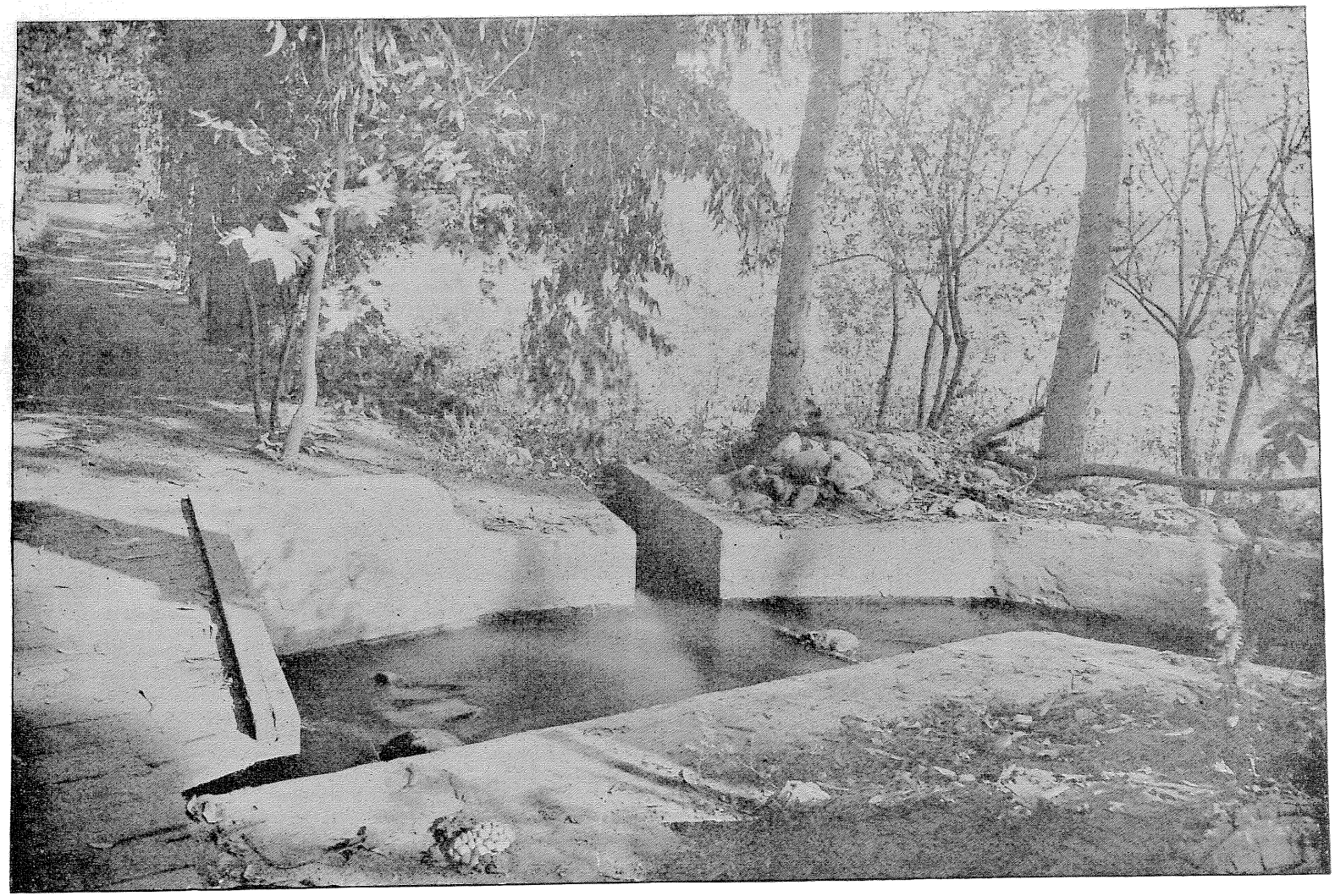

VIEW OF DISTRIBUTING DITCH, LOS ANGELES COUNTY, CALIFORNIA, ILLUSTRATING METHOD OF CONSERVING WATER BY CEMENT LINED DITCHES

In Los Angeles county 627 have been enumerated as being upon farms, the depth of these ranging from 20 to 600 feet, the average being 187 feet. Comparatively a small proportion of the water is used immediately for irrigation, since many of the wells are upon lands already sufficiently moist for the ordinary crops. The flowing wells, however, have a great value in furnishing a supply for the numerous pipe lines laid for general municipal and agricultural use, as, for example, in the case of the Chino pipe line, taking water from the vicinity of Pomona for the Chino ranch. In the Physical Data and Statistics of California is a list of 40 wells, mainly in the vicinity of Pomona. The flowing wells recorded by the census enumerators were mainly in the vicinity of Artesia, 16 miles south of the city of Los Angeles; of Compton, 11 miles south, and of Florence, 6 miles south of the same place. Many of the farmers state that they have feared to use the water for general irrigation, since, as they believe, certain areas have been spoiled in this manner by the development of alkali upon the surface. The water in general is clear and pure, in some instances containing a notable amount of sulphur. The force of the water from some of these wells is sufficiently great to drive small machinery.

Certain of the wells are reported as being sunk as early as 1870, and a large proportion were put down previous to 1880. Within the last decade the increase in number has been so rapid that the effect is being shown in diminished pressure and flow from some of the older wells. In several instances farmers report that large wells sunk near the coast have plainly affected their water supply, while others state that wells nearer the mountains have had a similar effect. Evidence on all sides points to the fact that the discharge from the wells will soon equal the capacity of the supplying area, since many of the wells on the higher ground already fluctuate with the season, diminishing in summer to such an extent that windmills are occasionally used.

At San Gabriel, 9 miles east of Los Angeles, a well was put down to the depth of 564 feet, but without reaching artesian water. Near this town on the low ground, are a number of flowing wells, furnishing water for domestic purposes, but relatively of little use for irrigation. Northwesterly from Los Angeles, in San Fernando valley, are a number of flowing wells, also at Newhall, a town on the Santa Clara river about 30 miles northwesterly from Los Angeles, and at Lancaster, in Antelope valley.

To attempt to describe the different systems of water distribution or even to satisfactorily enumerate them is not possible within the limitations of this discussion, and therefore, as in the case of other counties, brief mention is made of some of the typical or important features. Among these may be mentioned the water supply furnished by the city of Los Angeles to the adjacent farming lands, among the most valuable in the county. The water for the city is diverted by several lines, one from the Los Angeles river about 5 miles above the city, and again about a mile within the city limits, this latter conduit being known as the Zanja Madre (Mother ditch). A third supply, for the east side, is taken out about 2 miles below the head of the Zanja Madre. The upper ditch carries about 26 second-feet, or 1,300 miner's inches, this considered as being 4 "heads". This quantity of water is estimated by the state engineer to be about the average low water or summer discharge of the river.

The water is distributed by something over 50 miles of conduits within the city, fully half of these being open, and by 40 miles or more of distributaries outside the city, besides numerous farm ditches. In 1888 nearly 3,000 acres were irrigated inside the city and 8,000 acres outside, besides 3,000 acres wet by sewerage. The water is controlled by the city council, which makes the necessary regulations and appoints the superintendent or zanjero. There is more water available than is needed on the lands within the city limits, and for this reason the excess is sold to the farmers outside, these having formed associations for the purpose of distributing the water among themselves. The price for the city water is governed by the city council, the cost to persons inside the city limits being considerably less than to those outside. In each case permits are issued to the irrigators to use a zanja for the purpose of carrying 1 "head" of water for a certain definite time. The quantity is not otherwise specified and depends upon different conditions.

The charge for the use of water during the day is greater than at night, being $5 or more to persons outside the city. The quantity of water contained in an irrigation "head" is supposed to be 100 miner's inches, or 2 second-feet, but, as shown by the state engineer, it has been nearer 200 miner's inches, or 4 second-feet. Considerably over one-half of the land irrigated is in vegetables and about one-third in orchards and vineyards. Many of the best vegetable gardens are those rented by Chinamen, who pay from $15 to $25 per acre. Much of this land has without irrigation sufficient moisture for the needs of one crop and for trees, but by irrigation and thorough tilling of the soil the Chinamen succeed in producing three or four crops each year. As a rule, they flood the ground before planting, and as soon as the soil is dry they plow, harrow, and plant at once. Later, when the crop is about half grown and has been carefully weeded, a deep furrow is plowed in every alternate row and filled with water. When this ground is sufficiently dry the furrow is cultivated, and later the other rows are filled with water and cultivated in turn. This is usually sufficient for maturing the crop. When this has been gathered the ground is flooded and again planted.

Next to the Los Angeles river and the systems of irrigation depending upon it is the San Gabriel river and its works for distributing water, only a few of which, and perhaps the less important, can be mentioned. The Azusa irrigating ditch takes water from the San Gabriel river, about 2 miles from the town of Azusa, bringing it

out on the east side, the Duarte ditch taking water out on the opposite or west side of the river. After leaving the river the main ditch is divided into a number of branches, covering a portion of township 1 south, range 10 west. On the line of the ditch are a few tunnels and flumes, but for the greater part of the way the water flows in open earth cuttings. The water is divided into what are known as "heads" or "runs", consisting of about 50 miner's inches, or 1 second-foot. Those entitled to the use of the water pay at the rate of $2 per day for a "head" of water. The greater part of the land irrigated is set out with orange, lemon, and deciduous fruit trees. Relatively small areas of vegetables and alfalfa are also irrigated.

The Duarte Mutual Irrigation and Canal Company has constructed a pipe line, taking water from San Gabriel river and Fish creek, the head works being about 4 miles from Azusa. Water is taken from the main stream first through a tunnel, then in a rock lined and cemented ditch for about one-half mile, later through a 26-inch pipe, a brick culvert, and cement pipes, ranging in size from 14 inches to 22 inches in diameter. Twenty shares of stock in this company call for 24 hours' run of a full "head" of about 100 miner's inches. Each irrigator is entitled to a full "run" about every 20 days, or a half "run" at intervals of about 10 days. A share is valued at $100, and is intended to furnish sufficient water for 1 acre of citrus fruits. The annual assessments vary from $3 to $4 per share. This corporation, taking water from the mouth of San Gabriel canyon, receives one-third of the whole amount, the other two-thirds going to Azusa. The accompanying figures show portions of cement ditches upon E. J. Baldwin's place at Santa Anita, and exhibit the methods of distributing and controlling the waters obtained from the streams or artesian wells.

The works of the Vineland irrigation district take water from near the mouth of the San Gabriel canyon, about 1.5 miles north of the town of Azusa, being on the east side of the river. The main ditch is 4 miles long and 3.5 feet wide. The total cost, exclusive of water right and of tunnel, was, in 1890, $27,000. The water is taken from the river into a covered flume 1,500 feet in length. The whole amount of the water is divided into "runs", each of these being not less than 80 nor more than 100 miner's inches, flowing continuously for 12 hours. The farmers are served in rotation, beginning with the lowest on the last lateral. Generally three persons are served each with a "run" at the same time. The district has constructed a tunnel 2,000 feet in length and about 5 feet in height to take out the water percolating through the bed of the San Gabriel river. In the dryest time of the year this tunnel is stated to yield 60 miner's inches.

The East Whittier conduit derives water from artesian wells and the seepage from gravels along the San Gabriel river, the wet lands controlled by the East Whittier Land and Water Company being between El Monte and Puente. A cut has been made on the west side of the river over 3,000 feet in length and having a depth of from 6 to 15 feet. Sheet piling has been driven along a portion of this cut to protect it from the river, and a flume 4 feet by 6 feet has been placed in the excavation, bringing the water out to the cement conduit. The water is conducted across the river to the east side and follows along the hillside to the East Whittier rancho. The total length of the flumes and cement conduits is about 10 miles, and the total cost approximately $60,000.

The Glendora Water Works derive a supply from Big Dalton canyon by means of a tunnel 1,500 feet in length. From this a 12-inch pipe leads the water to points where it is distributed to 3 reservoirs, from which in turn iron pipes bring the water to the town of Glendora. The total cost up to 1890 was $55,000. Only a small acreage of citrus fruits is irrigated.

The Palmdale Irrigation Company takes water from Little Rock creek, their ditch, 7 miles in length, carrying it out on the west side of the creek in a northerly direction. The total cost of this ditch is stated to have been $16,000. Stockholders in the company pay 10 cents per hour for 100 miner's inches as measured through an opening 10 inches square under a 4-inch pressure. The principal crops irrigated are alfalfa, corn, potatoes, and vegetables, together with fruit trees and vineyards.

A number of districts have been formed in this county, these being Big Rock creek, Glendora, Pomona Orange Belt, Santa Gertrudes, and Vineland. The location of these is shown on the general map for the state, and the principal facts concerning the area and valuation are given in the table accompanying this figure. The Big Rock creek district, which is located on the north side of the San Gabriel range, is reported to have been unsuccessful in its attempts to raise money, and apparently little has been accomplished. It is proposed to obtain the water supply for this district from small streams flowing northerly into the desert, but it is doubtful if a sufficient amount can be obtained to bring all of the lands under irrigation.

The Glendora district embraces 3,000 acres in the vicinity of the town of Glendora, near the eastern boundary of the county. Bonds to the amount of $170,000 have been voted, but not sold. Pomona Orange Belt district, embracing 4,000 acres in the vicinity of Pomona and east of the Glendora district, has no immediately available source of water supply, but various projects have been discussed, especially the plan of purchasing water from the Arrowhead Reservoir Company, the sites for whose storage works are in the higher valleys of the San Bernardino range. The Santa Gertrudes district comprises 2,600 acres in the vicinity of Santa Fe springs. Water will probably be obtained from what is known as New San Gabriel river. The Vineland district, in the vicinity of the town of that name, has been bonded for $50,000 or over for the purpose of developing water primarily by means of a tunnel under the channel of San Gabriel river.

MARIN COUNTY occupies the peninsula immediately north of San Francisco, and as a consequence of its position on the coast the climate is sufficiently moist, so that irrigation is not required. The principal industry is dairy farming, the city furnishing a constant market for all products of this kind. Fruit raising, especially on the inland side of the county, is becoming of importance as the suburban population increases. On the side toward the ocean the fogs and winds render the lands less favorable for fruit culture, but the moisture in the air adds to the value for grazing purposes.

MARIPOSA COUNTY is north of Fresno, extending from the summits of the Sierras westerly to the San Joaquin plain. It thus comprises a great range of topographic features from the foothills to the high mountain peaks. Within this county is the celebrated Yosemite valley, through which flows Merced river, a stream of considerable importance for irrigation in the San Joaquin valley. In the county, irrigation is little practiced, for the agricultural land in the narrow valleys usually receives sufficient rainfall for cereals and forage crops. The fruit trees are sometimes watered, especially those on the lower lands to the west. For this purpose the old abandoned mining ditches have been utilized and other works have been built.

In the higher portions of the county there are numerous springs, and the water supply is well distributed, so that irrigation can be carried on at many points. The smaller streams when they reach the lower grounds usually dwindle, and in the latter part of June or first of July become dry, so that in order to utilize these completely for the irrigation of fruit trees it will be necessary to construct storage reservoirs. The irrigating ditches now in use are mainly of from 1 to 2 miles in length and are owned by the individual farmers whose lands are partly watered. In a few instances pumps are used to raise water to orchards on the hillsides. Probably the irrigating system of most interest is that in the vicinity of Coulterville, the ditches deriving water from Maxwell creek, a short distance above Merced river, and also from this latter stream. One of these ditches, 2 miles in length, supplies water to a Leffel turbine, which in turn drives a pump, elevating water at the rate of from 6,000 to 10,000 gallons per hour through about 800 feet of pipe a vertical distance of 120 feet to a large reservoir, and from this and a second reservoir it is distributed to the orchard.

MENDOCINO COUNTY lies south of Humboldt and west of Lake county, and its surface, like that of surrounding areas, is mountainous, the valley area being relatively small. Lumbering is the principal industry, the county being within the celebrated redwood belt of California. General agriculture, stock raising, and fruit growing, though relatively of less importance, are gradually developing and demanding larger areas. Irrigation is practiced to a very small extent and that merely for gardens, fruit trees, and patches of alfalfa, mainly in the vicinity of Ukiah, Pomo, and other towns. The rainfall as a whole is large, averaging over 30 inches per year, but occasionally is less than 20 inches in depth, and were it not for the long, dry summer the artificial application of water would not be thought of. Even with these conditions two crops of alfalfa can usually be obtained, but with watering five crops are cut. The smaller streams are usually perennial, but the larger creeks, especially those of the upper Russian river, sometimes become nearly or quite dry at points in the valleys. As a whole, however, it may be said that the water supply of the county is large, and little difficulty will be encountered in this regard toward increasing the area under irrigation.

MERCED COUNTY lies across the San Joaquin valley north of Fresno, and thus includes the fertile agricultural lands from the foothills of the Sierra Nevadas across to those of the coast ranges. Most of these lands have been owned in large bodies and utilized to a great extent for the cultivation of wheat and other cereals. These are fairly successful without irrigation, but a full crop can not be depended upon every year. Irrigation was introduced on a large scale in this county, but it was found by the land owners that their gains could be greatly increased by subdividing the larger holdings into small fruit farms and founding colonies, of which there are several, Rotterdam, British, Deane, Yosemite, and others. It is stated by some of the largest land owners in California that irrigation on a large scale for wheat and other cereals has not paid in the long run.

On the nearly level grounds of this county large areas of field crops have been irrigated by means of systems of checks or levees of from 1 to 2 feet or more in height, and so built that the lower one backs up the water to the foot of the next higher. When a field has been prepared in this manner, one or two men can irrigate from 40 to 50 acres a day, or with an ample supply of water even up to 100 acres. On some of the lands two crops per year have been raised. For example, after harvesting an early crop, as of barley, the fields are planted in what is known as Egyptian corn, which, however, must be irrigated. In many places in the county water stands within about 10 feet of the surface, and after trees and vines are two years old they seldom need irrigation. The annual charges for water must usually be met, since these are an annual lien upon the land.

Hay, wheat, barley, and other grain, as stated above, are often raised successfully by dependence upon spring rains. As showing the fluctuations, the following statement of success or failure in "dry" farming is instructive: in 1869 a paying crop was raised; in 1870 and 1871 the crops were a failure; in 1872 paying; in 1873, 1874, and 1875 partial crops only were raised; in 1876 paying; in 1877 failure; in 1878 paying; in 1879 failure; in 1880 paying; in 1881, 1882, and 1883 partial; in 1884 paying; in 1885 partial; in 1886 paying; in 1887 failure; in 1888, 1889, and 1890 paying. This record, while perhaps not applying to all farmers, serves to give the degree of confidence to be placed in nonirrigated crops.

The principal streams of the county are the Merced river, Bear and Mariposa creeks, and others coming from the mountains on the east, and the San Joaquin river, which flows northwesterly through the lowest grounds. The mountain streams rise far to the east among the summits of the Sierra Nevadas, their catchment basins being largely in Mariposa county. The discharges of Bear, Mariposa, and Chowchilla creeks, as estimated by the state engineering department (*a*), are shown in the following tables. Their watersheds do not extend back to the regions of perennial snow, and therefore their flow is characterized by sudden rises after heavy rains.

