Geology and Water Resources of the Santa Ynez River Basin, Santa Barbara County, California

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GEOLOGY AND WATER RESOURCES OF THE SANTA YNEZ RIVER BASIN SANTA BARBARA COUNTY, CALIFORNIA

By J. E. Upson and H. G. Thomasson, Jr.

ABSTRACT

The Santa Ynez River basin is a westward-trending, linear, somewhat irregular structural depression between rugged mountain ranges and hills in the southern part of Santa Barbara County, Calif. It opens on the Pacific Ocean at the west end. Mean annual rainfall ranges from about 14 inches on the coast to 35 or 40 inches on the higher mountains. About 85 percent of each year's rain ordinarily falls between December 1 and April 30. Yearly variation is extreme; hence full utilization of the water resources must include use of underground and surface storage during dry years.

Unconsolidated water-bearing deposits of Tertiary and Quaternary age are about 3,000 feet in maximum thickness. These rest on consolidated rocks of Mesozoic and Tertiary age that are essentially not water-bearing. The consolidated rocks comprise the Franciscan, Knoxville, Tejon, Sespe, Vaqueros, Rincon, Monterey, Foxen, and Sisquoc formations, ranging in age from Jurassic (?) to Pliocene. The unconsolidated deposits comprise the Careaga sand of upper Pliocene age, the Paso Robles formation of Pliocene and Pleistocene (?) age, the Orcutt sand and terrace deposits of Pleistocene age, and younger alluvium, river-channel deposits, and eolian deposits, all of Recent age.

The Careaga sand in most places is saturated but yields little water to wells. Its permeability is about 70 gallons per day per square foot as determined from laboratory tests on outcrop samples. The Paso Robles formation is also largely saturated with water and constitutes a large reservoir, but is generally not very permeable. However, it supplies moderate quantities of water to wells that tap it. The Orcutt sand is comparable to the Paso Robles formation in permeability, but is tapped by only a few wells.

The terrace deposits are mostly thin discontinuous bodies of sand and gravel that cap benches and terraces along the streams, and are mainly not saturated with water. However, one extensive body and some discontinuous bodies that are buried by alluvium yield water more or less readily to wells.

The younger alluvium occurs along the Santa Ynez River and tributary streams. It consists of two members: an upper member, not very productive of water, which is composed of clay and silt with some sand and gravel, and a lower member which consists of sand and gravel and yields water copiously to most irrigation wells drilled along the river. This lower member is the most productive water-bearing formation of the area. In the lower part of the valley it is fairly thick and extensive and is there termed the main water-bearing zone. Its permeability, as determined from discharging-well tests ranges from about 1,000 to 4,500.

The river-channel deposits consist mostly of coarse gravel and sand which occur in the river flood channel. Their permeability has been determined from laboratory tests to range from 425 to 4,320, but they are tapped by only a few wells.

The river valley comprises five hydrologically distinct subareas designated in downstream order the Headwater, Santa Ynez, Buellton, Santa Rita, and Lompoc subareas. The Headwater subarea includes that part of the Santa Ynez and tributary drainage that lies above San Lucas Bridge. The Santa Ynez subarea includes the corresponding areas between San Lucas Bridge and the Mission Bridge at Solvang. The Buellton subarea includes the river and tributary areas thence downstream to the east end of the Santa Rita Hills; and the Santa Rita subarea thence to The Narrows above Robinson Bridge. The Lompoc subarea lies between The Narrows and the ocean.

Surface-water resources are analyzed in large part on the basis of a 16-year period ending September 30, 1944 which is the longest period common to the runoff records for the four principal gaging stations on the river. This period is considered to be fairly representative of long-term average conditions. Flashy runoff concurrent with storms and progressive depletion through the summer and autumn characterize the river regimen. For the 16-year base period, average and median yearly natural runoff past 3 main stem gaging stations are respectively as follows: Gibraltar Dam, 44,430 and 19,230 acre-feet; San Lucas Bridge, 95,300 and 35,440 acre-feet; and Robinson Bridge, 134,000 and 58,940 acre-feet. Four major floods during that period had about the same peak discharge at San Lucas Bridge (drainage area 435 square miles) as at Robinson Bridge (drainage area 790 square miles), 31.4 miles downstream.

Underflow in the alluvium and channel deposits along the river course, estimated at six places downstream from San Lucas Bridge, ranges from 320 to 1,080 acre-feet per year.

Surface-water and ground-water resources of the five subareas of the Santa Ynez River basin are as follows:

The Headwater subarea ordinarily delivers about two-thirds of the total runoff from the entire basin, and is the wettest of the subareas; average and median yearly runoff during the 16-year base period were respectively 219 and 82 acre-feet per square mile. Except for the two small reservoirs formed by Juncal Dam and Gibraltar Dam the surface-water resources are essentially unused. Ground-water bodies along the Santa Ynez River are small, but a large body occupies unconsolidated deposits north of the river in the drainage basins of Cachuma and Santa Cruz Creeks. Essentially no water is pumped from the ground-water body north of the river, but a few wells have been drilled in deposits along the river in recent years.

