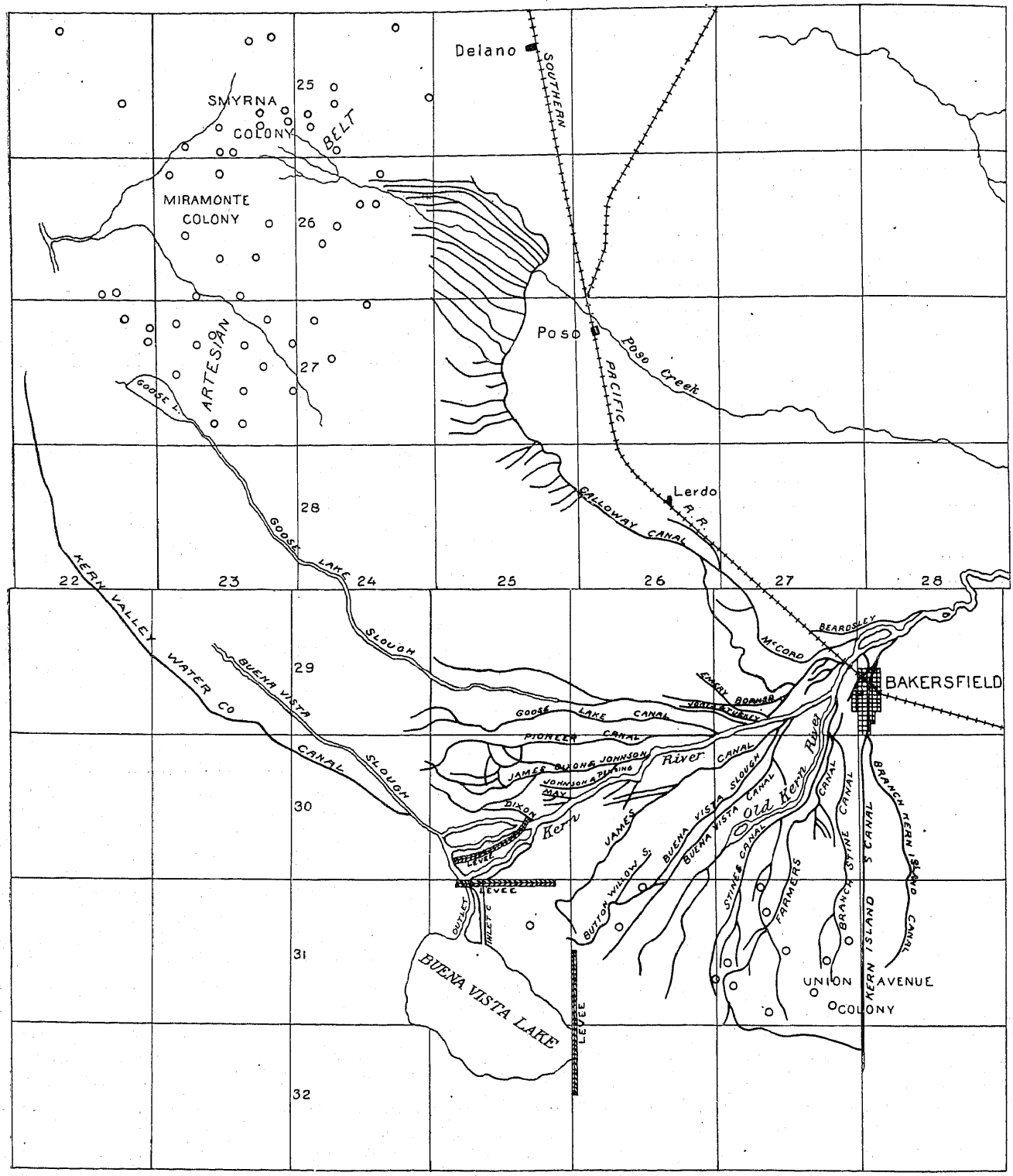
a Canals owned by incorporated companies. *b* Abandoned canals.

The Railroad, Wible, and Goose Lake canals discharge into a natural channel called Goose Lake slough, which, as shown by the map, runs to Goose lake, the water being taken out at various points along this channel and used by the owners of shares in these 3 canals. All of these canals were completed to their present length within 3 years of the date of their location. As they are cleaned out, however, the banks are being made higher and their capacity increased to meet the requirements of the lands brought under irrigation each year. All of the canals are carried through a nearly flat country where there is no rock or expensive excavations, the cuttings not exceeding 3 feet in depth. Several of the canals, as, for example, the Beardsley, Calloway, and McCord, after leaving the river, follow as nearly on contour lines as is possible with cuttings of from 2 to 3 feet.