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

(Drainage area, 166 square miles.)

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1879	0	25	57	54	0	0	0	0	0	0	0	18	13
1880	25	61	31	321	23	0	0	0	0	0	0	115	48
1881	169	214	48	6	0	0	0	0	0	0	0	0	36
1882	0	33	100	130	0	0	0	0	0	17	25	17	27
1883	66	33	170	100	50	0	0	0	0	0	0	0	35
1884	17	660	910	660	330	170	66	0	0	0	.....	.....	.....

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

(Drainage area, 122 square miles.)

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1879	0	20	45	43	4	0	0	0	0	0	0	15	11
1880	20	49	24	24	18	12	0	0	0	0	0	92	20
1881	134	171	38	5	0	0	0	0	0	0	0	0	29
1882	0	24	74	98	0	0	0	0	0	0	18	12	19
1883	49	24	122	73	37	0	0	0	0	0	0	0	25
1884	12	488	671	488	244	122	49	0	0	0	.....	.....	.....

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

(Drainage area, 268 square miles.)

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1879	8	56	63	48	14	0	0	0	0	0	0	12	17
1880	5	167	19	1,266	53	27	0	0	0	0	0	201	145
1881	295	375	83	11	0	0	0	0	0	0	0	27	66
1882	54	164	1,168	268	54	0	0	0	0	0	53	27	149
1883	80	53	268	134	107	0	0	0	0	0	0	0	54
1884	27	1,340	1,608	1,072	804	804	268	27	0	0	.....	.....	.....

The principal gaugings on Merced river were made at Merced Falls, above all diversions by irrigation canals, and from these and other measurements the mean monthly discharge has been computed, as shown in the following table:

DISCHARGE IN SECOND-FEET OF MERCED RIVER AT MERCED FALLS, CALIFORNIA.

(Drainage area, 1,076 square miles.)

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1879	354	1,506	2,098	3,120	3,336	3,336	968	172	75	75	172	646	1,322
1880	387	753	807	4,250	4,842	5,111	2,744	753	323	269	237	1,291	1,814
1881	2,044	3,443	1,560	2,798	4,412	3,336	1,506	377	129	75	75	323	1,673
1882	172	753	1,506	2,260	3,658	3,336	1,076	215	129	484	387	237	1,184
1883	344	355	915	2,260	5,488	4,412	1,184	377	237	183	161	172	1,341
1884	237	2,712	3,820	4,896	5,434	6,510	4,358	1,130	237	172	.....	.....	.....

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, 1886. Pages 408, 434–442.

Artesian wells are found west of the main line of the Southern Pacific railroad, beginning at distances of from 2 to 5 miles from it, the artesian area extending to the low grounds along the San Joaquin river. The general location of many of the older of these wells is indicated by the circles upon the accompanying map. The total number enumerated upon farms in the census year was 112. These were from 170 to 700 feet in depth, averaging 326 feet, and having an average discharge of 65 gallons per minute. Very few were used for irrigation. Most of them furnished a pure, clear water, employed for domestic purposes, but mainly for cattle. The water from a number of the wells contained a notable percentage of earthy salts, and was reputed to possess medicinal qualities.

The principal irrigation works of this county are those owned by the Crocker-Huffman Land and Water Company, taking water from Merced river to irrigate lands on the east side of San Joaquin valley, and those of the San Joaquin and Kings River Canal and Irrigation Company, taking water from the San Joaquin river in Fresno county to cover land on the west side of that stream. Besides these are the East Side canal, west of Merced, and a number of smaller canals and ditches owned by individuals and associations. Among these may be mentioned the Merced Falls, Murray Mill, Snelling, Scott, and Ruddle ditches, these being on the north side of Merced river, and the Feldhaus and Reed, Hamlin, and the Griffith and Shaver ditches, on the south side of Merced river

The Merced canal, owned by the Crocker-Huffman Land and Water Company, takes water from the south side of Merced river, about 3 miles below Merced Falls. It is 27 miles long, from 60 to 70 feet wide on bottom and 100 feet wide on top, the estimated capacity at the head being 4,000 second-feet. At two points along the line it passes through tunnels, one of which, with approaches, is 5,000 feet long, the other 1,650 feet in length. These are 22 feet wide and 12 feet high. The canal empties into a large reservoir known as Lake Yosemite, situated about 5 miles northerly from Merced. The dam forming this reservoir is 4,000 feet long, 275 feet thick at base, and 20 feet thick at top, the greatest height being 60 feet. The estimated contents of the reservoir are 20,000 acre-feet. Water by means of pipe is conducted to Merced city, the head or pressure being about 90 feet. From the main canal are a number of laterals, carrying the water for irrigation to the various colonies and farming lands. The total cost of this irrigation system is upward of $2,000,000. It has been constructed to irrigate lands owned by Messrs. Crocker, Huffman, and others, these great tracts being subdivided into lots of 20 acres, on each of which it is expected a settler or colonist will be able to make a living by raising grapes and other fruits. Land, with water right, is sold at from $50 to $150 per acre and upward, subject to an annual charge of $1 per acre for the use of the water.

The main works of the San Joaquin and Kings River Canal and Irrigation Company obtain water from San Joaquin river and from Kings river through Fresno slough, the head of the main canal being situated in Fresno county, about 35 miles westerly from Fresno. The general course of the canal is northwesterly along the western side of the San Joaquin valley across Merced county and into Stanislaus. The total length of the main canal is 71 miles, the width being 30 feet on bottom and 60 feet on top. The total cost of the system has been over $1,500,000. The company owns and controls the main canal, the branches and distributaries belonging to other parties. Each year water rates are voted by the board of directors, those for the census year being for alfalfa lands $2.50 per acre, for cereals $2, for fruit trees and vineyards $2, and for vegetable gardens $5 per acre.

MODOC COUNTY is in the northeastern corner of the state, adjoining Oregon and Nevada. In the western end it consists largely of broad lava covered plateaus, having an altitude of about 5,000 feet. The surface is extremely rough and irregular, being broken by mountain masses. In the eastern end is a range known as Warner mountains, crossing the county in a northerly and southerly direction, and consisting of great blocks of the earth's crust tilted gently to the west, the broken edges rising abruptly from the plains on the opposite side. On each side of this range are basins resulting from the tilting of the mountain masses, these being in part occupied by lakes which have no visible outlet, their waters escaping by evaporation. The land around these lakes is usually low and marshy, and as the lakes fluctuate in height, rising at the time of melting snow and falling during the heat of summer, the area increases or diminishes by a large amount.

On the east side of Warner mountains is Surprise valley, extending along the foot of the steep declivities. This is occupied largely by the chain of lakes known, respectively, as Upper, Middle, and Lower Alkali lakes. On the opposite (western) side of the range, and at the foot of the relatively gentle inclination of the mountains, is the north Goose lake, and on the south the marshes of the south fork of Pitt river. Goose lake at some former time in its history overflowed into the north fork of Pitt river, but now this stream obtains its water wholly from creeks draining Warner mountains. Flowing southerly, the north fork joins the south fork, which comes from the opposite direction, and, uniting, the stream flows westerly for about 40 miles and then turns south through Big valley, entering Lassen county. At short intervals along its course dams have been placed, diverting the waters upon the meadows and grass lands.

Owing to the distance of this county from railroads, the principal industry has been stock raising, and agricultural operations have been directed mainly toward producing forage plants and cereals for home consumption. Little can be raised without irrigation, although an occasional crop of small grains is said to have been successful. Irrigation, as practiced, is in its crudest state, each farmer or stock raiser having taken up lands near a spring,

creek, or other stream, from which water is diverted in the cheapest manner possible. Thus, although the aggregate area irrigated is large, the investment and average value of products are small. By far the greater part of the lands are irrigated for forage and pasturage, so that the products do not appear in the agricultural returns. The irrigated lands are to be found along the foot of Warner mountains, both on the east and west, each small stream being utilized when swollen in spring by the melting snows. Also, as previously stated, there are numerous localities along Pitt river and its tributaries.

The country about the south end of Goose lake was examined in August, 1889. At that time the lake surface was reported to be about 5 feet below its average or normal low water plane owing to the excessively dry seasons during the two or three years preceding. Each winter the lake ordinarily fills nearly to the level of its former outlet and during summer recedes by evaporation, losing about 3 feet of water in depth. Taking a series of years, the average elevation is probably lower than in the early part of the last decade. Proceeding southerly along the old outlet, the ground was found to be for a mile or more at an elevation of 6 feet above the water surface of August, 1889, gradually falling until, at a distance of 6 miles, the ground was found to be practically at the same level as that of the water in the lake. A long and relatively shallow cut would thus convert this body of water into a reservoir, supplying water for lands along Pitt river. The extent of arable land which can be irrigated from the north fork of Pitt river is somewhat limited. Canals could be diverted at a point about 6 miles northeasterly from Alturas, covering all the good land in that vicinity. Also other canals, taken out on both sides of the river about 5 miles west of Alturas, could be constructed to irrigate Warm Spring valley. At a point 6 miles north of Lookout canals could be carried out on both sides covering all the good lands, of which there are approximately 70 square miles.

In Surprise valley, along the eastern front of Warner mountains, from Fort Bidwell to Eagleville, are a number of flowing wells, ranging in depth from about 50 to 150 feet and over. On the western side of the range no successful artesian wells have been reported. At Alturas a well was sunk in 1890 to the depth of 400 feet, but failed to obtain flowing water. In the whole county there were reported to be 12 flowing wells upon farms in the census year, the depth ranging from 56 to 280 feet, and the average discharge being 50 gallons per minute.

MONO COUNTY lies east of the Sierra Nevadas, between Alpine on the north and Inyo on the south It thus includes a narrow strip of country along the eastern face of the mountains, together with some of the valley region near the Nevada line. The principal industries are mining, lumbering, and cattle raising, the altitude as a rule being too great for most of the agricultural operations. The lands reported as irrigated are valley bottoms flooded for the production of hay. This area is in most respects similar to the western part of Nevada, and, like the adjoining counties, with the decline of mining operations population and wealth have rapidly diminished. In the northern end of the county are the head waters of the east and west forks of Walker river, both of these streams being of great importance in the development of irrigation in Douglas, Lyon, and Esmeralda counties, Nevada. To California, however, their waters have relatively less value, since they are used mainly for irrigating common grasses.

MONTEREY COUNTY is one of the southern coast counties, lying west of the southern part of San Joaquin valley. It includes the greater part of the Salinas valley, which is formed by the Santa Lucia mountains, stretching along the coast, and to the east by the nearly parallel Gabilan range, the summits of these latter mountains being the boundary of San Benito county. The Salinas river, rising in San Luis Obispo county, flows northwesterly between the parallel ranges through a broad valley and empties into Monterey bay, on the southern shore of which is the celebrated health and pleasure resort of Monterey. In this and the smaller valleys agriculture is carried on successfully without irrigation in spite of the fact that the annual rainfall is very small, averaging probably from 10 to 15 inches. The small amount of the annual precipitation is in part compensated by the relatively moist winds from the ocean. Most of the best agricultural land has been covered by land grants, and is still held in large bodies, used principally for grazing. Irrigation, where practiced, is conducted on a small scale, the waters of springs and rivulets being utilized by individuals having land conveniently situated. On the low grounds near the mouth of Salinas river there were reported to be 60 flowing wells upon farms in 1890, most of these being not far from Castroville. They range in depth from 60 to 189 feet, the average being 136 feet, and the discharge only about 3 gallons per minute. They are reported to fluctuate with the season, many of them ceasing to flow in summer and in winter barely discharging at the surface of the ground. At Salinas, about 10 miles from the coast, most of the deep wells are pumped by windmills. The water generally contains a perceptible amount of mineral matter and in a few cases has an oily scum. At Pleyto, in the southern end of the county, there are also reported to be flowing wells.

The canal of the San Bernardo and Salinas Valley Canal and Irrigation Company takes water from Salinas river in the southern part of the county not far from the town of Sargent. It is built on the east side of the river for a distance of 6 miles. The average width is 10 feet, and the cost was $25,000. The canal, owned by a corporation, was begun in 1884 and first used about 1888. The principal crop irrigated at present is alfalfa. The water supply is fairly good, although the river is dry at times, the water sinking in the bed of the stream.

NAPA COUNTY is one of the small counties north of San Francisco and bordering on San Pablo bay. It includes a number of broad valleys in which agriculture has been carried on for many years. The chief source of wealth is in the vineyards, whose products are known throughout the country. Besides grapes, almost every variety of the so-called deciduous fruits is produced, as well as notable quantities of olives, oranges, and lemons. Irrigation is not practiced on a scale sufficiently extensive to require enumeration. There are a few flower gardens and small areas cultivated by Italians and Chinese, to which water is applied during droughts, being lifted by wheels or pumps. As a rule the valley lands need drainage rather than irrigation.

NEVADA COUNTY extends from the extreme eastern boundary of the state over the Sierra Nevadas to the Sacramento valley. It is from 10 to 20 miles in width and about 70 miles in length. On the eastern side of the mountains are streams tributary to Truckee river, the outlet of Lake Tahoe, and one of the most important sources of water supply for the state of Nevada. Comparatively little of the water of this stream is utilized for irrigation in California, but it is employed in furnishing water power for mills and for floating logs down to the mill ponds. The fluctuations of Truckee river and its tributaries are discussed in the description of Washoe county, Nevada, since for the agricultural development of that area it is of the greatest importance.

West of the summits of the Sierra Nevadas are a number of localities in which water is held in reservoirs to supply the canals and flumes built for hydraulic mining. This industry has been of first importance, but owing to the unfavorable legislation it has almost gone out of existence. The ditches built for hydraulic work are utilized to a large extent by the mills, and water is also sold by the miner's inch to farmers and fruit growers. The prices paid have been from 10 to 12.5 cents per miner's inch for 10 hours, or from $3 to $6 per acre each season. There is considerable complaint on account of the high rates charged for water, it being asserted that under favorable circumstances the prices should not exceed $2.50 per acre per annum. The orchardists depending upon mining companies for water have little security as to the permanence of supply. Should this water be needed for mining purposes they are liable to be deprived of it, thus imperiling their trees and vines. The principal ditch systems from which water is used for irrigation are the Excelsior, Eureka Lake, Milton, North Bloomfield, and South Yuba. Besides these are many small private ditches depending upon springs or creeks. Water is used mainly for fruit trees and alfalfa, the cereals not requiring irrigation throughout the greater part of the area. On the west fruits even of a semitropic character are raised to perfection, so that this industry promises to surpass mining in value of products.

ORANGE COUNTY lies along the coast southwesterly from San Bernardino county and south of Los Angeles county, from which it was set off in 1889. It includes the lands from the coast range of hills or mountains to the Pacific ocean, extending from Coyote creek southwesterly beyond San Juan Capistrano. The coast range or Santa Ana mountains, as they are locally known, are relative to the Sierra Madre of little importance as furnishing a water supply, since the altitude rarely exceeds 5,000 feet, and the slopes are not as steep. From the base of these mountains the ground falls rapidly seaward, the greater part being less than 300 feet in elevation. Much of this low land is sufficiently moist for agriculture, and on some parts of the plain the conditions are favorable for flowing wells.

The Santa Ana river has cut a deep gap in the coast range, through which its waters escape from the San Bernardino valley seaward. This canyon extends in a nearly east and west direction, having a total length of less than 10 miles and a width from one-fourth to a mile. At the upper end of the canyon the river is at an elevation of about 420 feet and at the lower end of about 275 feet. The fall within the canyon is thus favorable for the diversion of water, rendering it possible to take out irrigating canals commanding almost any part of the coastal plain.

Fruit raising is the principal industry of the county, the returns from this being usually large. Oranges and lemons are raised to some extent, but are relatively of less importance than in San Bernardino and Los Angeles counties. Large areas were formerly devoted to vineyards, and great quantities of grapes were raised, but in 1889 and 1890 disease destroyed nearly if not quite all of the vines, resulting in the loss of millions of dollars. The returns from oranges, from groves of 6 years of age and upward, are reported to be $400 per acre and upward; from English walnuts, from trees 8 years old, $300 per acre. In many localities the orchards require comparatively little, if any, water, especially for walnuts and deciduous fruits. The orange groves, being usually on a dryer soil, are watered every 30 or 40 days during the interval from April to October.

The field crops, such as barley, corn, and other cereals, are irrigated to a small extent. Many of the lands when in a natural state are not sufficiently moist for these crops, but they can be made productive by a single watering during the winter, if the ground is thoroughly soaked. An important crop in parts of this county is the peanut, the acreage being of considerable extent. Spring crops rarely require irrigation, and these when gathered early in the season are followed by a second crop, which, however, may require water. For example, barley sown in the latter part of December is harvested early in May, and the ground is planted at once to potatoes, corn, or pumpkins. Lands in the county without water are quoted at values from $25 to $100 per acre and upward, depending upon the moisture of the soil, while those under ditch were worth from $150 up to $500 per acre or more, in some instances the annual value of the crop being apparently as much if not more than that of the land.

The water supply for the county is obtained from the Santa Ana river at points within its canyon, also from its tributary, Santiago creek, and smaller streams coming from the coast range. In addition to the surface drainage, considerable water is obtained from underground sources by the development of springs and artesian wells, the more important irrigation systems being supplied by the surface drainage. In the canyon of the Santa Ana river about halfway of its length the bed rock outcrops in places and apparently forces to the surface the water percolating through the gravel and bowlder filled channel. Thus, although the channel of the river may be dry some miles above and below this locality, yet at this point the river is perennial, the discharge sinking in summer to as low as 40 second-feet.

Santiago creek drains a portion of the coast range, having a catchment area of less than 80 square miles. It passes out of the range through a narrow gorge, thus affording a perennial supply to lands below this point, this, with the Santa Ana river, being the principal stream of the county. The creeks draining the high grounds to the south are intermittent in character, and during the summer season their waters rarely reach the sea.

In the western end of the county, in the vicinity of Garden Grove and Westminster, are a large number of flowing wells, so many in fact that it is currently stated that every farmer has one. They are little used for irrigation on account of the moist character of the soil in the vicinity, water sometimes standing within 3 or 4 feet of the surface. Their principal value is in furnishing water for domestic use and for gardens. The total number of wells reported as being upon the farms of the county was 649, the depth ranging from 26 feet to 450 feet. The average depth was 147 feet, the average cost was $209, and the average discharge was 110 gallons per minute, or 0.24 second-foot. Unfortunately the flowing water does not rise to the level of the lands most requiring irrigation, and attempts made at such points have often been unsuccessful. As in the case of Los Angeles county, many of the farmers were prejudiced against the use of artesian water for irrigation, believing that good lands had been thus ruined by the development of alkali upon the surface following the too lavish application of this water.