From the Santa Ynez subarea, in the eight predominantly dry water-years 1929–36 in which a year-round gaging station was operated at Mission Bridge, the average yearly runoff was 8,330 acre-feet, or 56 acre-feet per square mile. For the 12 years 1929–40 the average inflow to the river during the month of November was 333 acre-feet. This inflow probably represents base ground-water discharge from, and hence replenishment to the alluvial deposits along the river. It represents a minimum inflow of about 4,000 acre-feet a year, of which about 95 percent is from the area north of the river.

Ground water in the Santa Ynez subarea occurs in the Paso Robles and Careaga formations beneath the Santa Ynez upland north of the river, and in the alluvium and channel deposits along the river. The main body to the north is separated from the river by the impermeable consolidated rocks, and obtains recharge chiefly from infiltration of rain. It discharges perennially into Santa Agueda, Zanja Cota, and Alamo Pintado Creeks, the flow of which in turn largely con-

stitutes the low-water inflow to the river in the subarea. Pumpage of ground water for irrigation on the upland averaged about 500 acre-feet a year from 1935 through 1944. It has been within the natural yield of the body, which is estimated to be on the order of 4,000 acre-feet a year.

Pumpage from the alluvium along the river has been on the order of 500 acre-feet a year. It is considerably less than the total inflow to the river in this reach and is negligible in comparison with the total runoff from upstream in most years.

Within the Buellton subarea, the principal ground-water body is in the younger alluvium along and in hydraulic continuity with the river. Discharge from this body to the river during late autumn has been at an average rate of about 5 second-feet. In summer the river loses by influent seepage to the ground-water body at a rate of from 3 to 8 second-feet largely as a result of pumpage for irrigation. Yearly recharge to ground-water from this source has been 700 to 1,000 acre-feet. Pumpage from ground water has averaged about 3,000 acre-feet per year in recent years. Practicable perennial yield of the ground-water body under current conditions is estimated to be between 2,400 acre-feet a year, average net pumpage, and 7,600 acre-feet a year, estimated total replenishment.

In the Santa Rita subarea the river receives little surface inflow except from Salsipuedes Creek which in the 3 water years 1942–44 delivered about 10,000 acre-feet each year. In addition to measured tributary inflow, the river has gained slightly but consistently in the years 1941–44 in the lower part of the reach, thus indicating that the base rate of ground-water inflow during those years was greater than current withdrawals.

There are two ground-water bodies in the Santa Rita subarea, one north of the Santa Rita Hills in the Paso Robles and Careaga formations, and the other along the river principally in the lower member of the younger alluvium. Little water is pumped from the body north of the Santa Rita Hills, and it is replenished largely by infiltration of rain. Withdrawals from deposits along the river in the period 1935–44 averaged about 2,000 acre-feet a year. This ground-water body is replenished by direct seepage from the river, by ground-water inflow from the sides, and by infiltration of rain. Perennial yield for the period 1935–44 is estimated to be between 1,400 acre-feet a year, the estimated net pumpage, and 7,500 acre-feet a year, the estimated total replenishment.

In the Lompoc subarea, the river loses some water in the vicinity of Robinson Bridge, holds steady flow or gains slightly in a reach between the H Street Bridge and Dyer Bridge, intermittently loses water between 1 mile and 3 miles below Dyer Bridge, and normally gains in flow in the lower end of the valley near the ocean. Under the present state of agricultural development, the river supplies about from 2,800 and 3,300 acre-feet a year to the Lompoc Valley by underflow, seepage losses, and direct pumpage.

Ground-water in the Lompoc subarea occurs in two bodies. A shallow water body is in the upper member of the younger alluvium and in the river-channel deposits; and throughout much of the area is hydraulically separate from a deep body. The deep body occurs continuously in the lower member of the younger alluvium and also in adjacent and outlying deposits including buried terrace deposits, the Orcutt sand, Paso Robles formation, and Careaga sand. Essentially all the pumpage of ground water, which averaged about 10,000 acre-feet per year from 1935 to 1944, is taken from the deep water body. This body is replenished only in part from the Santa Ynez River which supplies about 2,800 acre-feet a year. The pumpage has caused no apparent over-all decline of water levels in the area; hence, the perennial yield is probably about equal to current withdrawals or on the order of 10,000 acre-feet a year.

At present there seems to be no contamination of the deep water body by sea water, but excessive lowering of head could result in encroachment of sea water into the main pumped zones.