At the head of the Beardsley canal is a weir 60 feet long, extending to an island in the river. Also at the head of the McCord canal is a similar structure. The head works of the Kern Island canal are provided with a wing dam built of sand and brush, and requiring repairs in every change of the stage of water. A wasteway at the head gate serves to some extent to save this dam. The South Fork canal, which has its head near that of the Kern Island canal, occupies in common with the Farmers canal a natural channel. At the heads of the Farmers and Calloway canals, which take out water on opposite sides of the river, is a weir extending completely across the channel and having a length of 400 feet. It is notable from the fact that it is built upon piles driven into the sandy channel, and, though constructed in the lightest and most simple fashion, has for several years withstood the attacks of heavy floods.

At the head of the Buena Vista and James canals there is a weir in the river 300 feet long, and at the head of the Pioneer, Meacham, Wilson, Goose Lake, Wible, and Railroad canals there is a weir 360 feet long crossing the river. At the head of the Johnson and James and Dixon canals is a weir 200 feet long, and at the head of the Joice canal is a weir 280 feet long. Water is diverted to all of the other canals by means of temporary wing dams. From the canals the water is taken through side gates, weirs being necessary to regulate the fall in the canals and the flow of water through these side gates. The quantity of water in the canal is estimated by measurements over the weirs. On none of these canals excepting the Kern Island, Stine, Beardsley, and Calloway is the water measured to the consumers. In the case of the first two of these the quantity is measured in miner's inches under a 4-inch pressure and charged for at the rate of 75 cents per second-foot for 24 hours. On the Beardsley and Calloway the water is measured through submerged openings, the charges being at the rate of $2.16 per second-foot for 24 hours. It is estimated that 1 second-foot will irrigate in 24 hours 10 acres of orchards or vines or 1 acre of grass or grain.

MAP OF IRRIGATING CANALS IN THE VICINITY OF BAKERSFIELD, KERN COUNTY, CALIFORNIA.



In addition to the water supply obtained from the canals there are in this county several pumping plants by which water is raised to a height of from 10 to 30 feet, and at a cost not greater than that just given above. Besides these there are, as previously described, many artesian wells, furnishing considerable quantities of water. It is estimated by Mr. James that from all sources of supply an area of from 500,000 to 600,000 acres may be irrigated, all of this being under the canals above mentioned. In the case of each of these canals the water is distributed to shareholders according to the number of shares owned by each, except at times when the water is in excess of demands, when each owner receives as much as he wishes. The canals are usually cleaned in the fall at the times when water is not needed, but are sometimes allowed to run uncleaned for two or three years.

The lands under irrigation in this county, as stated by Mr. James, in a state of nature, would produce feed for stock in quantity to the value of, say, 10 cents an acre per year. In other words, a stock raiser could not afford to pay as rental more than 10 cents per acre; for the land in its natural condition in this portion of the San Joaquin valley is of little use for other purposes than grazing.

Besides the canals taking water from the Kern river and other streams in the lower end of the San Joaquin valley, there are a number of small ditches deriving a supply from the tributaries of the Kern river and irrigating small areas in the mountain valleys. Among these may be mentioned those in the vicinity of Havilah in Hot Spring valley and in the vicinity of Kernville and Weldon. In the southern part of the county, also, south of the Tehachapi pass, are small irrigating systems and others projected or under construction. The principal ones of these have in view the reclamation of lands in Antelope valley, the greater part of which is in the northern end of Los Angeles county. On Oak creek, 10 miles southwest from Mohave, it has been proposed to irrigate lands by means of water from a reservoir supplied by Oak creek and its numerous springs. Under present conditions the settlers are too poor and too widely scattered to accomplish much, and the land, though highly fertile under irrigation, is naturally of such a desert character that the pioneers barely make a living.