The three principal systems of the county are, first, that on the north side of the Santa Ana river irrigating lands in the vicinity of Anaheim; second, that on the south side of the river covering lands in the vicinity of Orange, Santa Ana, and Tustin, and, third, that receiving water from Santiago creek and irrigating the grounds above the canal system just named. The most northern system has been owned for many years by the Anaheim Union Water Company, which constructed or bought over 100 miles of open canals and branches, covering 12,000 acres, of which about 7,000 were usually irrigated. The water was sold by "heads" at varying rates, the charge during summer, when the supply was scanty, being greater than in winter. A "head" was considered to be about 100 miner's inches, and the privilege of buying or hiring one of these "heads" was limited to stockholders in the company. The summer rate was for the census year 50 cents per hour during the daytime and 25 cents per hour at night, while the winter rate was 25 cents per hour for day and 15 cents per hour for night water.

The Santa Ana Valley Irrigation Company had in the census year probably the largest and most important irrigation canal in this part of the state. Water was taken from the south side of the Santa Ana river at a point about 12 miles above Orange by a canal, a portion of which was lined and cemented. The canal, following along on the south side of the river in the canyon, passed by means of a tunnel through a spur of the hills and then divided, commanding 20,000 acres within the old rancho Santiago de Santa Ana. The maximum quantity in the canal as measured by the state engineering department was 45 second-feet. The charge for water per 100 miner's inches was 20 cents an hour during the daytime and 10 cents an hour at night. In times of scarcity the charges were 30 cents an hour during the day and 15 cents an hour at night. The sales of water were made to the holders of shares of which there were 20,000, or one for each acre under the ditch. The original cost of a share was from $5 to $10 and the value during the census year was $20.

The water from Santiago creek was taken by the Serrano and Carpenter Water Companies, who joined in constructing diverting works, dividing water after it had been taken into one canal. An interesting feature of the headworks was the submerged dam which intercepted water percolating through the channel. At the narrowest part of the pass, at the outlet of the creek, an excavation was made to bed rock, the open cutting 12 feet wide extending across the channel of the creek from wall to wall. This was filled with a puddle wall of clay. The efficiency of this wall in stopping the seepage was shown by the fact that the willows and cottonwoods growing along the channel below this point died, apparently from lack of moisture. Water is distributed by these companies mainly by pipes. The summer supply is probably about 5 or 6 second-feet, or at times even less, and the area irrigated was approximately 2,000 acres.

In this county one successful irrigation district has been formed, covering land in the vicinity of Anaheim. The total area is 32,500 acres, and the assessed valuation is stated to be $1,245,742. Bonds to the amount of $600,000 have been voted, this being at the rate of $18.46 per acre, and half of these have been sold at 90 per cent of par value. This is reputed to be one of the best irrigation districts in the state as regards its organization and financial ability. It includes large areas of land which have been under cultivation for years, some of which set out to orchards is worth from $1,000 to $2,000 per acre. The unimproved land within the district is probably worth upward of $100 per acre. It is proposed to purchase the property of the Anaheim Union Water Company and to develop other sources of supply.

PLACER COUNTY is south of Nevada county, and, like it, extends from the state line on the east down the slopes of the Sierras in a long, narrow strip to the Sacramento plains. On the eastern edge is Lake Tahoe, this body of water being partly in the state of Nevada. The drainage area tributary to this lake is small, and the greater part of the precipitation within the county flows westerly into the American, Bear, and other rivers. As in the case of Nevada county to the north, the cultivation of fruit is rapidly becoming a most important industry, especially in the foothill region between the mountains and the Sacramento valley. Localities in former years celebrated for mineral wealth are again becoming known through the excellence of the fruits cultivated in the vicinity. Irrigation is widely employed, although there are still many orchardists who claim that they can raise as good or better fruit without the artificial application of water. It is necessary, however, to cultivate the ground thoroughly and keep the surface of the soil well pulverized to prevent excessive evaporation during the long summer drought. Most of the cereals are raised without irrigation, and in many localities alfalfa is seldom watered.

The principal irrigation system is that belonging to the South Yuba Water Company. This originally derived water from Bear river, but as this stream often became nearly dry during July it was found essential to draw upon other rivers. A canal has been constructed by which water is taken from South Yuba river and from storage reservoirs in Nevada county to supply the deficiency in Bear river. The total length of the main ditches and branches in both Nevada and Placer counties is stated to be about 380 miles. There are also 8 important storage reservoirs high among the mountains and a number of smaller distributing reservoirs near the localities to be served. Water is sold at the rate of 30 cents per miner's inch a day for 5 months, or at the rate of 12.5 cents a day for 1 year. This is equivalent to $45 per miner's inch per year. This quantity of water is considered to be sufficient for from 4 to 6 acres or even up to 10 acres when used with care. Thus the cost of water may be stated to range from $4.50 up to $11.25 per acre per annum.

PLUMAS COUNTY is in the northern part of the Sierra Nevada range, being bounded on its eastern edge by the watershed of the Great Interior basin. In spite of its mountainous character it contains a number of open valleys suitable for agriculture, the principal among these being at altitudes of nearly 5,000 feet and upward. As in the adjoining counties, mining and stock raising are the principal industries, dairy products assuming considerable importance. The lack of facilities of transportation has retarded development to a large extent. The rainfall is relatively heavy and the ordinary operations of agriculture are successful without irrigation, wheat, barley, oats, and other cereals being raised by "dry" farming, but water is applied artificially for the purpose of making meadows and increasing the quantity of hay. The area reported as irrigated includes much of this land, upon which water is turned in the spring and allowed to find its way with little guidance over the fields. In this respect this and other counties of northern California may be compared to those of Nevada, in which large acreages are irrigated or partially flooded in the cheapest manner possible. From the high mountains surrounding each valley almost numberless streams issue, each of the larger of these being diverted from its natural course and by means of short ditches forced to cover the lands of one or two ranchers in the valley.

The water used for irrigation is obtained to a large extent from ditches built by the miners, but besides these are the numerous short ditches constructed by the owners of ranches taking out water generally for the use of one or two persons. The land which is not under ditch but is utilized for pasture is worth from $3 to $5 per acre, while the same with water is quoted at from $20 to $50 per acre. A number of fruit trees have been set out in various parts of the county, and many of these are thriving and producing sufficient for local consumption. In the southeastern corner of the county and extending southerly into Sierra county is a broad basin known as Sierra valley. This is drained by the head waters of Feather river, but in many respects is similar to the valleys of the Great Interior basin. Like them it is filled to a depth of 1,000 feet or more with recent sedimentary deposits in which the conditions are favorable for obtaining flowing wells. The first wells were drilled probably about 1863 or 1864, but the number was not greatly increased for nearly 20 years. When the fact was fully appreciated that flowing wells could be obtained in nearly all parts of the valley many were put down, the result being that in some instances the discharge from old wells ceased and all decreased with more or less rapidity. In 1890 there were reported as being on farms in Plumas county 159 of these flowing wells. The depth of these ranged from 60 to 1,132 feet, the average depth being 550 feet. The average cost per well was $165 and the average discharge 40 gallons per minute. The small average cost is due to the fact that in the Sierra valley at least the wells are drilled rapidly through clay, only one length of casing being used, that being placed at the top in order to keep out surface water. The clay stays in place remarkably well and does not require mechanical support. The water is generally warm, sometimes hot, and is used mainly for watering stock, a small amount being employed for gardens and for raising vegetables.

SACRAMENTO COUNTY includes a portion of the central part of Sacramento valley east of the river and extending to the foothill regions. The greater part of the area is less than 100 feet above sea level, and on the western and southwestern sides the lands in their original condition were overflowed and marshy. Extensive systems of dikes have been built, reclaiming valuable tracts whose surface, though below water level, is covered by a soil of wonderful fertility. Adjoining these are extensive areas at a slightly greater altitude, but kept moist

by the presence of the ground waters saturating the subsoil or lower layers. Still further to the east are the higher grounds, also of great fertility, but subject to summer droughts. Irrigation is practiced to a relatively small extent, since all the cereals are successfully raised upon the broad plains, water being employed mainly for orchards and vineyards on the higher grounds of the county. In the southwestern prolongation of the county lying between Mokelumne and Sacramento rivers are a number of large islands reclaimed by dikes and upon which flooding can be practiced, if required. This can hardly be called irrigation in the sense in which the word is ordinarily used, and therefore these areas of swamp lands have not been included among the irrigated farms.

Water for a large proportion of the irrigated orchards is obtained from wells varying in depth from 10 to 40 feet. This is pumped by means of windmills or by steam or horse power. The wind can usually be depended upon from April to August, but in the latter part of the summer is often light and fickle. In other respects this method of obtaining water is usually preferred by owners of small orchards. The cost of the windmills is placed at from $75 to $110, of pumps at from $15 to $40, and of wells at about $1 per foot in depth or less for the more shallow. A large windmill having a wheel of about 14 feet in diameter and driving two 6-inch pumps will usually furnish sufficient water for 5 acres. Various forms of steam pumps are used, depending largely upon the height to which water must be raised. In this county there are several deep wells, but it is doubtful whether any of them can be classed as artesian. On Tyler island, 30 miles south of the city, is a well 102 feet deep, in which water rises to within 6 feet of the surface. Near Arcade, about 8 miles northeasterly from Sacramento, a well was drilled to the depth of 2,160 feet, at a cost, it is stated, of $30,000, but without success so far as flowing water is concerned. Other wells near Sacramento have been drilled nearly 600 feet deep with the same result. West of Sacramento, near Davisville and Woodland, in Yolo county, wells have been drilled to depths of 200 feet or more. The water in these rises nearly to the surface, and in the case of one at least flows during a part of the year. Further to the southwest are flowing wells north of Suisun and San Pablo bays.

Measurements of the amount of water flowing in the streams of this county have been made by the state engineer, as previously noted. The total discharge of Sacramento river at its mouth has been estimated for the period extending from 1879 to 1885, inclusive, as shown on a preceding page. Computations of the discharge of Dry creek were also made by the state engineer, giving its discharge at the base of the foothills, and of Cosumnes river, the most northern tributary of San Joaquin river. The following table gives the fluctuations of this stream, the quantities applying to a point within the foothills above Deer and Carson creeks:

DISCHARGE IN SECOND-FEET OF COSUMNES RIVER AT LIVE OAK SUSPENSION BRIDGE, CALIFORNIA.

(Drainage area, 580 square miles.)

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1879	290	1,218	1,740	3,132	3,248	3,480	422	116	23	17	52	406	1,179
1880	232	441	696	4,582	5,104	6,090	2,726	348	29	17	12	290	1,714
1881	1,624	3,074	1,102	3,190	3,074	1,218	174	87	87	58	174	522	1,199
1882	522	522	1,740	2,320	4,524	2,900	696	580	52	232	100	100	1,191
1883	348	290	522	1,740	3,480	2,320	580	232	87	87	116	116	827
1884	145	1,740	3,480	3,480	2,900	2,320	2,320	580	116	87	.....	.....	.....

The most important project in connection with irrigation in this county is the dam across American river, built by the Folsom Water Power Company at a point a short distance above the penitentiary. This structure is of the most substantial character, being built throughout of masonry. It was constructed through co-operation with the state authorities, by which convict labor was utilized. The main portion of the dam is 250 feet in length, and the greatest height is about 70 feet on the upstream side and nearly 100 on the downstream face. It is 24 feet in width on top and 87 at bottom. All parts of the structure have been designed to withstand the floods of the American river, these rising to heights of over 30 feet above the crest of the dam. On each side of the river are suitable headworks for canals, that on the right-hand or eastern side being completed. The works on the west side will probably not be undertaken for sometime, but the canal on the east, 50 feet wide on top, has been built to and beyond the penitentiary grounds. Water from this canal will be utilized for power and also for irrigation on lands south of American river. There are already small ditches covering a portion of this area, these being the property of the Natoma Water Company or of individuals.

SAN BENITO COUNTY lies southeasterly from San Francisco, comprising a portion of the long, narrow valleys between the two nearly parallel ranges west of Fresno and Merced counties. To the north is Santa Clara county, which extends also between mountain ranges to the bay of San Francisco. The greater part of the streams unite to form San Benito river, which, instead of continuing northerly through Santa Clara county, when near the northern county line turns abruptly and flows westerly into the bay of Monterey. The greater part of the surface of the county is undulating or mountainous, and the area of agricultural land is relatively small. The grazing upon the hill slopes is good and stock raising is an important industry, especially in the southern end of the county. Fruit raising is also profitably carried on, especially in the vicinity of San Juan, Hollister, and other

towns. Irrigation is little practiced, since nearly all products are successful without the artificial application of water. Along San Benito river, however, and other streams a number of small irrigating ditches have been dug, these being usually from 1 to 2 miles in length. Water from artesian wells is also used to a small extent for fruit trees and alfalfa.

In the northern end of the county on the lower lands are a number of flowing wells, there being in all 117 enumerated upon farms in 1890. In depth these range from 29 to 329 feet, the average depth being 111 feet and the average cost $188. The artesian area appears to extend along San Felipe valley, wells being found upon both sides of the river, those on the north being in Santa Clara county. The quantity of water delivered by these wells fluctuates with the season, the flow being usually greater during a wet year. Only a small proportion of the water is used for alfalfa, fruits, and vegetables, the remainder flowing to waste.

SAN BERNARDINO COUNTY is in southern California, being separated from Mexico by San Diego county only. It extends from the Colorado river and the state line of Nevada on the east westward nearly to the Pacific ocean, at least at its southwestern corner. By far the greater part of the county is upon the Colorado or Mohave desert, the southwestern prolongation extending over the lofty mountains down into the valleys drained by the Santa Ana and other streams flowing to the sea. It is in this relatively small portion of the county that are concentrated nearly all the population and wealth of this the largest political division of the state.

This county contains some of the best examples of irrigation development to be found in the whole country. Although dealing with comparatively small quantities of water, these systems are notable for the elaboration of details and the care and expense lavished in saving and utilizing the water resources. There are to be found in the southwestern part of the county storage reservoirs, carefully built ditches, many of them paved and cemented, tunnels, flumes, pipes of cement, iron, and steel, many devices for measuring, dividing, and distributing the water; in short, examples of nearly every type of irrigation works, from the most crude to the latest improvements. In the point of cost and thoroughness of construction these works can best be compared with those built for municipal supply, some of the systems, though used for irrigation, being of the nature of city waterworks, bringing water under pressure both to the houses and to the orchards.

The high state of development of irrigation in San Bernardino and adjoining counties is due to the peculiarly favorable topography and the existence of physical features, duplicates of which can hardly be found in any other part of the United States. Two remarkably high and precipitous mountain ranges enter the southwestern part of the county from directions nearly at right angles to each other, and apparently culminate in the peaks northeasterly of the city of San Bernardino. The first of these, the Sierra Madre range, or San Bernardino mountains, has a general east and west trend through Los Angeles and Ventura counties, while coming up from the south are the San Jacinto and other mountains, trending in general parallel to the coast. The San Bernardino mountains have a height of from 6,000 to 7,000 feet, a few of the peaks rising to 9,000, 10,000, or even 11,000 feet and over in altitude. To the north and east of these stretches out the broad plain, broken by short ranges of mountains, among which the channel of the Mohave river meanders. The precipitation both of rain and snow upon these steep and lofty peaks is very great, giving rise to streams which flow down with rapid descent to the plains below. Each of these streams has cut for itself deep, narrow gashes, or canyons, in the mountain side, and the debris, consisting of sand, gravel, and bowlders, has been piled in great masses at the points where the streams enter upon the lower plains. A great part of the water, especially during the summer, disappears into these pervious deposits, to come to the surface again in springs, or cienegas, at lower points. These cienagas are found sometimes on or near the mesas bordering the valley or on the bottom lands, but wherever they occur they are of very great value, lands upon which they are situated being purchased at enormous cost.

Among the high peaks are open valleys, several of which have a topography favorable for the construction of reservoirs, in which can be held the water from rain and melting snows. The waters thus held can be discharged into the stream channels and to a large extent recovered at points of diversion below. Much of the water which sinks into the gravel or bowlder channels of the streams can be or has been brought out by means of tunnels driven into the steeply sloping beds until solid rock is reached, the percolating waters being intercepted in this manner.

The water thus obtained from the surface streams, from storage reservoirs, tunnels, springs, and artesian wells is conducted by open channels, flumes, and pipes to the rich mesa and valley lands, the systems of distribution being in the aggregate exceedingly complicated, sometimes crossing and recrossing, water from one side of the valley being brought to the other and lands in the vicinity of one source of supply being covered by water from a distant locality. This is the result that might be expected from the gradual evolution of crude methods of irrigation and the growth without plan or system, adding a piece here, reconstructing there, and compromising quarrels or difficulties in the manner that at the time seemed best or easiest. All of these facts, as well as the physical features, have been so graphically described by the state engineer (*a*) and shown in such detail on the irrigation sheets prepared by him that it seems unnecessary to enter further into them. (*b*)

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a Irrigation in Southern California, by William Ham. Hall, C. E.

b The county and its irrigation works have also been described by F. C. Finkle, C. E., in the Engineering News. Irrigation and Irrigation Districts in San Bernardino County, California. Engineering News and American Railway Journal, New York, 1891, volume 26, pages 2, 75, 76, 171, 172, 182, 183.

By bringing water upon the mesas or benches which lie along the foot of the mountains large areas of this fertile land have become of extraordinary value, advancing from a few dollars to several hundred per acre, the expenditure for water supply being but a small fraction of its present worth. The soil on these mesas varies greatly, but much of it is well adapted to the cultivation of citrus fruits, to which also the climate and other influences are peculiarly favorable. Many thousand orange and lemon trees have been cultivated with success, as well as olives, grapes, and the so-called deciduous fruits. Under favorable circumstances the product per acre has been marvelous, reaching $1,000 or more. Such profits, both in the increase of land values and in the annual productions, justify extraordinary expenditures in the conservation of water even to an extent far greater than now practiced. Progress is being made in this direction not only by the water companies but also by the formation of irrigation districts, which either develop their own source of supply or purchase a stated quantity of water from companies already formed.

In order to increase the efficiency of the supply and to prevent loss of water in distribution many of the ditch owners have made decided improvements in the methods of conducting and distributing the water. The old open channels have in many cases been lined with cement or replaced in part by pipes of iron, steel, earthenware, or wood, and every precaution has been taken to prevent waste, thus tending to raise the water duty to an amount higher than that obtained in other parts of the arid region. As a rule it may be said that water is too valuable to be used upon any but the higher class of fruits and vegetables. Nearly all of the cereals are grown upon the lands of the San Bernardino valley and along the Santa Ana river without irrigation, the average production being relatively small.