INTRODUCTION

LOCATION OF THE AREA

The Santa Ynez River basin is in the southern part of Santa Barbara County, Calif., which lies between longitudes 119°27′ and 120°40′ W. and latitudes 34°21′ and 35°10′ N. This county is in the sharp angle of the California coast, which trends nearly west to Point Conception and nearly south to Point Arguello. (See fig. 1.) The Santa Ynez

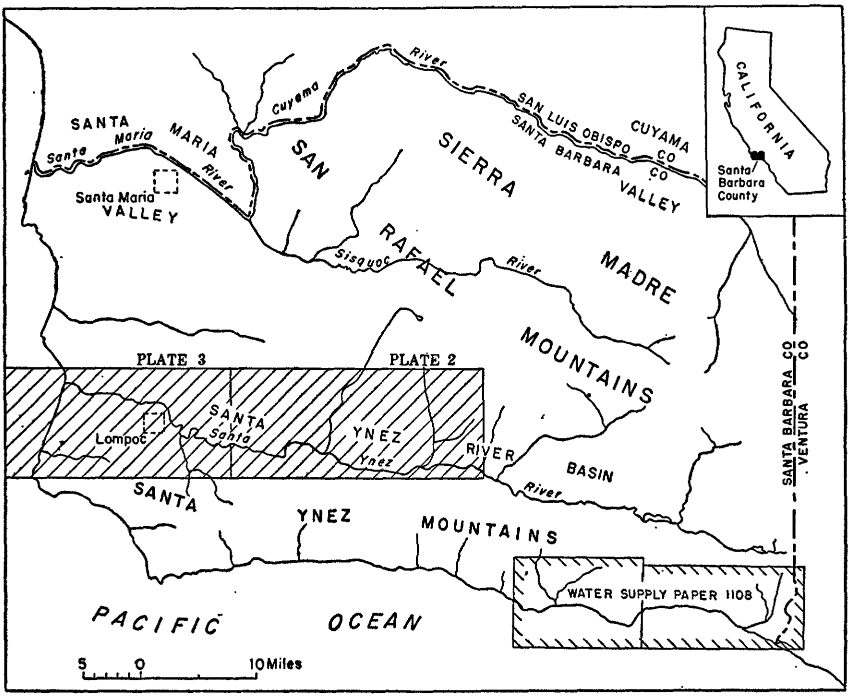

FIGURE 1.—Index map of Santa Barbara County, Calif. showing the Santa Ynez River basin and areas of intensive ground-water investigation covered by this report.

River basin parallels the westward-trending reach of the coast, from which it is separated by the narrow Santa Ynez Mountains. It heads about half a mile east of the county boundary and terminates on the coast at Surf, about 7½ miles north of Point Arguello.

PURPOSE AND SCOPE OF THE REPORT

The investigations, of which this report is one result, were begun by the Geological Survey, United States Department of the Interior, in January 1941 in cooperation with the county of Santa Barbara. These investigations have been coordinated with over-all plans for utilization of the county's water resources, both surface water and ground water, on a county-wide basis. The main objectives have been to determine the yield of the several ground-water basins of the county, to determine the possible effect, if any, on those basins of regulating and diverting streamflow, and to evaluate the presence or possibility of salt-water contamination of the ground-water bodies.

This report is the first of a series of interpretive reports setting forth the desired conclusions and determinations. It deals with the entire valley of the Santa Ynez River, which contains two of the six main agricultural districts of Santa Barbara County and numerous small tracts of cultivated land along the river. Water for irrigation in these areas is taken largely from wells that tap ground-water bodies. In part, these ground-water bodies depend upon the Santa Ynez River for replenishment.

Specifically, the report delimits five subdivisions of the valley in each of which the occurrence of ground water, its relation to the river, and the characteristics of stream flow are distinct to some degree. For most of these subareas the report gives an estimate of the yield of the ground-water bodies, describes the extent of dependence of the bodies on the river for replenishment, and for certain of them gives the variation of river flow and of underflow and relates these data to current and potential replenishment of ground water. It discusses the quality of the ground water and, for the seaward end of the valley, discusses the possibility of salt-water contamination. Thus, the report accomplishes the main objectives of the investigation insofar as they relate to the Santa Ynez River basin.

Factual data on the geology, permeability of water-bearing deposits. pumpage, pumping tests, and certain records of water-level fluctuations are included in this report. Basic data on wells and most records of water-level fluctuations are assembled elsewhere and have been released or published (Meinzer, Wenzel, and others, 1943, 1944, 1945; La Rocque, Upson, and Worts, 1950).