LAKE COUNTY is one of the smaller interior counties lying within the coast range of mountains. The nearest part of the county is about 60 miles north of San Francisco, and from this point it extends northerly for approximately the same distance. The most conspicuous topographic feature of the county, and the one from which it receives its name, is the large lake near its center. This, known as Clear lake, drains easterly and southerly by means of Cache creek through Capay valley, Yolo county, to the Sacramento. Around the shores of the lake are several valleys in which agriculture is carried on. Irrigation is practiced to a relatively small extent, principally for vegetable gardens, trees, and alfalfa. For general farming purposes the annual rainfall is sufficient. The water supply of the county as a whole is large, although during the latter part of the summer the tributaries to Clear lake dwindle and become almost if not quite dry. In a few instances water is pumped from the lake by means of horse power and used in truck farming, but otherwise the lake itself is not utilized toward irrigation within the county. In Scotts valley and around Upper lake are a number of flowing wells, having a depth of 50 to 160 feet, the average being 81 feet. There were in all 45 of these enumerated as being on farms in 1890. The average cost of these was $90, and the average discharge 59 gallons per minute. They were sunk mainly for the purpose of watering stock, but a small amount of water is used for irrigating vegetables and trees.

Clear lake has been looked upon as an excellent reservoir site, requiring but small expenditure to utilize it for the purpose of holding water for use on land along Cache creek and out on the Sacramento valley. A detailed survey of the lake was made in 1889 by the United States Geological Survey. (*a*) Estimates were made of the outflow of the lake on two days only, the first on August 2, 1889, showing a discharge of 86 second-feet, and the second on October 4, 1889, when there was a discharge of about 4 second-feet.

As an example of the ditches of the county, may be given the Rocca and Voluntine. This takes water from Putah creek below the junction of St. Helena and Dry creeks, the head being about 7 miles from Middletown. The total length is 2 miles, the width 4 feet, and the cost was $3,000. Water is diverted through a tunnel 1,600 feet in length. The work was begun in 1883, finished the next year, and in 1889 150 acres were irrigated, this area being mainly in alfalfa.

LASSEN COUNTY is in the northeastern part of California, adjacent to the state of Nevada, being east of the Sierra Nevada range. The county as a whole has an altitude of from about 4,000 to 5,000 feet, the mountains rising 2,000 to 3,000 feet higher. There are a number of broad plains of almost a desert character within this area. The soil of these is highly fertile, and whenever water can be applied large crops are produced. Without irrigation nothing will succeed except perhaps an occasional crop of small grains, the yield per acre being insignificant. Within the county are two large lakes, Eagle and Honey, the former at an altitude of over 5,100 feet, the latter at about 3,950, occupying the lowest point in that part of the country. Eagle lake has an area of about 45 square miles, has precipitous shores at many points, and is probably very deep. In contrast to this is Honey lake, occupying at times twice this area, the water being very shallow, the lake in fact occasionally disappearing completely by evaporation. The two lakes are about 30 miles apart, but the catchment area tributary to Honey lake extends almost to the shores of Eagle lake, Willow creek, one of the tributaries of Susan river, heading near a low divide east of the center of Eagle lake. It is thus possible by making a deep cut to cause the waters of Eagle lake to discharge easterly down Willow creek to Honey lake.

In the northwestern corner of the county is Big valley, traversed by Pitt river, from which water is taken for irrigation. East of this is Ash valley, in which some land is irrigated from Ash creek. Southeasterly from this latter area are the Madeline plains, having an altitude of about 5,200 feet and almost entirely destitute of water. The most important area of agricultural land is in the vicinity of Susan river and around Honey lake, the facilities for irrigation being exceptionally good. The county as a whole is devoted to stock raising, and thus the forage plants form the principal crop. Some fruit is raised, but the difficulty and expense of shipment tend to restrain development in this direction. As a rule, the methods of irrigation are crude, being those adapted for flooding

a The results of this survey are shown in Part 3 of the Thirteenth Annual Report of the Geological Survey, 1892, accompanied by a contoured map.

large areas of nearly level land at the least possible expense. Dams are built in the smaller streams and the water of the spring floods is turned out and conducted by ditches or guided by small dikes or levees, submerging as large an area as possible. The duty of water is thus relatively low, and with more careful use larger areas could be covered. The expense, however, is small, in one instance 900 acres being brought under irrigation at a cost of $1,200.