There is as great diversity in the methods of distributing water as in its ownership. Under perhaps the best system water is piped, under pressure, to each small tract and can be drawn from a hydrant at the pleasure of the irrigator, he paying a certain rate per year. In this way probably the greatest economy of water and time is insured, for the right quantity can be applied to the ground at the proper moment. Under other systems the owner of a share in a ditch or pipe line receives the whole flow for so many hours or minutes, depending upon his proportion to the total ownership. In this case he must be ready at any time, day or night, to apply the water to the ground, or else lose his turn. To obviate the inconvenience and loss, as, for instance, at night, working by the light of a lantern, neighboring irrigators sometimes make arrangements to "pool" together and rearrange the time to suit themselves, or if a man can afford it he constructs a small reservoir to hold his share of the water until needed. Under still other systems the irrigator receives a constant small stream of water day and night, and this to be advantageously used must be received in cement tanks or reservoirs until sufficient has accumulated to flow readily over the dry ground. Many of the water companies, irrigation districts, or associations of land owners own stock or have partnership arrangements with other corporations, so that the business relations, as well as the irrigation works, are somewhat complicated and can not be made plain in a brief description. These purchases of stock and interrelations have grown up from compromises made in settlement of disputes, which in some cases have cost more than the construction of the works themselves.

The quantities of water handled by the different companies in this county are small relative to those carried by the great ditches of other parts of the state, as, for example, those of Kern county. There have been but few measurements made of streams in this county, but these will serve to show the size of the principal ones. The following table of the mean daily discharge of the Santa Ana river is taken from the report of the state engineer (*a*), the quantities being converted into second-feet. It should be noted that the discharge in these years was regarded as exceptionally small. (*b*)

MEAN DAILY DISCHARGE OF SANTA ANA RIVER AT THE POINT WHERE IT LEAVES THE MOUNTAINS.

MONTHS.	1881	1882	1883	MONTHS.	1881	1882	1883
May	24	24	24	September	16	13	13
June	22	23	23	October	20	17	17
July	20	18	18	November	22	21	21
August	14	13	13	December	22	22	22

a Irrigation in Southern California. William Ham. Hall, C. E., page 191.

b The maximum and minimum discharges of Lytle creek, as observed by F. C. Finkle, C. E., at the mouth of the canyon are as follows:

YEARS.	DISCHARGE IN SECOND-FEET.		YEARS.	DISCHARGE IN SECOND-FEET.	
	Minimum.	Maximum.		Minimum.	Maximum.
1887	14.83	1,842	1890	23.46	2,752
1888	18.67	2,231	1891	18.21	3,179
1889	17.39	2,113	1892	13.73	893

The minimum discharges occur in August or September and the maximum discharges in January or February.

In San Bernardino county in 1890 there were enumerated as being on farms 301 artesian wells, ranging from 65 to 700 feet in depth, and having an average discharge of 283 gallons per minute. The water of many of the larger of these wells is piped to the various towns, giving them an ample supply of clear, pure water. A few of the wells are used for purposes of irrigation, an average of 20 acres being watered to each well thus employed. A large number of wells have been put down by land companies in order to ascertain the extent and amount of the artesian supply, and the resources of the county in this direction are quite well explored. A few of the farmers complain that these large wells, which have been allowed to flow freely for months or years, have resulted in the drying up of the shallow wells near the edge of the basin.

The following list, prepared in 1890, gives the names of the principal irrigating systems, together with the total area which it was estimated could be irrigated by each at that time:

	ACRES.		ACRES.
Total	144,750	Mill creek	5,000
		North Riverside canal	10,000
Riverside	10,000	Vivienda pipe line	5,000
Gage canal	15,000	Rincon ditch	4,000
South Riverside	6,000	Chino pipe line	2,500
Pomona	12,000	City creek	500
Ontario	5,000	Twin creeks	3,000
Etiwanda	3,200	Banning	4,800
Cucamonga	10,000	Colton Terrace	1,500
Lytle creek	15,000	Bear Valley reservoir	18,000
North Fork ditch	4,000	Glen Ellen	2,000
South Fork ditch	4,000	Meeks and Daly ditch	4,250

The list given above comprises only the more important systems of water supply, there being others in operation or under construction which might properly be mentioned. In attempting to describe even in a brief way the irrigation works of San Bernardino county a compiler is presented with such a mass of facts and statistics that it seems impossible in the space alloted to do justice to the various systems. An attempt is made, however, to describe some of the more novel features, especially in connection with the utilization of storage reservoirs and artesian wells. These matters are taken up in a general geographic order, beginning with the works of the Bear Valley Company, on the head waters of Santa Ana river. On the south side of this river the principal works mentioned are the Gage, Riverside, and South Riverside canals, and on the north or left hand bank the North Riverside and Jurupa. Brief mention is also made of some of the irrigating systems receiving water from the canyons on the north side of the valley, namely, the Rialto, Semi-Tropic, and Etiwonda, and of the Arrowhead storage scheme, whose reservoirs, high in the mountains, will probably supply water to this part of the county.

The irrigation system most widely known is that of the Bear Valley Company, taking its name from that of its reservoir, located in the high mountains northeast of San Bernardino. This company has not only constructed one of the largest reservoirs in the country but has other projects for saving water and for distributing it widely over the country to the south and west. It appears that the principal part of the business of this company consists not in selling water to individual consumers but in disposing of it in large quantities to other water companies or to irrigation districts, who in turn apportion the water to the consumers. The water is obtained by the company not only by storage in Bear Valley reservoir but also to some extent from the flow of surface streams and from tunnels and wells. Efforts are being constantly made to increase these sources in number and in availability, the works being extended from time to time.

The Bear Valley reservoir has been formed by placing a dam across the outlet of a high mountain valley about 20 miles northeasterly from the city of San Bernardino. This valley is described by the state engineer as being a remarkably large and flat mountain basin lying at an altitude of from 6,200 to 6,300 feet above the sea. Out of its western extremity is a deep gorge cutting southerly, allowing the waters from this valley to flow into Santa Ana river. The bottom of the valley is about 12 miles long and from an eighth of a mile to a mile in width. A dam 120 feet high would create here a pond over 11 miles long, submerging a little less than 8,000 acres. The catchment area tributary to this valley is less than 45 miles in extent, and for the most part is steep and heavily timbered. The precipitation is very large, owing to the peculiar topography. The dam built by the Bear Valley Company is remarkable, from the fact that it consists of a stone wall, curving up stream, and held from being overturned by the water above it by the arched form. Its extreme height is 64 feet, length at top 300 feet, thickness at top 3 feet, and at 48 feet below the top only 8.5 feet. In spite of many predictions to the contrary this dam has stood, but in order to increase the storage capacity and for other reasons the company has decided to construct a new masonry dam below the first, and one which does not depend upon the principle of the arch to hold its place. The areas and capacity of the reservoir at different elevations are shown by the table on the following page. (*a*)

a Irrigation in Southern California. William Ham. Hall, page 182.

ELEVATIONS OF WATER PLANE.		Corresponding areas of reservoir surface. (Acres.)	CAPACITIES OF RESERVOIR: TOTALS ABOVE GROUND SURFACE.	
Above base of dam. (Feet.)	Above outlet. (Feet.)		Cubic feet.	Gallons.
10	0	4.95	631,000	4,000,000.72
20	10	34.93	6,921,900	51,000,000.78
30	20	264.54	67,850,660	507,000,000.52
40	30	1,060.01	312,153,521	2,334,000,000.91
50	40	1,691.41	920,824,487	6,887,000,000.77
60	50	2,251.50	1,763,166,320	13,188,000,000.38
70	60	2,812.00	2,834,253,750	21,199,000,000.22
80	70	3,300.00	4,161,190,000	31,125,000,000.70

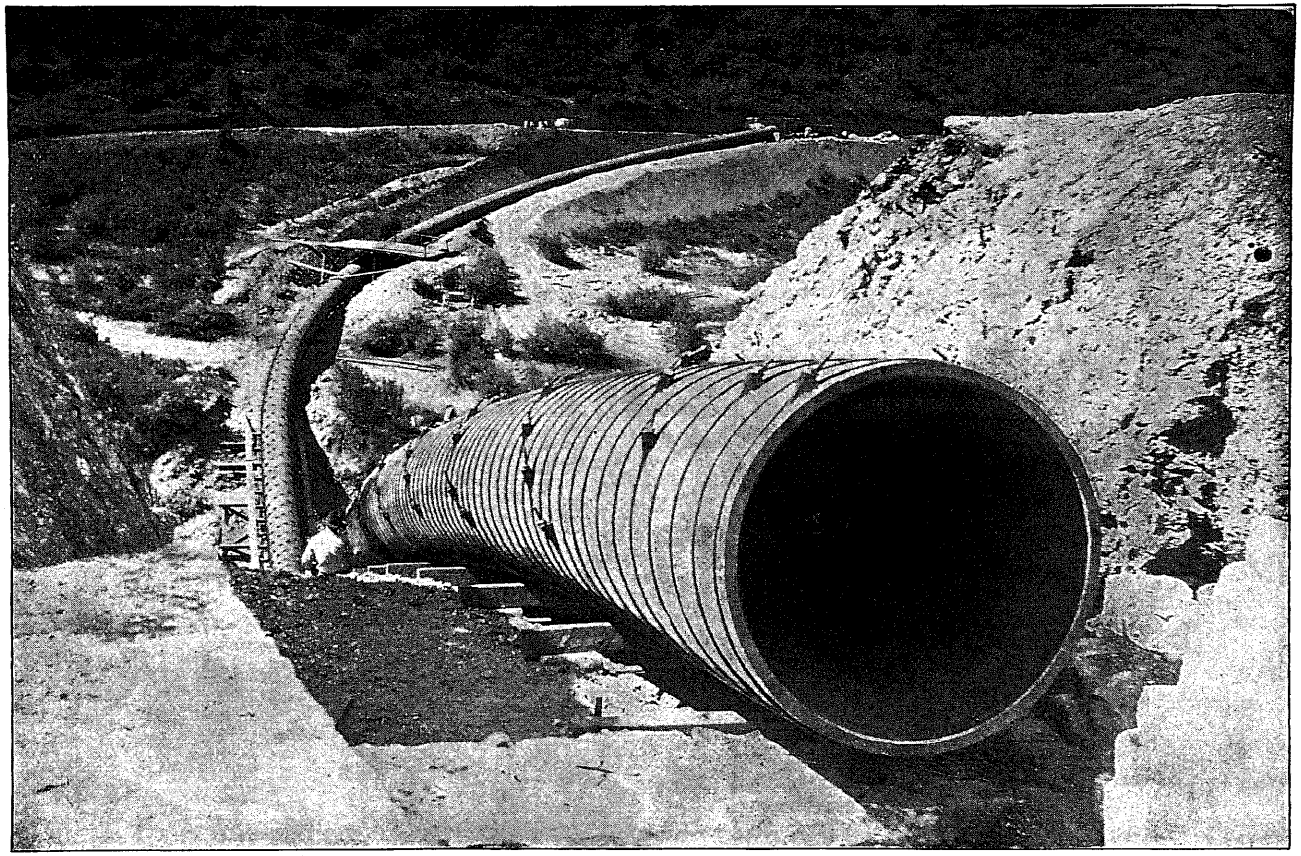
The dam cost upward of $75,000, a sum largely in excess of what it would have cost had it not been for the great difficulties of transportation between this point and the lower valleys. From the reservoir the waters flow down Bear creek to the Santa Ana river and are diverted by ditches owned by the Bear Valley Company acting in co-operation with other companies. These ditches carry the water out on the north and south sides of the river and in turn deliver it to irrigators' ditches and to pipe lines owned by the various water companies or irrigation districts. In the case of the Alessandro and certain other districts the company agrees to deliver a supply of water sufficient for the irrigation of all lands, this being estimated to be at the rate of 1 miner's inch to each 4 acres, or 1 second-foot to 200 acres, a water right larger than possessed by many irrigators. Each certificate issued entitles the owner to 1 acre-foot of water per year upon the payment of $1.39 on the 1st of April, and $1.39 on the 1st of October of each year, the water being delivered in general at the times and in the quantities desired by the user. The reservoir company issues two classes of water certificates, known respectively as A and B. Of class A, there were issued on June 1, 1886, 7,200 certificates on the basis of 1 miner's inch to 7 acres. The water called for by these must be used for irrigating lands in Redlands, Lugonia, Mound City, Highlands, and vicinity. The certificates of class B, mentioned above, have been sold in part to the Perris, Alessandro, and other irrigation districts.

The property of the Bear Valley Company consists, besides the reservoir, of a half interest in the North Fork canal, the canal on the south side of the river, the pipe line to the Crafton reservoir, the pipe line to the Alessandro and Perris districts, and other lines and distributing systems. The pipe line to the Alessandro tract after passing by a tunnel through the San Timoteo hills has a fall of about 300 feet, furnishing a water power of great value.

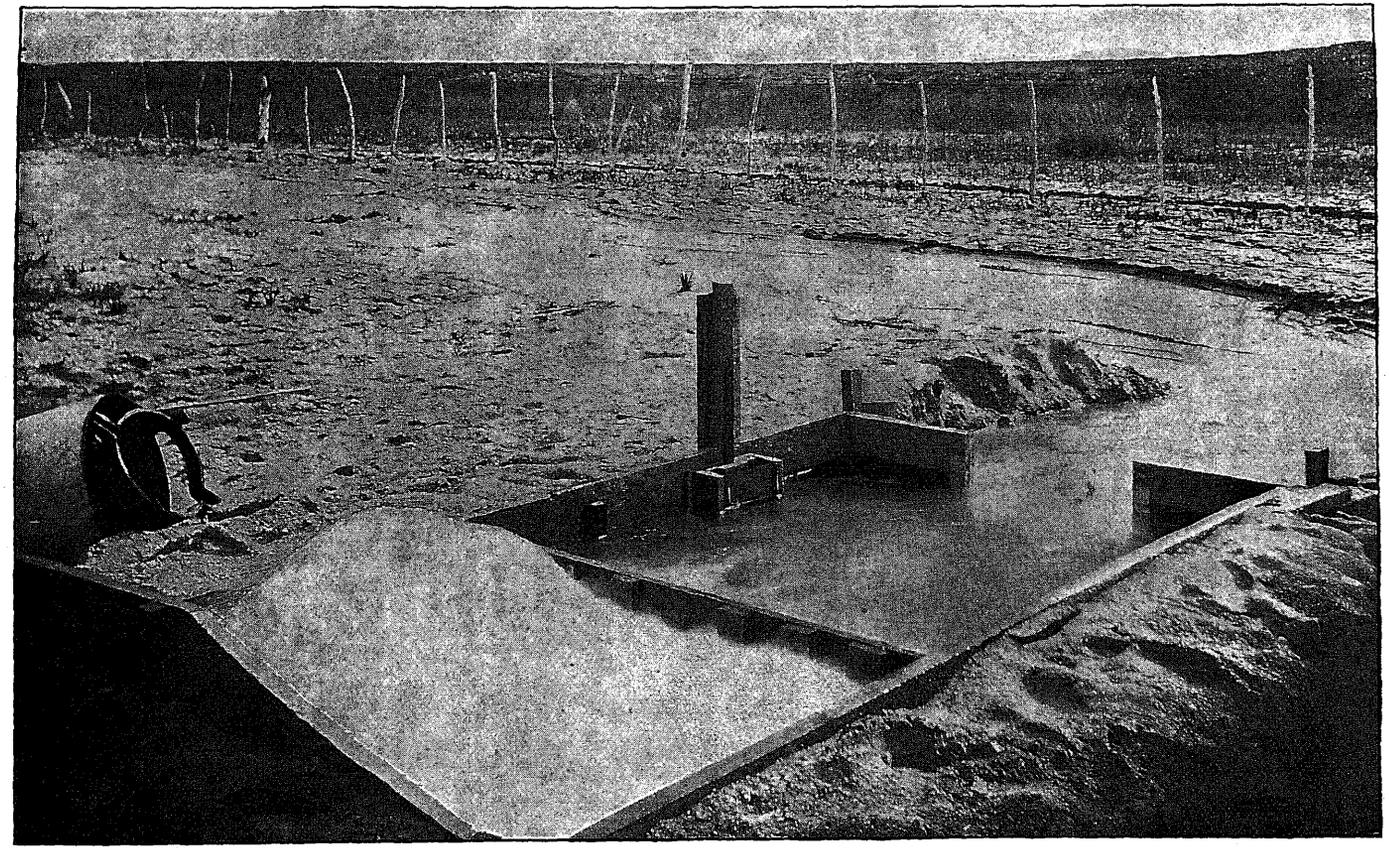
The irrigating system of the Gage canal is remarkable in many ways, and not the least of these is the method of obtaining water. The greater part of the supply is had from 51 artesian wells, whose aggregate discharge was found to be 1,793.45 miner's inches, or, at 50 inches to the second-foot, 35.87 second-feet. In addition, water is obtained from the Santa Ana river, so that the canal company has a minimum supply in all of something over 42 second-feet. The artesian area extends along the Santa Ana river, embracing a considerable tract of land located at from 2 to 3 miles southeasterly from San Bernardino. The wells are widely distributed, but in general extend for a distance of 3 miles along the upper part of the canal and in the river bottom.

GAGE ARTESIAN WELLS—DEPTH AND CAPACITY.

NUMBER OF WELL.	Distance apart in feet.	Depth in feet.	Pressure in feet.	Capacity in miner's inches.	NUMBER OF WELL.	Distance apart in feet.	Depth in feet.	Pressure in feet.	Capacity in miner's inches.
Total				1,793.45					
1	0	656	25	5.00	26	280	123	13	21.00
2	1,216	534	70	32.50	27	320	125	14	9.00
3	296	382	76	20.00	28	280	144	15	38.00
4	525	482	74	41.25	29	310	140	16	28.35
5	561	320	23	3.50	30	790	138	13	11.25
6	265	784	80	45.00	31	430	106	15	3.75
7	4,620	196	11	13.75	32	35	130	16	16.25
8	353	190	11	21.00	33	315	146	18	41.00
9	204	142	11	3.50	34	550	116	16	48.00
10	320	148	12	3.25	35	130	134	15	30.50
11	714	141	28	24.50	36	120	116	16	16.00
12	80	181	29	21.62	37	680	147	16	42.00
13	765	426	16	86.50	38	90	122	16	28.75
14	530	472	17	101.50	39	276	115	17	10.50
15	1,680	518	17	62.50	40	1,090	169	17	77.15
16	190	388	50	50.00	41	474	193	14	63.50
17	175	380	50	32.00	42	510	192	17	85.75
18	480	386	50	27.00	43	510	390	18	109.75
19	330	196	17	43.50	44	500	224	20	92.75
20	270	124	12	9.50	45	1,580	123	25	76.50
21	260	116	13	24.75	46	15	133	25	6.70
22	270	134	17	50.50	47	15	133	25	24.40
23	265	168	11	36.00	48	40	139	25	29.33
24	265	166	14	26.00	49	50	211	23	28.40
25	320	152	14	19.75	50	40	100	25	15.00
					51	1,590	300	22	80.00



VIEW OF FIFTY-TWO-INCH REDWOOD PIPE, CROSSING WARM SPRINGS CREEK NEAR REDLANDS, SAN BERNARDINO COUNTY, CALIFORNIA, ON THE MAIN HIGH LINE OF THE BEAR VALLEY CANAL.



VIEW OF ARTESIAN WELL AND MEASURING DEVICE, GAGE SYSTEM, SAN BERNARDINO COUNTY, CALIFORNIA.

The figures given in the preceding table were obtained from the engineer of the company, who states that measurements of discharge were taken at the end of the irrigating season while all the wells were open and after they had been flowing freely during the summer. The pressure in feet was taken of each well while it was closed. The accompanying illustration gives a near view of one of these wells and shows the method of measuring the discharge. At the left the water is seen flowing over the top of the pipe and falling into a small wooden compartment. From this it passes through a screen made of wooden slats into the second compartment, the object of the screen or partition being to break and diffuse the motion of the water. On the far side of the second compartment is an opening, the edge of which is covered by a metal plate accurately placed so as to form a weir. At one side is a small chamber, and in this is placed the hook gauge for measuring the height of water.

All the wells are put down by means of a sand pump, which works inside of a double thick iron casing, this casing being forced down by means of hydraulic jacks. The sand pump consists of a tube with a valve at the bottom so arranged that sand and small gravel can enter freely. When the sand pump is lifted the valve closes and the sand and gravel are brought to the surface. As the material is thus excavated the casing or lining of the well is forced farther and farther down. This lining is made of two thicknesses of sheet iron of No. 10 or 12 gauge and consists of sections 2 feet in length. The inside and outside lengths are inserted alternately, the joints of an outside pair coming opposite the middle of an inside piece and vice versa. The casing is thus practically continuous and after being put in place soon becomes perfectly tight.

Water from the river is diverted by means of temporary brush and sand dams renewed each year, the expense of so doing being less than the probable interest and cost of maintenance for more permanent works, since the channel of the stream is composed of shifting sands and of other unstable material. The flood discharge at times reaches 2,000 second-feet or over, this quantity quickly diminishing to medium or low stages, at which time all the water in the river can, if necessary, be diverted into the canal by quickly throwing up a small embankment of sand. The total length of the canal is a little over 20 miles, and throughout the greater part of the line it has been excavated, generally in clay, to a depth of 4 feet, and on a grade of from 2 to 3 feet per mile. Work was begun in 1885, and construction was practically completed in 1888. Since that time, however, many improvements and alterations have been made.

For the greater part of its length the canal is lined with masonry, which in all tunnels and fills is 5 inches thick, this being covered with cement mortar. The remaining portions are lined with cement plaster having a thickness of three-fourths of an inch. The aggregate length of the tunnels is very nearly one mile, and of the flumes three-fourths of a mile.

From the canal water is distributed by means of pipes located at convenient intervals. Water is admitted to these by means of metal valves inserted in brick bulkheads. In each of these bulkheads is a small measuring weir, so that the amount diverted at each point can be accurately ascertained. The steel pipes traverse the streets of the towns under the canal and are provided with lateral connections to each lot, water being thus carried to a hydrant located at the highest point of 10-acre subdivisions. The water from the hydrants can then be conducted in small open flumes to the irrigating furrows. The whole distributing system is under control of an officer charged with the duty of subdividing the water to the several owners in accordance with the number of shares held by each. The duty of the water is stated to be at the rate of 5 acres to the miner's inch, or 250 acres to the second-foot. Each purchaser of land under this system becomes a shareholder in the canal and can participate to the extent of his ownership in the management of the company. The lands supplied are mainly those included in what are known as East Riverside and Arlington Heights.

The Riverside irrigating system, constructed before the Gage canal, covers lower lands near the river. It comprises two canals, in a general way parallel to the Gage, and known respectively as the upper and lower, both of these taking water from the Santa Ana river. Water is diverted by means of brush dams, which are liable to be washed out during heavy floods. This comparatively crude method has been followed because the Santa Ana river in this portion of its course has a wide sandy channel which shifts and washes out in times of flood. It is therefore cheaper to build temporary dams than to pay the interest on large and elaborate headworks whose stability might be questionable. The supply is increased also by waters from Warm creek and from artesian wells. At one point on the upper canal is a drop of 40 feet, the water power being used to develop electricity. This is conducted a distance of 8 miles to the city of San Bernardino. Under these canals are some of the oldest and most noted orange groves of southern California, the returns from which have attracted much attention in all parts of the United States. The total cost of the Riverside canal and distribution system is estimated to have been about $375,000.

The South Riverside system, consisting mainly of pipe lines, covers land southwesterly from Riverside. The supply is obtained by collecting water from a number of small canyons in the Temescal mountains, by draining cienegas and by sinking artesian wells, in all the quantity being estimated at about 23 second-feet. This, or at least the greater part of it, is conducted by means of a cement pipe 30 inches in diameter and about 9 miles in length. The water is distributed by means of pipes of various sizes to the town of South Riverside and to adjacent property. Efforts are being made to increase the amount of water available by means of a dam in the Temescal canyon where bed rock approaches the surface. The dam, if constructed to the height of 50 or 60 feet,

will flood an area of several square miles. It is estimated that the system has cost on an average $40 per acre irrigated, while the present value is upward of $100 or even $200 per acre. The statement is made that $1.25 per acre will cover the annual expenditures. The Jurupa canal is on the north side of Santa Ana river northerly from Riverside. It obtains water from Warm creek and the Santa Ana river and from a cienega developed by means of a deep cut in which has been placed a redwood drain. From the cienega the canal is in all 18 miles in length, water being carried across the Santa Ana river on a trestle flume.

The irrigating works of the Semi-Tropic Land and Water Company of Rialto are located south of Lytle creek canyon and consist of about 5 miles of cement ditch, costing $40,000, and capable of carrying 3,000 miner's inches. The artesian wells furnish from about 600 to 800 miner's inches of water and the surface developments about 500 miner's inches additional. The distributing system consists of 55 miles of cement pipe of various dimensions. The total cost of the works when completed will be in the neighborhood of $250,000, the water development costing about $75,000. It is proposed to increase the water supply and bring the so-called "underflow" in Lytle creek canyon to the surface by means of a submerged dam placed in the canyon.

The Etiwanda Water Company obtains water from the Day and Young canyons, carrying it out by means of a V-shaped flume which cost probably about $5,000. The flume is made of redwood plank, the sides being 18 inches wide, and the total length is 4 miles. The water flows first to a sand box and then to a small reservoir about 20 feet square. From this it is distributed to 8 concrete pipes, each of from 6 to 8 inches in diameter. These carry the water to the highest portion of each 10-acre lot. To each of these 10-acre pieces 37.5 miner's inches for 24 hours is given at intervals of 30 days. The value of the land with water is placed at from $150 to $200 per acre and the annual expense about $1 per acre. Of the 1,000 acres supplied by this flume about 750 acres are planted with raisin grapes, 100 acres with deciduous fruits, and 150 acres with citrus fruits. The land cost the present owners about $25 per acre. Irrigation is practiced generally in June, July, and August, the ground being continually cultivated at short intervals throughout the year. For raisin grapes in bearing only two irrigations per season have been given, the young vineyards receiving three or four. The deciduous and citrus fruit trees are watered from three to six times.

The Arrowhead Reservoir Company proposes to construct three reservoirs on the north side of the San Bernardino range, each of these to be filled by canals taking water from streams tributary to the Mohave river, the principal of these being Deep creek. If constructed according to the plans, the reservoir in Little Bear valley will hold 22,000,000,000 gallons, that in Grass valley 10,000,000,000 gallons, and that in Huston Flat 6,000,000,000 gallons. The Hesperia Land and Water Company, whose works are on the north side of San Bernardino range, takes water from the Hesperia or east fork of the Mohave river by means of a ditch and pipes, the total cost of the system being estimated to have been $150,000. The ditch is about 4 miles in length, and for a great part of the way was built through the rocky walls bounding the river. From its lower end the pipe line, 14 inches in diameter, descends to and across the river and up on the opposite side, the pressure at the lowest point being, it is stated, over 176 pounds to the square inch. The water is conducted to the vicinity of the town of Hesperia, a station on the California Southern railroad about one-third of the distance from San Bernardino to Barstow.

In this county 7 irrigation districts have been formed, namely, the Alessandro, Citrus Belt, East Riverside, Grapeland, Olive, Rialto, and Riverside Heights. The Alessandro district is outside of the San Bernardino valley proper, being separated from it by the San Jacinto hills. It adjoins on the south the Perris district, in San Diego county. Water for both of these districts is obtained by purchase from the Bear Valley company, being conducted from the Santa Ana river at the point where it leaves the mountains by means of a steel pipe line 10 miles in length and 24 inches in diameter. From this main pipe line water will be distributed to each 10-acre lot by means of vitrified and cemented pipes. The lands in this district are owned mainly by the Bear Valley Company, who sell the lots, together with a water supply, the annual rate for this being $2.78 per acre. The total area of the district is 25,500 acres and the assessed valuation $2,493,000. The district is bonded to the extent of $765,000, all of the bonds being taken by the Bear Valley Company in consideration of furnishing a water supply.

The Citrus Belt district, comprising 12,000 acres, is between Etiwanda and Rialto. The assessed valuation is $622,722, and bonds to the amount of $800,000 have been voted. It is proposed to obtain water from artesian wells or from other sources, possibly by purchase from some large storage company. The East Riverside district, comprising 3,600 acres above the town of Riverside, is to be irrigated by means of artesian wells, the water being conveyed to each 40-acre lot by iron pipes, at an estimated cost of $250,000. Bonds to this amount have been voted, and of these a portion have been sold for cash. The Grapeland district is northwest of Rialto and on the west side of Lytle creek. Water is to be obtained by means of a tunnel driven beneath the bed of Lytle creek and possibly from other sources. In order to carry out this work bonds to the amount of $200,000 have been voted. (*a*) The Olive district comprises a relatively small area, 1,280 acres, on the north side of Santa Ana river west of Colton and contiguous to the Citrus Belt and Rialto districts. It is proposed to obtain water from artesian wells, from Lytle creek, or possibly from the Arrowhead system.

a For details concerning the East Riverside and Grapeland districts refer to reports of the chief engineer, F. C. Finkle. Reports of officers of the East Riverside irrigation district, San Bernardino county, California; pamphlet, 48 pages. Also chief engineer's report on the Grapeland irrigation district, 1892; pamphlet, 58 pages.

The Rialto district is southwest of the town of that name and consists of 7,200 acres, whose assessed valuation is $534,360. Bonds to the amount of $500,000 have been voted in order to obtain a water supply, to be derived from artesian wells in Lytle creek basin and to be distributed by means of cement ditches and pipes. Riverside Heights district, including 3,500 acres, has been formed for the purpose of obtaining a water supply, if possible, from Box springs or from artesian wells, or by means of a tunnel to bring out the ground waters.

SAN DIEGO COUNTY occupies the extreme southern end of the state of California, extending from the Colorado river on the east to the Pacific ocean on the west. The description of this county given in the report upon irrigation in southern California (*a*) is so complete that little more need be said. Within the western valleys and in places upon the mesas agriculture has been practiced for many years, crops being raised by dependence upon the rainfall. Large areas of small grains are cultivated in this manner, the yield per acre being somewhat small. The orchards and vineyards also in many places are fairly successful without artificial watering, but the most profitable of these are under irrigation. The reputation of this county as a fruit producing area rests almost entirely upon the irrigated orchards and vineyards, and it is often a matter of surprise to strangers to find that there are large areas upon which fruit is raised every year without moisture artificially applied. Indeed in several of the valleys, for instance, that of El Cajon, the inhabitants have regarded it almost as an insult to intimate that it was necessary to irrigate the vineyards. Experience has shown, however, that by employing water at suitable times the raisin crop can be doubled or even trebled, the yield increasing from $50 or $60 per acre to $150 or $200 in value.

The general appreciation of the value of irrigation, even on lands on which crops can be raised by dependence upon the rainfall, is perhaps best shown by the increase in selling value after a system of water supply has been established. Taking the ordinary farming land, whose value averaged $15 per acre, it has been found that the average cost of bringing water to this has been $25 per acre, and the cost of cultivation, not including the setting out of an orchard or vineyard, $30 per acre, making a total of $70. Such land has sold for from $100 to $200 or more per acre. It may be stated here that the attempt to ascertain average values of farm land in this and other counties of southern California is rendered difficult by the fact that there are relatively few farms in the sense that the word is used in other parts of the United States. A great part of the lands under irrigation have been subdivided into small tracts of from 5 to 10 acres, each of these being designed as a place of residence as well as a source of income from horticulture and small farming. Many improvements have been made upon or near these tracts, and thus the land has acquired a value dependent largely upon what may be called its suburban character. The statistics from these small farms thus have a peculiar influence upon the general agricultural results for the state.

When this land has been set with orchards and vineyards its value is placed at from $1,000 to $1,500 or more per acre, dependent upon its location, the character of the trees and vines, and surrounding circumstances. The production per acre from some of these tracts almost surpasses belief. In favorable situations in the county all the fruits of the semitropic and temperate zones reach extraordinary development.

As previously stated, many of these fruits, as, for example, grapes, apples, olives, peaches, and apricots, are often successful without irrigation, and many of the fruit growers still insist that in the case of grapes, for example, the quality is better although the quantity is less. It has been stated that in raisin making there is less contrast than might be expected between the irrigated and nonirrigated vineyards, for although the yield of grapes raised by artificial watering is far heavier, yet after drying the difference is not as marked. Wheat and barley also, according to some farmers, make a better hay when cultivated without artificial watering, but the weight is less. Shade trees, such for example, as the eucalyptus or Australian blue-gum, the catalpa, mulberry, and acacia, grow well without water, but do not reach the extraordinary development that they do when near irrigating ditches. It is almost useless to attempt to raise the citrus fruits without plenty of water. The quantity actually employed varies greatly, but in a general way it may be said that alfalfa receives sufficient water during the year in the aggregate to flood the ground to a depth of from 2 to 3 feet, while the vineyards and orchards receive in all perhaps a fifth or even a tenth of this.

The quantity of water necessary to irrigate an acre as estimated by the different companies ranges from 1 miner's inch to 5 acres to 1 miner's inch to 20 acres, the miner's inch in this county being defined as a quantity equaling 12,960 gallons in 24 hours, or almost exactly 0.02 second-foot, this being the amount which has been delivered under a 4-inch head, measured from the center of the opening. Under this assumption 1 second-foot should irrigate from 250 to 1,000 acres. This is on the basis of delivering the water in pipes or cemented channels in the immediate vicinity of the trees or vines to be irrigated. If it is assumed that 1 miner's inch is allowed for 10 acres, or 1 second-foot for 500 acres, this quantity of water flowing from May to October, inclusive, will cover the ground to a depth of a little over seven-tenths of a foot, or 8.8 inches, a quantity which with the care and cultivation usually employed has been found to be sufficient. The method of applying water governs to some extent the amount used. In the case of alfalfa flooding is practiced; with small grains the water is run in furrows, while in the case of orchards the water is sometimes applied directly to each tree. In this case a little earth basin

a 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. Wm. Ham. Hall, C. E., state engineer. Sacramento. 1888.

about 6 feet or more across and 6 inches deep is formed around each tree and partially filled with water. The better way, however, is probably that of running water in furrows, four or five of these being plowed between each two rows of trees. The water is applied very slowly, several days being spent in watering 5 acres, and when dry the ground is thoroughly cultivated.

The first cost of water or of water rights where these have been sold independent of the land has been from $15 to $25 per acre, while subsequent transfers have been made for far larger sums. The annual charges when by the acre have been as low as $3, and from this rising to $6 or more per acre. In the case of the San Diego Flume Company it is stated that water was sold for $600 per miner's inch, with an annual charge or rental of $60, 1 miner's inch being considered sufficient for from 10 to 20 acres, depending upon the soil and growth. The annual charge for water from the Sweetwater system (San Diego Land and Town Company) was for orchards $3.50 per acre.

The chief water supply for the western part of San Diego county is derived from the Tia Juana, Otay, Sweetwater, San Diego, San Dieguito, San Luis Rey, Santa Margarita, and San Jacinto rivers. Systematic measurements of the discharge of these streams have not been carried on for any considerable length of time, but the state engineer estimated that the Sweetwater discharged at its maximum 1,000 second-feet, dwindling in dry weather almost or quite to nothing. The San Diego may reach 1,000 second-feet or even 2,000 second-feet for a few days, quickly falling to less than 100 second-feet. The San Luis Rey, with its relatively large and high watershed, probably delivers the largest quantity of water and with fluctuations somewhat less than the other streams. The Santa Margarita or Temecula possibly reached 5,000 second-feet in the great flood of 1884–1885, while its ordinary winter flow is from 600 to 800 second-feet, dropping to from 2 to 4 second feet in the dryest season. The San Jacinto reaches a maximum of from 2,000 to 4,000 second-feet in winter and probably flows never less than from 6 to 8 second-feet through its rocky channel.

Along the San Diego, Santa Margarita, San Jacinto, and a few other streams are a few open ditches comparable to those used in other parts of the arid region, but these are old and may be considered exceptional to the general methods of irrigation. The important systems of the county are those in which water is conducted by flumes or pipes, dependence being placed upon reservoirs for permanence of supply. The best known of these is that constructed by the San Diego Land and Town Company, commonly known as the Sweetwater system, from the reservoir and dam of that name. This is located about 8 miles easterly from San Diego. It has been fully described by the state engineer, so that at this time it is essential to give only a few figures to serve for comparison with other projects. As published by the company the principal dimensions are as follows: length at base, 76 feet; length at top, 396 feet; thickness at base, 46 feet; thickness at top, 12 feet. The dam is built of granite and Portland cement. It was commenced in November, 1886, and completed in April, 1888, at a cost in round numbers of $200,000. The reservoir covers about 700 acres and has a capacity of 6,000,000,000 gallons. The area and capacity at various levels are shown by the following table:

AREA AND CAPACITY OF SWEETWATER RESERVOIR AT DIFFERENT LEVELS.

ELEVATIONS OF WATER PLANE.		Corresponding areas, reservoir surface. (Acres.)	CAPACITIES OF RESERVOIR ABOVE LOWEST WORKING OUTLET.	
Above sea level. (Feet.)	Above lowest working outlet. (Feet.)		Gallons.	Cubic feet.
150	5	10.72	11,000,000.64	1,556,000
160	15	43.10	79,000,000.62	10,643,000
170	25	113.40	329,000,000.45	44,044,000
180	35	290.77	835,000,000.95	111,758,000
190	45	326.96	1,710,000,000.58	228,687,000
200	55	463.80	3,005,000,000.64	401,823,000
210	65	630.94	4,778,000,000.54	638,842,000

The San Diego Flume Company's enterprise is another notable feature of irrigation in this county. The system embraces a number of projects and is by no means fully complete in all its parts. The main reservoir now constructed is that known as the Cuyamaca, about 43 miles northeast of San Diego in the Cuyamaca mountains, and at an altitude of 4,500 feet above sea level. The record of rainfall for that locality begins July 1, 1887, and is as follows: (a)

	INCHES.
1887–1888	22.00
1888–1889	52.65
1889–1890	61.51

a The following is the record since 1890:

	INCHES.
1890–1891	63.76
1891–1892	39.61

There has been ample water to fill the reservoir each year. The dam is of earth and is 635 feet long on top and 40 feet in height. The capacity of the reservoir is a little over one-half that of the Sweetwater, its contents at various heights being shown by the following table, also from the state engineer's report:

CAPACITY OF CUYAMACA RESERVOIR AT DIFFERENT LEVELS.