The water supply of the county taken as a whole is large, there being many small streams, and one or two rivers of notable size. Pitt river, one of the upper tributaries of the Sacramento, flows through the northwestern corner of the county, but with the exception of this nearly all of the streams flow into sinks or lakes, from which the water escapes only by evaporation. Next in size to Pitt river is probably Susan river, which flows easterly along the front of the Sierra Nevadas into Honey lake. On the opposite side of this body of water is Long Valley creek, which, also draining the face of the Sierra Nevadas, flows northerly and westerly. Both of these streams, with adjacent creeks, are of great importance in the development of irrigation in the county. No long series of measurements have been made of the available supply, but it is probably ample for all systems now projected. Artesian wells of a depth of from 200 to 400 feet have been sunk on the east side of Honey lake in the vicinity of Amadee, but at Janesville, on the western side of the lake, it is stated that borings have been unsuccessful. East of Pittville, below Big valley, are also a number of flowing wells, these having a depth of about 200 feet.

Besides the numerous smaller irrigating systems are two large projects for irrigating lands in the vicinity of Honey lake. On the west and north of this lake are the works of the Eagle Lake Land and Irrigation Company, and on the south and east of the lake those of the Honey Lake Land and Water Company. The first named company has canals taking water from the north side of Willow creek and one from the south side of Susan river, these canals heading above the junction of the streams and covering opposite sides of the valley in the vicinity of the town of Lassen. Near this place the two systems are connected by an iron pipe 22 inches in diameter crossing the valley, the intention being to transfer water from one canal to the other according to any necessity which may arise. Along each canal are storage reservoirs, in which it is proposed to hold a part of the flood waters of each stream. The supply is to be further increased by cutting an outlet from Eagle lake through the divide separating it from the head waters of Willow creek, which rises in springs within 1 or 2 miles of the shores of this lake. When this is done, Eagle lake can be used to a certain extent as a reservoir, furnishing an enormous volume of water to Willow creek, part of which can, if necessary, be carried by the iron pipe across to the canal on the south side of Susan river.

The irrigation system of the Honey Lake Valley Land and Water Company depends for water upon storage on Long Valley creek. It is proposed to construct a large earthen dam at the point where this creek enters Honey Lake valley and conduct the water thus held by a system of canals leading to the north, and covering land in the vicinity of Liegan, and northerly toward Amadee. The drainage area of the creek above the dam site is stated by the company's engineer to be 400 square miles, and it is estimated that there will be ample water to fill the proposed reservoir, which has an available capacity of 10,000,000,000 gallons. (*a*)

LOS ANGELES COUNTY is immediately south of Kern, extending from the nearly desert lands of the interior basin southerly over the Sierra Madre mountains to the Pacific ocean. The population is concentrated between the mountains and the seacoast, and agriculture is mainly confined to the same area, namely, to the coastal plains and the valleys whose drainage escapes seaward. The Sierra Madre mountains trend in a nearly east and west direction, extending from Ventura county across Los Angeles and into San Bernardino county, where apparently they culminate in Grayback mountain northeasterly from the city of San Bernardino. This mountain range is notable for its precipitous slopes and the rapidity with which the elevation increases from the base toward the summits. In fact, there are few if any other mountain ranges in the United States which as a whole rise as abruptly. This remarkable topography has, as might be supposed, a great effect upon the climate, and especially upon the humidity and precipitation. The valleys at the southern foot, even though not receiving a large rainfall, are comparatively well watered, while the lands to the northward of the range have an aridity approaching that of a complete desert.

The physical characteristics, water supply, and condition of irrigation development in Los Angeles, Orange, San Bernardino, and San Diego counties were most fully discussed by the state engineer of California, in his report upon irrigation in southern California. (*b*) This work treats in an exhaustive manner not only of the topography

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a The discharge of Long Valley creek, as measured for the company at the dam site, was as follows:

	SECOND-FEET.
December, 1890	32
January, 1891	60
February, 1891	206
March, 1891	300
April, 1891	220
May, 1891	116
June, 1891	16

Later in the year the creek becomes almost if not quite dry. (Report of L. H. Taylor, engineer in chief.)

b Irrigation in California, Southern. The field, water supply, and works, organization and operation in San Diego, San Bernardino, and Los Angeles counties. The second part of the report of the state engineer of California on irrigation and the irrigation question. William Ham. Hall, C. E., state engineer. Sacramento. 1888.