HEIGHTS.	Gallons.	Cubic feet.
5 feet above outlet	0.11	15,060
10 feet above outlet	5,000,000.04	675,065
15 feet above outlet	126,000,000.54	16,917,400
20 feet above outlet	523,000,000.15	69,940,300
25 feet above outlet	1,262,000,000.10	168,730,200
30 feet above outlet	2,342,000,000.28	313,139,300
35 feet above outlet	3,739,000,000.11	499,880,930

The water of the San Diego river supplies the flume until April or May, when the reservoir is drawn upon. The water from this flows down Bowlder creek for about 12 miles, and, as in the case of the river, water is diverted into the flume by a masonry dam 30 feet high and 450 feet long. The flume itself is 6 feet wide by 4 feet deep, built of redwood plank, and has a total length of 35.9 miles, with a grade of 4.75 feet per mile. There are 8 tunnels on the line, with an aggregate length of 4,168 feet, and at several points the flume passes over high trestles. Water is delivered at points along the line, for example, in El Cajon valley, and from the lower end of the flume, which terminates a mile east of La Mesa colony, is a pipe line 8 miles in length carrying the water to the city limits of San Diego. The cost of the Cuyamaca reservoir is estimated to have been nearly $50,000, of the flume upward of $800,000, and of the entire system $1,500,000.

There are several other projects of great magnitude and in various stages of construction or operation, some of these being under the control of companies and others of the irrigation districts. Among these should be mentioned the works of the San Jacinto Land, Flume, and Irrigation Company, the Hemet Water Company, the Fairview Land and Water Company, in the San Jacinto valley, and others elsewhere, each deserving more than casual mention. All of these large systems involve the storage of water and its distribution through pipes or tight conduits. Surveys have been made for a number of other schemes, but progress has been slow on account of the enormous expenditures involved. On the side of the mountains toward the desert, in the lower valleys, are several opportunities for the development of irrigation, some of which have already been used, as in the case of Palm valley. These localities are perhaps unrivaled for the early production of fruits.

In the northern end of the county, in the San Jacinto valley, and also on the east of the mountains, are a number of artesian wells, some of these being utilized in irrigation. Besides the flowing wells, water is obtained at various points in the county from wells pumped by wind power, a few acres near each well being thus brought under cultivation. According to the enumeration made in 1890 there were 60 flowing wells on farms, most of these being in the vicinity of San Jacinto, about 20 miles southerly from San Bernardino. These are from 108 to 389 feet in depth and have an average flow of 112 gallons per minute. Many of them decrease in discharge during the summer. In the eastern part of San Diego and San Bernardino counties, beyond the mountains, a few flowing wells have been reported, notably at Indio and in the Mohave desert, and there is probability that in many places artesian conditions prevail; also, north of this great desert area, in Owens valley, near Independence, is a small flowing well. Many attempts have been made to obtain water along the route of the Southern Pacific railroad, some of these being successful. At Indio and Walters stations, near the edge of the desert, having elevations respectively of 20 feet and 195 feet below sea level, good water has been found at depths of from 75 to 100 feet below the surface. From Walters to Yuma, a distance of 107 miles, no water suitable for locomotives has been obtained. At the station called Flowing Well a hole was drilled to the depth of about 400 feet and an artesian flow of brine was obtained.

There are 8 irrigation districts within the county, known respectively as the Elsinore, Escondido, Fallbrook, Linda Vista, Murietta, Perris, Jamacha, and San Jacinto and Pleasant Valley. The Elsinore district, including the towns of Elsinore and Wildomar, has accomplished little, and it is probable that the district organization has been definitely abandoned. The Escondido district made surveys to determine the feasibility of obtaining water from San Luis Rey river and from storage sites among the mountains. It is reported that attempts have been made to dissolve the district organization. The Fallbrook district includes 12,000 acres between Santa Margarita and San Luis Rey rivers. The assessed valuation is $426,545, and bonds to the amount of $400,000 have been voted. Difficulty has been experienced in selling these, and it is stated that assessments have been levied for current expenses. The Linda Vista district consists of 42,000 acres north of San Diego river. The assessed valuation of this is only $515,340, but bonds to the amount of $1,000,000 have been voted. Various surveys have been made in order to determine the most available source of water supply.

The Perris district adjoins the Alessandro district, as mentioned in the description of San Bernandino county. The area of this is 13,422 acres, the assessed valuation $624,054, and bonds have been voted to the amount of

$442,000. Of these $240,000 have been exchanged for water supply and $74,500 sold for cash. Water is obtained from the Bear Valley Company, being conducted to the district by means of a wooden pipe, shown in the illustration. Considerable dissatisfaction has been expressed concerning the original propositions for supplying water and the lines of the district have been changed, excluding owners who objected to certain arrangements. The Jamacha district is east of San Diego and north of Sweetwater river, including 22,000 acres of land adapted for fruit culture. The assessed valuation is $830,000. Bonds to the amount of $700,000 have been voted, of these $165,000 being traded for water. The San Jacinto and Pleasant Valley district, including 18,000 acres in the vicinity of Winchester, proposes to obtain water from San Jacinto river, having purchased certain rights from the Florida Water Company.

SAN FRANCISCO COUNTY is the smallest in the state, and comprises the point of the peninsula upon which the city of San Francisco is located. Agriculture can hardly be said to be carried on within the county, but the enumerators have found a number of areas under cultivation. These are principally devoted to truck farming, and for the most part are watered by means of windmills or other devices for pumping from wells. Most of the irrigated areas are owned or operated by Italians and Chinese, who give constant care and attention to the cultivation of the ground, raising crop after crop in as rapid succession as the conditions will permit.

SAN JOAQUIN COUNTY is south of Sacramento county, occupying the lower end of the San Joaquin valley, partially including the delta at the junction of the Sacramento and San Joaquin rivers. A number of large streams coming from Tuolumne, Calaveras, and Amador counties on the east cross this valley land on their way to join the large rivers above mentioned. Taking these in order from the south, the first is Stanislaus river, forming the southern boundary of the county. About 20 miles north of this is Calaveras river, and beyond this Mokelumne, this latter stream near its mouth forming the dividing line between this and Sacramento county. The broad plains between the rivers are devoted mainly to the cultivation of cereals, for the successful production of which there is usually ample rainfall. The lower overflowed lands on the west have to a large extent been reclaimed by levees, the farms thus made having great value. Horticulture has been of comparatively small importance, but the area in orchards is being extended as the demand for fruit increases.

The water supply of the county is large, for besides the rivers above mentioned there are a number of streams whose waters flow out from the foothills during the spring and early summer. Except in the higher parts of the county wells can be had at moderate depth, and from these a practically inexhaustible quantity of water is obtained. Many windmills are in use, pumping from these wells and irrigating gardens and fruit trees, especially in the vicinity of the towns. Comparatively little water is used for this purpose, since by careful cultivation trees and vines flourish at most localities. In the vicinity of Lathrop and Stockton are a number of artesian wells, none, however, being reported upon farms in the census year. There are also several deep wells yielding inflammable gas, the supply of which is reported to be large and of considerable value for lighting and heating purposes.

The Stanislaus river, on the southern edge of the county, has been measured, as shown further on in the description of Stanislaus county, and gaugings have also been made of the Calaveras and Mokelumne. The observations on the Calaveras river, given below, were made at a point several miles above Bellota, being thus near the county line. It is stated that the drainage basin of this stream, not extending back to the higher mountains, does not furnish as constant a flow as does that of the Mokelumne. The following table gives the results as computed by the California state engineering department:

DISCHARGE IN SECOND-FEET OF CALAVERAS RIVER AT BELLOTA, CALIFORNIA.

(Drainage area, 491 square miles.)

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1879	229	648	1,068	680	166	98	24	.....	.....	.....	.....	295	267
1880	221	393	614	4,174	1,473	196	24	10	.....	.....	.....	246	613
1881	1,473	2,700	982	982	196	74	49	.....	.....	.....	.....	74	544
1882	344	442	1,719	1,719	2,946	246	.....	.....	.....	98	147	147	651
1883	491	393	737	982	491	196	.....	.....	.....	74	24	49	286
1884	196	2,455	2,946	2,455	491	491	196	.....	.....	.....	.....	.....	.....

The Mokelumne river was measured by the California engineers at a point north of Clements and observations of water height made at a bridge about 12 miles above. From the data thus obtained the estimate contained in the table on the following page was prepared.

DISCHARGE IN SECOND-FEET OF MOKELUMNE RIVER AT LONE STAR MILL, CALIFORNIA.

(Drainage area, 657 square miles.)

EARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
.....	328	1,198	1,369	3,065	3,247	3,629	538	164	26	19	59	465	1,176
.....	279	396	644	4,553	5,031	6,054	2,745	365	29	164	98	291	1,721
.....	1,037	3,049	1,126	3,195	3,034	1,237	159	98	98	66	207	624	1,160
.....	591	624	1,971	2,628	4,927	3,285	788	66	59	230	207	207	1,299
.....	414	328	591	1,971	3,942	2,628	657	263	98	98	132	132	928
.....	164	1,971	3,942	3,942	3,285	2,957	2,628	657	131	98	.....	.....	.....

mber of projects for irrigation works have been undertaken at points within this county, and considerable noney have been subscribed or invested, but up to the time of the taking of the census a comparatively ount of land had been brought under ditch. One company has been formed for the purpose of irrigating : Lodi by means of water from Mokelumne river, this being diverted by means of a dam 280 feet long and r more in height. From the dam a canal has been projected 30 feet wide on bottom and having a of nearly 600 second-feet. This will conduct water to the channel of Bear creek, which is to become a f the distributing system. Other companies have begun work with the intention of diverting water from slaus river, and it is probable that the area cultivated by the artificial application of water will be greatly , especially upon the higher lands on the eastern border.

LUIS OBISPO COUNTY includes the area between Kern county and the Pacific ocean. It thus consists of of the hilly and mountainous country designated as the coast range, together with the intermediate valley Stock raising and dairy farming are the principal industries, horticulture occupying a relatively small area. n is not practiced, although the water supply of the county is large, and in the interior valley especially ıld probably be applied to advantage during the summer months. Within the county there are reported number of flowing wells, these being on the low lands near the mouth of Santa Maria river, and at where it is not necessary to irrigate.

MATEO COUNTY includes the peninsula south of San Francisco and extends along the coast southerly, the gth being about 40 miles. The greater part of the surface is hilly or even mountainous, the highlands g the areas along the bay of San Francisco and shutting off from the eastern side of the county the fog p sea breeze. Agriculture is carried on to a small extent, mainly in connection with the large estates and homes of citizens of San Francisco. No irrigation is reported, since the precipitation is ample for the the crops and fruit trees.

TA BARBARA COUNTY has a moist climate, and irrigation is confined mainly to watering orchards, .s, and gardens in the vicinity of the towns along the southern coast, especially during the latter part of The water supply is small, being derived from the streams flowing from the mountains bordering the The greater part of the land is irrigated by means of pumps or engines or by pipe lines laid from some r mountain stream. North of the Santa Inez mountains, which stretch along the southern coast, are broad valleys in which agriculture is carried on successfully. It is probable that irrigation may be ed to a small extent as development proceeds, as there are a number of streams whose waters can be at reasonable expense.

TA CLARA COUNTY is immediately south of the lower end of San Francisco bay and includes the valley of ıe bay may be considered as a continuation. The lower lands in the center of the county are protected ocean winds and fogs by the mountain range on the west, and the water supply is increased by a nearly range on the east. Throughout the broad Santa Clara valley and among the adjoining foothills the ion of fruit is carried on extensively, and the area thus under cultivation is increasing with great rapidity. the fruits prunes are probably the most important, and next to these come peaches, apricots, and then the ls, from which are obtained both raisin and table grapes. Much of the fruit is shipped to market in the or what is known as green condition, but larger quantities are canned, dried, or otherwise preserved for use throughout the year. Irrigation is practiced to a relatively small extent. Most of the orchardists at the nonirrigated fruits are better in flavor than those irrigated, although as a matter of course much upon the skill in cultivation and in applying the water. Orchards and vineyards in which the trees and ıve been properly placed and the soil thoroughly cultivated yield as a rule large returns. The soils of the vary and there are undoubtedly localities in which, owing to the dry, sandy condition of the soil, irrigation utely necessary.

Santa Clara valley is noted for the large number of flowing wells. In 1890 there were 460 of these ated as being upon farms, the depth ranging from 59 to 740 feet and averaging 280 feet. The average cost

was $555 per well, and the average discharge of those then flowing was 316 gallons per minute. The earliest of these were sunk probably about 1855, and at that time all had a strong perennial flow. As the number has increased, however, the discharge in most cases has diminished, so that now many of the wells only flow during the rainy season, and in nearly if not quite all the discharge is less during the summer than during the winter. The flowing wells are mainly on the low lands near the bay, and in many cases the pressure is very slight, only sufficient to raise the water a few inches above the level of the ground. In a few instances, however, water has been reported as rising as high as 20 feet above the surface.

Most of the artesian wells have been allowed to flow continuously in order to furnish water for stock and other purposes, and apparently the local regulations requiring that wells be capped or otherwise closed when the water is not in actual use have not generally been obeyed. Thus a large proportion of the water has been allowed to run to waste, decreasing the pressure and injuring the whole basin. In some instances where the wells do not flow, steam and wind power are used to bring the water to the surface. Outside of the known artesian area a number of attempts have been made to find flowing water, and in one case a well was drilled to the depth of 950 feet, but without success. The water is generally warm, sometimes warmer than the atmosphere, and is used mainly for watering stock, for which purpose most of the wells were sunk. In many instances, however, strawberries and vegetables are irrigated, as well as a small acreage of forage. The small amount available from any one well requires great care and economy in its use. It has been the custom to measure the quantity in the wells roughly by means of the vertical height to which the water column rises above the open end of the pipe. A remarkably large well, one having unusual pressure, would be characterized by the spouting of the water to a height of from 10 to 12 inches above the top of the pipe, this being the elevation of the upper surface of the water.

Besides the flowing wells northerly from San Jose there are a number toward the southern part of the county near Gilroy and at points along the lower part of the valley. Also on each side of San Francisco bay northerly from the county are other flowing wells, as, for instance, in San Mateo county near Menlo Park, Redwood, and other towns. In San Francisco county also are a number of deep wells, but these, so far as reported, are pumped by means of windmills. In most of the wells on the west side of and near the bay, water rises about to the level of the surface, and is raised for watering gardens, strawberries, vines, and bushes, and for lawns and domestic purposes by means of the ordinary windmills. On the east side of the bay north from Santa Clara county are also flowing wells, 34 of these being reported in Alameda county. These in general behavior are similar to those above described.

SANTA CRUZ COUNTY includes a relatively small area of land lying along the ocean west of Santa Clara county. The greater part of the surface is mountainous, and the precipitation is sufficiently heavy to insure the success of farming operations upon the bodies of agricultural land. On the lower grounds near the coast a little irrigation is practiced, as in adjoining counties, water being applied during late summer to the gardens and trees. For this purpose there are a few small ditches, and in a number of instances water is pumped from wells or other sources of supply. In the vicinity of Watsonville there are a number of flowing wells, mainly on the low ground within a mile of the coast. In all, 33 were enumerated as being upon farms in the census year. Some of these wells, which formerly discharged all the year round, now flow only at high tide or after the winter rains. The water from these wells is used to a very small extent for irrigation.

SHASTA COUNTY is at the head of the Sacramento valley, including in its southern end a relatively small portion of the valley, together with the mountains which surround it on three sides. There are a number of large streams flowing through the county, but most of them are in deep, narrow valleys, rendering the diversion of their waters upon the farming lands of the county expensive if not impossible. Irrigation is not necessary for the production of the cereals and other field crops, since the precipitation during the winter is heavy and most of these products are nearly ready for harvesting by the time the summer drought begins to be severely felt. In the case of vegetables, fruit trees, and vines, irrigation, although not always absolutely necessary, is of very great benefit and is practiced whenever possible. For the forage crops, also, artificial watering increases the number of cuttings and the production per acre.

There have been a number of ditches constructed, primarily for mining purposes, as was the case in adjoining counties. The owners of some of these ditches are selling water to irrigators at the rate of 9, 10, or 12 cents per miner's inch, while other ditches have been extended and used almost entirely for irrigation. Much of the land best adapted to the cultivation of fruit is upon the benches or low hills around the sides of the valley and above the reach of water from the larger streams. Surveys have been made to determine the feasibility of bringing water from Pitt river, which flows westerly across the northern part of the county, by means of a canal through James pass, thus covering the higher fruit lands of this end of the Sacramento valley. It has been found, however, that this pass is too high to be crossed or to be pierced by a tunnel of moderate length.

In 1889 the reconnaissance and survey mentioned above and in the description of Modoc county was begun in the vicinity of Cow creek. This stream was measured on August 12, 1889, its discharge above its junction with Little Cow creek being 13 second-feet. This latter stream was discharging at that time only 0.3 second-foot. At that time there was on foot a project for taking water on the south side of Cow creek, near Millville, carrying it

along for 2 or 3 miles, then across the stream by means of a pipe or flume, and southerly 5 or 6 miles to Sacramento river. Stillwater creek in the latter part of August, 1889, was carrying at points about 5 miles east of Reading about 0.4 second-foot, this being an unusually small amount. Clear creek, as measured near its mouth, was discharging from 8 to 10 second-feet. Castle creek, in the northern part of the county, was ascertained to have a low water discharge of approximately 30 second-feet. The above figures, so far as can be ascertained, comprise the stream measurements made within this area, and although fragmentary they serve to give some idea as to the size of the smaller streams.

Fall River valley can probably be brought under irrigation almost entirely by means of canals heading near Pittville and deriving their supply from Pitt river. In the continuation of the survey mentioned in the description of Modoc county it was found that a canal heading in the canyon above Fall River valley would command about 30 square miles of territory. In this part of the county there are a few flowing wells similar to those across the line in Lassen county.

SIERRA COUNTY occupies a narrow strip between Nevada and Plumas counties and consists mainly of steep mountains and narrow valleys. On the northern side, and partly in Plumas county, is the broad Sierra valley, lying at an altitude of a little under 5,000 feet. This, as mentioned in the description of Plumas county, is drained to the northwest by the middle fork of Feather river. A number of streams enter this valley from the mountains upon all sides, most of these sinking in the pervious gravels near the edge of the plain. In spring the flood waters are conducted out upon the nearly level lands, irrigating large areas of hay and relatively smaller patches of cereals. Much of the grain, however, is sown in the fall and reaches maturity before it can be injured by the long summer drought. The irrigating ditches are small, seldom exceeding a mile in length. As previously mentioned, there are a number of flowing wells in the Sierra valley, these ranging from 45 to 1,130 feet in depth, the average being 458 feet. The quantity of water delivered is small, averaging only 47 gallons per minute. The water is allowed to flow out upon the ground, irrigating the grass lands adjacent to the well. Southwesterly from the Sierra valley are a number of mining ditches, some water from which is sold to fruit growers at the rate of about 12.5 cents per miner's inch for 24 hours.

SISKIYOU COUNTY is the central of the three counties in the northern end of California adjoining Oregon. It includes on the west a portion of the heavily timbered area of the coast mountains, and from these extends easterly to the lava covered plateau of the Great Interior basin. The Klamath river crosses the northwesterly part of the county, flowing in a narrow, deep valley, and receiving numerous large tributaries from the south. In the southeastern portion of the county is Mount Shasta, from which flow creeks belonging to the drainage system of Sacramento river. West and north of Shasta are several large valleys in which agriculture has come to be of importance, although still secondary to mining and stock raising. In these valleys, Scott, Shasta, Little Shasta, and Butte, cereals are raised without irrigation, although greater success is attained by the artificial application of water. The irrigated areas are devoted mainly to the raising of forage crops and to a less extent to orchards. Among the fruits raised the apples from Siskiyou county are perhaps the best known.

The development of mining has been of advantage to agriculture in its earlier stages of development, not only by furnishing home markets, but also by providing in many instances means of water supply. Some of the old ditches built for hydraulic mining have been utilized in irrigation, while in the case of others more or less water has been sold at certain seasons of the year. As a rule, however, irrigation is carried on by means of small ditches built by the farmers, each mountain stream being utilized, especially those flowing into the valleys previously named. Along Klamath river water is raised by bucket wheels, but owing to the difficulties no large canal for irrigation purposes has been built. As in adjoining counties, most of the irrigated areas are large and consist of lands flooded by the simplest and cheapest methods possible. Taking the county as a whole, it may be said that in the western end irrigation is not essential, since the small grains can be raised by careful cultivation, good crops of wheat being obtained by summer fallowing. The farther east one goes, however, the greater the necessity of irrigation and the more eager is the demand for water conservation and systematic control. Attempts have been made to find flowing water, and there is reported to be a well 700 feet deep in the vicinity of Yreka.

There are no large irrigation canals in the county, and the number of small ditches is so great that an enumeration of them has not been undertaken. A few of the typical irrigation works may be described briefly. The Farmers ditch takes water out on the east side of Scott river 2.5 miles below Callahan. The total length is about 10 miles, the width 4 feet, and the cost was approximately $3,000. It covers over 1,000 acres in Scott valley. Water is taken out for use about 2 miles below the diverting dam, which is built of tree trunks, brush, and stone. The water is divided by means of flumes 12 feet in length, in which a certain portion of the water is taken out. For example, if a farmer owns one-eighth of the ditch a division board is placed one-eighth the width of the flume and the water entering this narrow part is let out at the side. The principal crop irrigated is alfalfa, next in importance being the gardens and fruit trees. During April, May, and June the discharge of Scott river is so great that relatively but a small portion is utilized, but after July, especially in dry years, all of the water is diverted by the different ditches.

SOLANO COUNTY is in the lowest part of the Sacramento valley about midway between San Francisco and the city of Sacramento. It is bordered on the south by Suisun bay and connected bodies of water; the southern portion of the county as well as the eastern consists largely of swamp or overflowed lands, some of which have been reclaimed and form one of the richest farming sections of the state. There is ample moisture for all crops not only on these low lands but also among the hills and valley lands in other parts of the county, the annual rainfall being relatively large. Irrigation is not practiced, but the attempt is made rather to take away the surplus water. In the Vaca valley, lying in the northwestern part of the county, large quantities of fruit are produced, this locality being noted for the early ripening of its products. There is a good water supply and irrigation could be carried on if deemed essential, but most of the fruit growers state that the fruit is finer without the artificial application of water.

SONOMA COUNTY is on the northern coast, lying north of Marin, and including the greater part of the drainage basin of Russian river. It is noted for its vineyards and perhaps to a less extent for its fine orchards. For fruit culture and general farming the rains furnish sufficient moisture, although in the latter part of summer water might often be applied advantageously. Although irrigation in the larger sense of the word is not practiced, yet, especially in the vicinity of each large town, there are numbers of small market gardens owned by Italians, who employ water freely throughout the dry season. By this means they are enabled to raise vegetables and cause them to ripen at almost any time of the year, crop following crop in rapid succession. One or two farmers state that they have irrigated small patches of alfalfa, although this plant does well in most localities by dependence upon rainfall, especially on the bottom lands. It is necessary to cultivate the lighter soils thoroughly, for as a rule little rain falls from May 10 until harvest time. There are no flowing wells reported in the county, but there are a number of drilled wells, of from 20 to 60 feet in depth, from which water for gardens is pumped by windmills.

STANISLAUS COUNTY extends across the San Joaquin valley north of Merced county, to which it is similar in many respects. On the east side of the valley are irrigation canals from Merced river, Tuolumne river, and other streams, and on the west side the extension of the San Joaquin and Kings River canal. The areas irrigated in the census year were planted mainly to alfalfa and forage crops, fruit at that time having relatively little importance.

The principal irrigating canals in operation are the San Joaquin and Kings River canal, just mentioned, on the west side of the county, the San Joaquin ditch, on the east side, and the Knights Ferry Water Company's ditch. A small supply of water is also obtained from flowing wells, a number of which are reported in the vicinity of Hills Ferry and Crow Landing. Lands under irrigation are stated to be worth from $60 to $150 and upward, while the wheat lands above the ditches are quoted at from $20 to $30 per acre.

The principal rivers of this area are the San Joaquin, flowing northwesterly through the county, and its tributaries, the Stanislaus and Tuolumne, both of these coming from the Sierra Nevadas to the northeast. The Stanislaus for a portion of its course forms the northern boundary of the county, while the Tuolumne flows into about the center of this area. Measurements of the amount of water in these streams were made by the state engineering department, and the discharges computed from November, 1878, to October, 1884. The gaugings on the Tuolumne were made near the railroad bridge south of Modesto, the record of heights being kept from 1879 to 1882, with occasional observations at a later date. The computations of discharge were based on the data thus obtained.

DISCHARGE IN SECOND-FEET OF TUOLUMNE RIVER AT MODESTO, CALIFORNIA.

(Drainage area, 1,635 square miles.)

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1879	478	1,876	2,797	4,456	5,086	7,061	1,977	183	39	30	101	903	2,082
1880	409	625	832	7,141	10,371	14,075	7,618	1,233	134	56	35	1,095	3,635
1881	2,884	6,755	2,879	6,260	7,274	5,225	1,996	391	125	130	193	620	2,894
1882	620	573	2,164	3,543	7,461	8,046	2,745	574	225	873	570	327	2,310
1883	654	490	1,310	3,270	8,180	6,540	1,635	490	327	262	327	327	1,984
1884	410	490	6,540	7,360	7,360	8,180	6,540	1,635	327	245	.....	.....	.....

Measurements of the discharge of Toulumne river near Modesto were attempted in December, 1889, by Mr. William P. Trowbridge, jr. At that time the rainfall was exceedingly heavy, producing unusually high floods. The results of this work show that the river was about 220 feet wide, had a maximum depth of 18 feet, and discharged nearly 20,000 second-feet in flood. On January 4, 1890, with a gauge height of 11.4 feet, the river discharged 5,873 second-feet, and on January 17, 1890, at a gauge height of 8.7 feet, it discharged 4,053 second-feet.

The Stanislaus was gauged at Oakdale and from a relatively few observations computations of the monthly mean discharge were made, the estimates being based upon the probable run-off, the character of the drainage basin being known. The results thus obtained are shown in the table on the following page.

DISCHARGE IN SECOND-FEET OF STANISLAUS RIVER AT OAKDALE, CALIFORNIA.

(Drainage area, 1,051 square miles.)

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1879	525	1,994	4,523	4,307	4,098	4,387	1,584	126	21	21	74	630	1,858
1880	315	526	630	5,781	7,251	7,742	3,255	735	74	32	21	630	2,249
1881	2,102	5,255	2,102	4,729	5,255	2,733	960	360	140	120	150	1,488	2,116
1882	398	908	4,771	3,782	5,155	5,255	1,892	105	105	473	368	210	1,869
1883	525	420	840	2,102	5,255	4,204	1,051	315	210	168	210	210	1,293
1884	263	3,153	4,204	4,729	4,729	5,255	4,204	1,051	210	158	.....	.....	.....

There are in this county two irrigation districts, the Modesto and Turlock, each having its own system of canals, but uniting in the construction of the dam across Tuolumne river. This is being built near La Grange at a point about one-fourth of a mile below the boundary of Tuolumne county. This dam is curved in form and built of rubble masonry and concrete. When completed it will be 320 feet long at crest, over 100 feet high, 90 feet thick at base and 20 feet at top. It may be called upon to stand an overflow of more than 100,000 second-feet. The cost will probably be upward of $500,000. The Modesto district was formed in 1887, bonds to the amount of $800,000 being voted in December of that year. The district comprises 80,564 acres along the Tuolumne river in the vicinity of Modesto. The main canal furnishing water for this is computed to carry 640 second-feet. After following for about 2 miles along the steep bluffs of the river it enters upon the plateaus and benches, over which the construction is relatively simple with the exception of the crossings of deep ravines.

The Turlock district was formed in the spring of 1887, including 176,210 acres, a portion of this being in Merced county. For the construction of the dam and canal bonds to the amount of $1,200,000 have been voted. The canal is computed to have a capacity of 1,500 second-feet. The upper section of this canal was very expensive, since it was cut into slate, cemented gravel, and other rocks, and has 3 tunnels. Beyond the rock work much of the earth cutting was done by hydraulic works, water being obtained from the Hydraulic Mining Company's reservoir by means of ditches and flumes constructed for the purpose. At the end of the main canal are 5 laterals distributing water over the district. Over $800,000 has been expended in construction and buying rights of way.

SUTTER COUNTY includes a portion of the low lands of the Sacramento valley lying mainly between the Sacramento and Feather rivers. The county may thus be said to consist of a vast plain only a few feet above the average level of the rivers, this plain being broken only by the Marysville buttes, which rise to altitudes of from 1,800 to 2,100 feet. In the southern part of the county much of the land is annually overflowed, while other portions are protected from inundations by an elaborate and expensive system of levees. Irrigation is not practiced, since the soil in nearly all portions of the county is more or less saturated with water, remaining fairly moist through the droughts of summer. The only instances in which water is applied to the crops are perhaps in the case of the Chinese gardeners, who raise water from wells or from the river by means of windmills or what are known as China pumps. There is probably no portion of the county so dry but that good crops can be produced by cultivation. Southwesterly from Marysville about 16 miles is a well 360 feet deep; also at Marysville, in Yuba county, is a second well 306 feet in depth, neither of these wells flowing. Northwesterly from these, at Norman, in Colusa county, a well 1,000 feet in depth is reported as discharging a small quantity of water, none of this, however, being of use in irrigation.

TEHAMA COUNTY lies across the northern end of the Sacramento valley south of Shasta county. Sacramento river flows southerly across this area, receiving from the east a number of streams which rise in the vicinity of and south of Lassen peak. On the west side the streams are of less importance, most of them entering the edge of the valley only, except during the time of melting snow. On the valley lands cereals are raised without irrigation, and many of the farmers state that it is not necessary to apply water even to fruit trees and vines. Irrigation, where practiced, depends mainly upon water from the east side streams, Battle, Antelope, Mill, and Deer creeks, the latter being especially notable for the number of ditches taken from it. The production of fruit and grapes is rapidly becoming the leading industry. Many of the vineyards are seldom irrigated after the first year, but it is claimed that better results can be obtained by a judicious use of water. In the southern end of the county there has been formed an irrigation district known as the Kraft district, comprising 13,500 acres, the greater part of this being in Colusa county.

TRINITY COUNTY lies west of Shasta and Tehama counties, separating these from Humboldt, which borders on the ocean. It thus lies wholly within the coast range, the surface being mountainous and heavily timbered. Mining is the principal industry, and after this in importance comes stock raising. The agricultural areas are mostly small and scattered through the valleys, of which there are only two of notable size, Hay Fork and Trinity. Irrigation, though not strictly essential, is practiced for the purpose of increasing the hay crop and insuring the success of fruits, trees, and gardens. There are in the county a large number of ditches built for mining, some of which are

now used in whole or in part for irrigation purposes. These take water mainly from the mountain streams rather than from the large rivers like the Trinity. The water supply of the county as a whole is ample, although there are a few complaints from farmers that the miners interfere with their obtaining water necessary for the full development of the arable lands.

TULARE COUNTY extends from the summits of the Sierra Nevadas westward across a portion of the San Joaquin valley, narrowing in this direction so that its western boundary on the coast range is very short. It includes in this western apex Tulare lake and a large part of the moist grounds or marshes surrounding that body of water. In the eastern end of the county among the high Sierras is the Sequoia national park, and on the extreme rim is Mount Whitney, the culminating point of the range. This mountain and other peaks are drained by the head waters of King river and Kaweah river, these flowing westerly, and by Kern river, which flows toward the south. Besides these streams are many smaller creeks draining the western slopes. All of the streams flow through narrow mountain valleys, in which a little irrigation is practiced, mainly for winter feed for the cattle, which find an excellent summer range among the mountains.

Nearly all of the agricultural operations of the county, however, are upon the lower lands in the broad San Joaquin valley east of Tulare lake. Here the development, as in the other valley counties, has been very rapid. At first great areas of the small grains and alfalfa were irrigated, but of late years the large ranches have been cut up into smaller farms or colonies and large areas set with fruit trees and vines, resulting in a rapid increase in population and in values. Much of the land is of peculiar composition and texture, receiving water readily and transmitting it for long distances, so that it is not necessary to irrigate the land directly, at least in the manner usually practiced in other counties, the mere presence of water standing in a ditch around a 40 or 80 acre lot being sufficient. For example, in what is known as Mussel Slough or Lucern, a section of country about 24 miles in length and 12 miles in breadth lying between Kings river and the eastern shore of Tulare lake, irrigation is almost entirely by seepage. Ditches are run at a distance of from one-fourth to one-half mile apart, no water being applied directly to the surface. The main source of water supply for this region is King's river, from which 5 large canals are taken, the Peoples, Mussel Slough, Last Chance, Lower Kings, and Rhoads, these having an aggregate length of over 110 miles. Besides these are the Settlers and Lakeside ditches from Cross creek, the whole forming a complete network.

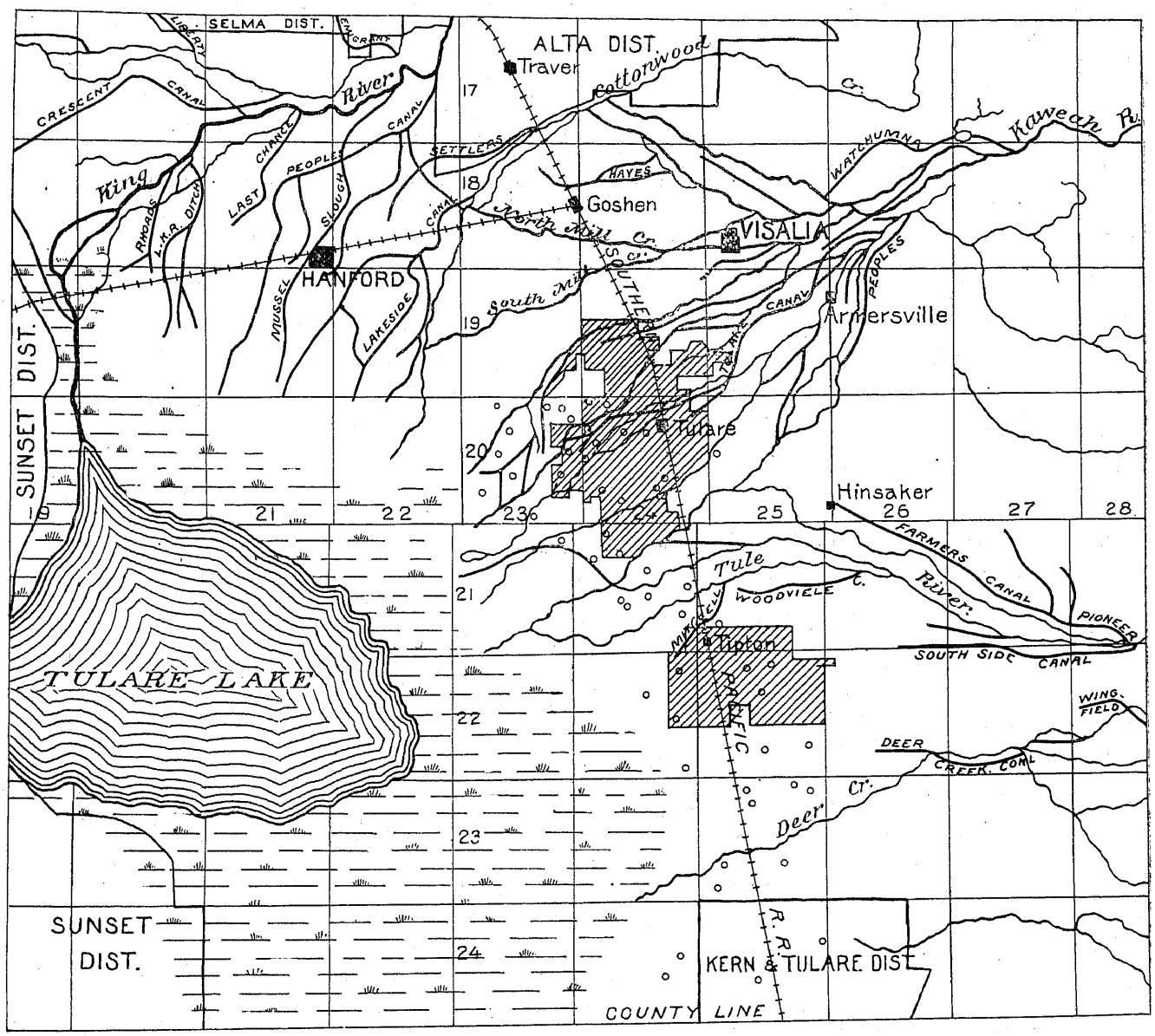
The Kaweah delta is a name sometimes given to the region east of Mussel Slough or Lucern. This area, as shown on the accompanying map, has a length of about 30 miles and a breadth of approximately 20 miles. It is intersected by the numerous branches of Kaweah river and by the many canals leading from these. On the lower lands of this area, as well as in Mussel Slough, are a number of artesian wells, and in places the land is naturally so moist that good grain crops can be raised without irrigation on lands remote from canals. On all these lands the orchards are irrigated at least once a year, when first set out the water being run along furrows on the surface. There has been some trouble from alkali on these soils, owing to careless irrigation and poor methods of cultivation.