VIEW OF CEMENT DISTRIBUTING DITCH, NORTH POMONA, LOS ANGELES COUNTY, CALIFORNIA, ILLUSTRATING METHOD OF DISTRIBUTING WATER TO ORCHARDS.

of the country, but also of the history and growth of the almost innumerable systems of irrigation now in use. At the time the book was prepared Orange county was a part of Los Angeles, and therefore in the descriptions the area now within the former county appears under the head of the latter.

The counties of Los Angeles, Orange, San Bernardino, and San Diego are collectively spoken of as forming southern California, a country quite distinct from the rest of the state in its topography and in resulting conditions. Ventura might be included, but perhaps it falls best into the coast division. The total area of these four counties is in round numbers 40,000 square miles, nearly equal that of the state of Ohio, Virginia, or Kentucky. The greater part of this area is so arid in character that the population is exceedingly scanty. It would be possible to segregate the portion of these counties extending from the ocean to the tops of the mountains, including all of the principal catchment areas, so that the piece thus cut off would contain nearly if not quite all of the population and the best of the farming lands. This tract would contain an area of, in round numbers, 6,000 square miles, three-quarters of the area of Massachusetts or about five-sixths of that of New Jersey. This relatively small area contains all of the cities and towns, the health resorts, the orchards, and the vineyards for which southern California is famed. The population in 1890 was in round numbers 173,000, a little more than that of Delaware. The remaining 34,000 square miles in Los Angeles, San Bernardino, and San Diego counties beyond the mountains contains doubtless many spots of great value, but these in the aggregate sink into insignificance compared with the 6,000 square miles nearer the coast.

The agricultural lands of Los Angeles county are mainly in San Gabriel and San Fernando valleys and upon the coastal plain. The San Gabriel valley is on the eastern side of the county, extending from near the city of Los Angeles easterly to within a few miles of the San Bernardino county line, lying thus along the foot of the Sierra Madre range. It is separated from the coast plains by the Puente hills, whose trend is in general parallel to that of the coast. From the high mountains at the north comes the San Gabriel river, the channel of which crosses the valley in a general southeasterly course. Smaller streams, coming also from narrow canyons, enter the upper or northern edge of this basin shaped valley. The San Fernando valley is a little north of west of the San Gabriel and is more nearly inclosed by high mountains than is the latter. On the south are the Cahuenga mountains and on the north the San Fernando range, this being a portion of the main divide of the Sierra Madre. The water of the streams which flow into this valley from all sides if not evaporated finally escapes at the southeastern corner of the basin, passing through the city of Los Angeles.

North of the Sierra Madres are several important valleys, some of them of great size, the water supply in general being deficient. The most notable of these valleys is that known as Antelope, lying partly in Kern county. Some of the land, as for example, around Elizabeth lake, is moist, and fair crops of forage are obtained. Several irrigation districts have been formed in this part of the county and development of the resources is progressing rapidly. Water must be obtained mainly by storage, although in the vicinity of Lancaster there are a number of flowing wells. The Antelope Valley Water Company has made surveys for the storage of waters of Piru creek, a tributary of Santa Clara river. Also, Crain lake, situated at the western apex or head of Antelope valley, has been examined for storage purposes, and it has been estimated that 75,000 acres in the upper end of the valley can be irrigated by this project.

Owing to the peculiar topography of the county, the abruptness and great altitude of the mountain range previously mentioned, the water supply of the southern part of the county is large. At the foot of the mountains the rainfall in some localities is sufficiently great for all fruits and field crops, and at other places, especially on the low grounds, there is sufficient moisture beneath the surface for the needs of plant life. However, much of the best land of the county, especially that most favorable for the production of the citrus fruits, requires irrigation, the orchards doing best in a warm, dry soil, occasionally watered. Thus, although the greater part of the agriculture of the county as far as gross acreage is concerned is carried on without irrigation, yet by far the most valuable part, the horticultural, depends immediately upon the water supply.

In this and the adjoining county of San Bernardino nearly all of the streams flow from the mountains through deep canyons, entering the valleys upon great piles or benches of loose sands and gravels hundreds of feet in thickness. Into these the water tends to sink, reappearing perhaps in springs, or cienegas, as the water-bearing lands are locally known, or in artesian wells. The irrigation works therefore are constructed in such a manner as to take water at the mouth of the canyons, or depend for their supply upon the springs or wells developed in various parts of the basin like valleys. There are thus less apparent system and regularity about the arrangement of these works than is the case in most localities where the irrigating ditches and canals head in succession down some one stream. One system of water distribution may obtain part of its water from a surface stream, another part from artesian wells, while a third source of supply may be by the development of springs in moist lands in some other part of the valley. There has been a gradual growth and evolution of the various water companies not along definite lines, and as a result the rights and property are highly complicated. Open ditches have in many localities been replaced by pipes placed under ground, resulting in great saving of the water.

The San Gabriel and Los Angeles rivers are the largest streams of the county, but even during the greater part of the year they do not reach the ocean, their waters sinking and rising in the pervious beds. Besides these

are many streams having a smaller drainage area, but carrying sufficient water to be of great importance in the irrigation of the county. Among these may be mentioned San Antonio creek, whose waters are divided between lands in this and San Bernardino county. To the west are the creeks coming from San Dimas, Dalton, and other canyons, and beyond San Gabriel river, Fish creek, Sawpit canyon, Santa Anita, Eaton, Arroyo Seco, Big Tejunga, Little Tejunga, Pacoima, San Fernando, Mormon canyon, and others, some rising in the valley, as does San Jose creek. The lowest summer discharge from San Dimas canyon is about 15 miner's inches, or a third of a second-foot, and from Big Dalton about half as much. San Antonio creek has been measured at a number of times, the results as given by Mr. Hall being as follows:

APPROXIMATE DISCHARGE OF SAN ANTONIO CREEK, CALIFORNIA.

DATES.	Miner's inches.	Second-feet.
July 6, 1885	410	8.2
August 3, 1885	200	4.0
September 8, 1885	190	3.8
July 6, 1886	661	13.2
August 2, 1886	589	11.8
September 6, 1886	444	8.9

Besides these there are few if any definite measurements of the quantity of water available in the different streams throughout the year, and even if there were this would not tell the whole story as to the water supply at hand, as many of the valuable sources do not appear as running creeks. There are a few farmers and horticulturists who claim that by thorough cultivation good results can be obtained without irrigation and that the fruits raised in this way are of superior quality. The matter rests of course largely upon the character of the soil as well as upon the amount of care given by the owner. The products of fruit culture by irrigation are, as is well known, enormous, reaching in value several hundred dollars per acre. The early crops, especially upon the damp lands, do not require the application of water, and in fact there are in the county large areas which could be benefited by draining. The fairly moist lands are worth from $50 to $75 per acre and upward, depending upon their proximity to towns. With water the higher bench lands are worth from $200 to $500 per acre and even more in the so-called colonies. The water itself has been valued at $1,000 per miner's inch, or $50,000 per second-foot. The value of course depends upon the duty, and it is doubtful whether many of the water rights would sell at these figures, although there have been transfers at as high as $1,500 per miner's inch or even more. For the use of water for short times, the prices, as given later on, vary in the different localities, the charge for 100 miner's inches during the day or night being from $1 to $5. With certain companies delivering water under pressure in pipes the charge is so much per hour for the use of a hydrant, the pressure not being given. For example, 15 cents per hour is paid for water from a 2-inch hydrant and 35 cents per hour for a 4-inch hydrant.

The water storage does not play as important a part here as in the case of San Bernardino county, with its Bear valley reservoir, or San Diego county, with the Sweetwater dam. Probably the largest storage works in the county are those in the northwestern part of San Fernando valley, the reservoir being in what is known as Mormon canyon. The dam in this canyon consists of an earth embankment 75 feet high, 270 feet long on top, 136 feet thick at base, and 6 feet thick at top. This dam is stated to have cost about $10,000, and the capacity of the reservoir thus formed is given by the state engineer as follows: (*a*)

ELEVATION OF WATER PLANE IN FEET.		CAPACITIES OF RESERVOIR ABOVE GROUND'S SURFACE.	
Above sea level.	Above base of dam.	Cubic feet.	Million gallons.
1,050	10	57,834	0.43
1,060	20	563,983	4.22
1,070	30	1,887,981	14.12
1,080	40	4,005,200	29.96
1,090	50	7,084,077	52.99

There are also in the county many large cement tanks or small reservoirs built by the owners of ranches or small farms at the highest points of these. They are filled sometimes by a small continuous supply from a spring or pipe line, or are used to receive the full flow of a ditch during certain stated times.

The artesian areas in Los Angeles and Orange counties are among the most important of California. In the valleys there are within certain areas so many wells that it may be said that every fruit grower has at least one.

a Irrigation in Southern California, page 532.