The water supply of the county comes almost entirely from the high mountains on the east, there being within this area several rivers of notable size. The largest of these is Kings river, which touches the northern boundary of the county, supplying canals both in Fresno and Tulare counties. South of this is Kaweah river, which flows in almost a straight line from Mount Whitney toward Tulare lake. South of this in turn are Tule river, Deer creek, and White creek, the line of Kern county being near the latter. The state engineering department of California carried on measurements of the discharge of these rivers and computed the maximum, minimum, and mean quantity delivered during the greater part of the period from 1879 to 1884.

Kings river, as stated in the report named above, is one of the most important irrigation feeders in the state, having a high watershed of the best character for plentiful and well delivered supply. Gaugings were made at a number of localities between Slate Point, 5 miles above Centerville, the place where it leaves the mountains, and Tulare lake, 65 miles below. These gaugings have not been in all respects satisfactory, but nevertheless are of very great value as showing the range in quantity of water discharged. At the railroad bridge south of Kingsburg, and below many of the canals, a record of the height of the river has been kept for many years, furnishing partial data for the estimation of the quantity of water available, as given in the description of Fresno county. (*a*)

a Physical Data and Statistics of California, page 409. The record of gauge height kept by the Southern Pacific company at this bridge near Kingsburg is shown in graphic form in the twelfth annual report of the United States Geological Survey, part 2, 1891, Irrigation, page 314.

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



The Kaweah river drains an area wholly within this county and furnishes a water supply to lands south of those covered by Kings river. The principal gaugings were made by the state engineering department at the station near Three Rivers, and from the data thus obtained an estimate of discharge was made for the entire stream entering the valley, including tributaries which join the main stream at points below the gauging station. The following table gives the mean monthly discharge in second-feet, estimated as above stated, and the figures show graphically the character of the fluctuations during 1879 and the greater part of 1880, 1881, and 1882:

DISCHARGE IN SECOND-FEET OF KAWEAH RIVER AT WATCHUMNA HILL, CALIFORNIA.

(Drainage area, 619 square miles.)

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1879	248	279	402	867	774	557	124	31	31	62	124	279	317
1880	248	310	464	2,352	2,786	3,900	743	155	99	50	74	371	963
1881	526	774	619	1,393	1,238	990	371	155	43	74	124	279	616
1882	155	310	464	1,393	2,228	929	743	198	93	87	124	93	568
1883	155	124	619	805	1,021	990	402	99	74	62	74	74	375
1884	248	2,177	2,290	1,548	2,847	4,271	3,497	990	495	248	.....	.....	.....

The mean discharges of Tule river, Deer creek, and White creek are shown in the following tables, these figures being obtained by computations based upon records of river height more or less fragmentary as well as upon observations and general information obtained from residents in the vicinity:

DISCHARGE IN SECOND-FEET OF TULE RIVER AT PORTERVILLE, CALIFORNIA.

(Drainage area, 437 square miles.)

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1879	57	87	61	118	105	350	35	26	26	74	140	271	104
1880	577	1,040	1,079	1,289	1,040	721	350	87	44	44	87	219	548
1881	219	437	437	874	874	437	219	175	87	66	57	66	412
1882	87	109	306	660	1,748	660	437	131	66	44	66	66	365
1883	87	87	437	656	874	874	350	87	66	44	44	66	306
1884	262	1,748	1,311	874	2,185	3,059	2,622	874	350	175	.....	.....	.....

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

(Drainage area, 110 square miles.)

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1879	9	15	8	28	20	7	0	0	0	0	29	55	14
1880	132	253	286	319	220	55	6	0	0	0	22	55	112
1881	55	110	110	110	110	55	0	0	0	0	0	23	48
1882	23	17	55	55	11	0	0	0	0	11	17	6	16
1883	17	17	88	55	44	0	0	0	0	11	11	17	22
1884	55	330	330	220	44	55	0	0	0	0	.....	.....	.....

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

(Drainage area, 90 square miles.)

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1879	7	12	6	23	16	5	0	0	0	0	23	45	11
1880	108	207	234	261	180	45	5	0	0	0	18	45	92
1881	45	90	90	90	90	45	0	0	0	0	0	11	38
1882	11	14	45	45	9	0	0	0	0	9	14	5	13
1883	14	14	72	45	36	0	0	0	0	9	9	14	18
1884	45	270	270	180	36	45	0	0	0	0	.....	.....	.....

This county, like those to the south, has a large number of artesian wells, these being located, as shown by the map, mainly within the belt east of Tulare lake and west of the main line of railroad. The total number enumerated upon farms in the census year was 139, these ranging in depth from 50 to 1,060 feet, the average depth being 587 feet. Taking the mean of all, the flow was 409 gallons per minute, this amount irrigating 100 acres per well when thus employed. Most of the wells, however, were put down for watering stock. One well, 7 inches in diameter and 1,058 feet deep, is reported as having a discharge of 1,000,000 gallons per day, or 1.55 second-feet. The water contains a small amount of sulphureted hydrogen, and some gas also issues with it. It has been used for irrigation for nearly three years, but with no injurious effects. There have been irrigated 200 acres of alfalfa and an equal amount of wheat. Taking the county as a whole, the farmers are raising a less proportional acreage of wheat and are increasing the area devoted to grapes and other fruits, and for this purpose the artesian water is especially valuable. Some of the wells, however, are unfortunately located on lands considered worthless on account of alkali.

A large number of canals have been built, taking water from each of the principal streams at points below where they enter the edge of the valley and lower down from the numerous channels or sloughs into which the rivers subdivide. The number and intricacy of these canals can best be shown by reference to the map. These canals are among the largest in the state, aggregating hundreds of miles in length. As the more important, may be mentioned the '76 canal, the Peoples canal, Mussel Slough, Last Chance, Lower Kings River, and Lakeside, deriving water mainly from Kings river, and the Watchumna, Tulare, Kaweah, from Kaweah river, the Pioneer, Farmers, and Southside, from Tule river. The Peoples ditch takes water from the south side of Kings river, the main canal having a length of nearly 7 miles and a width of from 30 to 40 feet. The total cost of the canal is

estimated to have been $150,000. The canal was begun in 1873 and used in the following year. The diverting dam is made of brush, held in place by sand bags, and is repaired each year. In the construction of the canal an old slough was utilized for a portion of the distance. There are 4 distributing ditches, these being known as the Settlers ditch, taking about one-fourth of the water, the East branch taking one-half of the water, and the West branch, this again dividing and contributing water to what is known as the Middle branch. The canal is owned by a corporation, there being only about 63 shares in all. Each share is considered to be worth $1,500. The annual cost for the water is estimated to be about 50 cents per acre irrigated. The principal crops irrigated consist of grain, alfalfa, and other forage plants. Large areas of orchards and vineyards are also watered, these being of more value than the field crops. When full the ditch is supposed to carry about 500 second-feet, and, allowing for loss, each share of stock probably is entitled to about 5 second-feet of water. The full capacity is received, however, usually only during April and May. One share in this canal is thought to furnish sufficient water for from 300 to 400 acres of alfalfa and grain or 640 acres of fruit.

The Lakeside canal receives water from Kaweah river by its branches, St. John river and Cross creek. The total length of the canal is placed at 44 miles and the width 30 feet. The canal was begun in 1873 and used in May, 1875. There are two main branches, the east branch, 17 feet wide on bottom, and the west, 22 feet wide on bottom. Besides these are five others, ranging from 12 to 15 feet in width. The canal is owned by a corporation of irrigators, 30,000 shares of stock at $1 a share having been issued. One share is supposed to furnish sufficent water to irrigate an acre when the ditch is full, water being distributed at the rate of a miner's inch to two shares or a second-foot for 100 acres. The annual assessment is about 25 cents per acre. Alfalfa and fruits are irrigated, as well as grains and vegetables.

The Southside ditch takes water out on land south of Tule river and east of Tipton. The total length of the main ditch is 10 miles and the width 12 feet. The original cost was about $5,000. The canal was begun in 1875 and used in 1876. There are twenty distributing ditches, having an average width of 6 feet and a length of from one-fourth to 3 miles or more. The ditch is owned by partnership, the water being divided between two or more stockholders at a time and for a given number of hours in proportion to the stock owned by each. The first cost of water right is stated to have been $2 per acre and the annual assessment 50 cents per acre. For trees and vines under this canal one irrigation a year is usually sufficient.

There are three irrigation districts lying wholly within this county and four only partly included, three of these extending into Fresno county on the north and one into Kern county on the south. These districts are known as follows: Tulare, Tule River, and Tipton, in Tulare county; Alta, Selma, and Sunset, in Fresno and Tulare counties, and Kern and Tulare in the counties of the same name. Tulare irrigation district includes 40,520 acres, a portion of this being within the city of Tulare. The district was formed in 1889, and the proceedings for the formation of the district, the issue and sale of bonds, were confirmed by the superior court of the county a year later. The assessed valuation of the district in 1892 was a little over $2,000,000. Bonds to the amount of $500,000 have been voted, nearly all of which have been sold or exchanged for canal property.

Water for this district is obtained from St. Johns river, Kaweah river, Deep creek, and Cameron creek. The main canal from St. Johns river has a capacity of 500 second-feet and the canal from the Kaweah river the same. The district has acquired the water franchise of the Settlers ditch, one of the oldest in the county, claiming 157 second-feet; the water system of the Kaweah Canal and Irrigation Company, having a capacity of 500 second-feet, and all the canals, subsidiary ditches, and rights of way of the Rocky Ford Canal and Irrigation Company, capacity about 200 second-feet. The works are nearly completed, but may be extended from time to time. A portion of the lands included in this district have been irrigated for at least 10 years. The unirrigated lands are worth from $10 to $25 per acre and the irrigated lands from $50 to $150 or even more. It is estimated that the cost of water under the district organization when fully developed will be about $1 per acre a year, while under private management it has cost from $2 to $3 or more. This reduction in the annual cost, however, will only take place when all of the area is brought under cultivation.

Tule River irrigation district comprises 20,000 acres, the assessed valuation of which is $280,000. Bonds amounting to $90,000 have been voted, but so far as can be ascertained none of these have been disposed of. The Tipton district, including 17,040 acres lying mainly to the south and east of the town of Tipton, has an assessed valuation of $189,595. Bonds amounting to $50,000 have been voted, but not sold. The Alta irrigation district is on Kings river, including 129,927 acres of land lying under the '76 canal. The assessed valuation of this district is $2,507,630. Soon after formation the district purchased the '76 canal and its appurtenances, bonds to the amount of $675,000 being voted for this purpose and to cover other necessary expenses. The canal was bought in July, 1890, at a cost of $410,000, and the system of distributaries has been extended to cover nearly all of the land within the district. The Selma district includes 271,000 acres of land lying opposite the Alta district on the west side of Kings river. This, like the Alta district, has been subject to attack.

The Sunset district includes 308,000 acres lying on the west side of the San Joaquin valley northwesterly from Tulare lake. The assessed valuation is $3,080,000. Bonds to the amount of $2,000,000 have been voted for the purpose of procuring funds to bring water across to this unwatered side of the valley. Comparatively little has been accomplished as yet, owing to the difficulty or impossibility of selling the bonds. The Kern and Tulare

irrigation district includes 84,355 acres on the southern border of Tulare county. Bonds to the amount of $700,000 have been voted, one-half of the issue being taken by a construction company which has undertaken to build systems of water supply.

TUOLUMNE COUNTY is east of Stanislaus county and includes the mountain head waters of rivers flowing westerly to the San Joaquin plains. Near the sources of many of these streams are small lakes or valleys, formerly containing bodies of water. These are surrounded by the lofty rugged peaks of the Sierra Nevadas, upon which the precipitation in the form of rain and snow is very heavy. There are thus numerous sites at which storage works could be constructed at relatively small expense, furnishing a supply of water for use in irrigation on the lower plains during the long hot summer. Some of these localities have been surveyed or examined by the United States Geological Survey, and descriptions of them are contained in the annual reports of that bureau. In the western or lower part of the county are larger valleys containing bodies of agricultural land upon which most of the crops are produced without irrigation. It has been found, however, that fruit raising can be carried on to profit, and that with irrigation even the citrus fruits can be cultivated. The principal orchards, however, are of apple, peach, and pear trees.

The water supply of the county is large and has been utilized to a considerable extent for mining and for power, the ditches aggregating probably over 150 miles in length. The principal of these belong to the Tuolumne County Water Company, the La Grange Company, and others. The main canal of the Tuolumne County Water Company takes water from the south fork of Stanislaus river at a point about 18 miles above Columbia, covering land in the vicinity of that town, branch lines running to Jamestown, Montezuma, Sonora, and other localities. It was constructed originally for mining purposes, but is now used to a certain extent for irrigation.

VENTURA COUNTY borders upon the ocean south of Kern and west of Los Angeles county. As in the case of the latter locality, the principal towns are near the seashore or within the valleys opening toward the ocean. Irrigation is rarely necessary except for orchards and vineyards and for late summer vegetables. The principal valley is that through which Santa Clara river flows in a general westerly direction. This is upward of 10 miles in width and contains many ranches, the principal crop being barley, which is raised both for hay and grain. Besides this are other valleys, many of which possess a climate well adapted for fruit raising, as well as for general agriculture. The water supply as a whole is good, although for complete development of resources there is necessity of water storage. There are no large systems of irrigation in any way comparable to those of counties to the east, but the ditches are mostly short, rarely exceeding 5 miles in length. As examples, may be given the following: the canal of the Sespe Land and Water Company obtains water from Sespe river at a point about 3 miles northwest of the town of Fillmore, covering land on the west side of the stream. It is 5 miles in length, 7 feet wide, and the cost is stated to have been $50,000. Water is diverted by means of a temporary wing dam, replaced after floods. Water is sold with the land at the rate of 1 miner's inch to 5 acres, the annual assessment being about $1 per acre. The largest part of the area irrigated is made up of orange groves. The Bardsdale ditch takes water from the south side of Santa Clara river about 5 miles above the mouth of Sespe river. It is 3 miles long, 8 feet wide, and is stated to have cost $2,300. As in the case of the ditch just mentioned, water is sold with the land, but the annual charges are apparently regulated by cost of maintenance. The Santa Ana Water Company takes water out on the east side of Ventura river, at a point 5 miles northwest of San Buena Ventura. The main ditch is 5 miles in length, 7 feet wide, and is used in connection with the pipe line supplying the town. The annual cost of water is stated to be from 50 cents to $1.50 per acre. Near the coast are a number of small flowing wells, most of them put down for the purpose of furnishing water for cattle and for household use, some of the water, however, being employed in irrigation.

YOLO COUNTY is one of the lower counties of the Sacramento valley, the large river of that name forming its eastern boundary. Much of the land on that side of the county is low, some being covered by tules. The western side is hilly or even mountainous, but contains one valley of considerable size, Capay, traversed by Cache creek, the outlet of Clear lake, situated in Lake county. South of this valley is Putah creek, which also rises in Lake county and flows in a general course parallel to that of Cache creek through Napa county and then for a short distance forms the southern boundary of Yolo. Both these creeks, Cache and Putah, discharge during the spring time large volumes of water, but during the droughts of late summer their waters shrink and disappear before reaching Sacramento river. Throughout the county the cereals are raised without irrigation, water being used to any considerable extent only in the vicinity of Woodland and in Capay valley for fruit and alfalfa. Attempts have been made to raise alfalfa without irrigation, but these have not always been successful, not wholly from the lack of moisture, but because of the destructive effects of the gophers. By irrigating the fields and flooding them thoroughly many of the gophers are drowned in their holes, checking the ravages.

The principal ditch of the county is that of the Woodland Ditch Company, commonly known as Moore's ditch. It takes water from Cache creek about 8 miles northwesterly from Woodland and carries it out on the south side. The main ditch extends east for about 2 miles and then divides into a number of branches. The total cost of the system has probably been over $50,000. Work was begun as early as 1856, and the ditch has been enlarged and extended at intervals since then. The capacity is probably from 60 to 70 second-feet. Water is sold by the second-

foot per hour, the charge being at the rate of 16⅔ cents per hour or $4 per day. It is estimated that to flood alfalfa 3 times costs about $2.50 per acre per year. About one-half the water is used on vineyards and orchards of apricots, oranges, figs, pears, and plums. The Capay ditch takes water from the south side of Cache creek near the town of Capay. It is 7 miles long, about 12 feet wide, and the cost was $20,000. It is owned by a corporation, the shareholders dividing the water among themselves. In 1889 none of the land under ditch was irrigated owing to the abundant rainfall.

YUBA COUNTY includes in its western end a portion of the Sacramento valley lying east of the Feather river. From this stream it extends in a comparatively narrow belt northeasterly to the high Sierras, embracing thus plain and foothill regions as well as the river lands. The character of the agriculture is dependent upon these topographic features. On the rich low lands broad fields of cereals were cultivated, while the rolling and hilly uplands were devoted mainly to grazing and were considered to have little value until their adaptability to fruit culture was made known. With the cessation of hydraulic mining in the mountains and the abandonment of the network of ditches and flumes built for this purpose came the opportunities for the extension of irrigation by taking advantage of the magnificent water supplies thus offered. The large returns of fruit raising also induced the construction of new ditches, utilizing the magnificent water supply of the county. All the deciduous fruits and also oranges are profitably raised, the areas planted to fruits and vines being found not only among the hills but also down upon the lower lands.

Irrigation is not considered necessary, especially on the lower lands, for the cereals and forage plants, although as a matter of course with a well regulated supply of water the crops are better and surer. For fruits and grapes on the dryer soils, on which these succeed best, irrigation is essential. Water is obtained for these areas from the numerous ditches extended from the hydraulic works. Payment for the water is generally made by quantity and time used, the charge being in different cases 9 cents, 10 cents, or 12.5 cents per miner's inch for 24 hours, the quantity being measured under a 6-inch head. Near Marysville orange and other fruit trees are irrigated by water raised from wells by means of a steam pump. The comparatively large expense for water in these cases is justified by the value of the products, which ranges from $200 to $300 per acre and upward. Under the Excelsior Water and Mining Company's canal, leading from the South Yuba river about 6 miles north of Nevada city, the charge for water is stated to be from $3 to $5 per acre.

The Browns Valley irrigation district was organized in October, 1888, comprising 44,000 acres of some of the choicest foothill land. This district extends from the Yuba river on the south north to Honcut creek, the boundary being about 11 miles east of Marysville. Bonds to the amount of $140,000 have been voted, a large part of these being sold. The district has purchased over 20 miles of distributing ditches owned by the South Feather Water and Union Mining Company and has built 18 miles of main canal, besides flumes, bridges, and pipe lines. It has also constructed a dam across the North Yuba river 25 feet high, 140 feet long, and 40 feet thick at base. This is built of crib work filled with stone, and is for the purpose of diverting water into the flumes placed 7 feet above high water mark.