ACKNOWLEDGMENTS

This report is based on work performed by the Geological Survey, United States Department of the Interior, in cooperation with Santa Barbara County. Ground-water aspects of the work have been under the direction of O. E. Meinzer, geologist in charge of the Division of Ground Water in the Geological Survey, and of A. M. Piper, district geologist. The project was under the local charge of G. A. LaRocque, Jr., until his furlough for military duty beginning in June 1943; subsequently, it was under the charge of the senior writer. Surface-water aspects of the work have been under the direction of H. D. McGlashan, district engineer for the Division of Surface Water, also of the late F. C. Ebert and of H. M. Stafford, engineers in charge at Los Angeles.

Geologic mapping in the Santa Ynez River basin was begun by G. F. Brown and completed by the senior writer. This work was facilitated by a map of the Santa Maria oil district, which overlaps the northern part of Santa Ynez Valley, by W. P. Woodring and others. A copy of this map was made available by the Geologic Branch of the Geological Survey prior to its publication.

The writers wish to acknowledge the help and constructive criticism of colleagues in the Geological Survey in the preparation of the manuscript and illustrations. Particular acknowledgment is due Penn P. Livingston, who compiled and interpreted much of the basic data. S. F. Turner contributed advice as to the construction and operation of apparatus for determining the permeability of water-bearing materials and loaned some equipment.

CLIMATE

GENERAL COUNTY-WIDE FEATURES

Santa Barbara County is bordered on two sides by the Pacific Ocean, from which the prevailing winds blow throughout the year. These winds, blowing over the cold California Current and the cold water upwelling offshore, lower the temperatures over the land in summer and moderate the cold in winter, thus reducing the annual range of temperature in the coastal area. However, in all the climatic factors, both diurnal and seasonal fluctuations increase progressively inland, as the effects of mountain ranges are felt. Tables 1 through 4 (pp. 10 to 23) give representative factual climatic data for several stations within and near the county. (See fig. 1 and pl. 1.)

Climatologic stations not shown on these plates include Ojai, about 25 miles east of Santa Barbara; San Luis Obispo, about 25 miles northwest of Santa Maria; and Bakersfield, about 40 miles northeast of the northeast part of Santa Barbara County. Rainfall stations not shown on these plates include Ozena, about 5 miles east of Santa Barbara County on the Cuyama River, and Pattiway, about 7 miles northeast of the northeast part of the county and about 17 miles northwest of Ozena.

Frosts are infrequent along the coast so that in general two crops a year are possible. The average lengths of the frost-free season at the representative stations are included in table 1 and range from 231 to 333 days. Along the coast, fog and high humidity are common in the mornings during the summer, but the afternoons ordinarily are clear and much less humid. For example, at the airway station near Goleta, about 8 miles west of Santa Barbara, for 3 years ending in 1944 the average yearly relative humidity was 86.2 percent at 4:30 a. m. and 63.1 percent at 4:30 p. m. For July, August, and September, the corresponding figures were 91.8 and 66.2 percent, respectively. At San Luis Obispo, for 28 years ending in 1922 the average yearly humidity was 81 percent at 5 a. m. and 60 percent at 5 p. m.; for July, August, and September the corresponding figures were 87 and 57 percent, respectively. Although records are not available at this time, the humidity is much lower in the interior parts of the county.

The agricultural districts around Carpinteria, Goleta, Lompoc, and Santa Maria all are adjacent to the coast and are in the area of mildest and most equable climate. The climatologic data for Santa Barbara and Santa Maria are representative. (See table 1.) The principal crops of these areas are vegetables, flower seeds, walnuts, and lemons. In addition to the above-mentioned crops, which are irrigated, considerable quantities of beans and tomatoes are grown by dry-farming methods which take advantage of the summer fogs.

The central valleys (Santa Ynez, San Antonio, and Sisquoc) are separated from the coast by low hills to the west, and in those valleys the diurnal and seasonal fluctuations in temperature are slightly greater than at the coast. The growing season is somewhat shorter, but the winters are mild. Vegetables, dairy products, and grain are the chief agricultural products.

The agricultural district most remote from the coast is the upper Cuyama Valley. This fairly extensive valley is semiarid, is from 2,000 to 2,500 feet above sea level, and is shut off from the ocean by the Sierra Madre. With hot summers, cool winters, and scant rainfall, its climate ranges more widely than in any of the valleys or areas previously described. Its climatologic characteristics resemble but are somewhat less variable than those of Bakersfield, which is in the San Joaquin Valley and about 25 miles to the northeast. (See table 1.) Formerly its principal agricultural products were cattle and grain, but since 1940 some diversified crops have been grown under irrigation from wells.

PRECIPITATION IN THE COUNTY AND IN THE SANTA YNEZ RIVER BASIN

Within Santa Barbara County, precipitation ranges widely with the seasons. At Santa Barbara about 85 percent of the yearly total falls between December 1 and April 30, and only about 2 percent falls in June, July, and August (table 2). Precipitation is almost entirely in the form of rain. Snow falls occasionally on the higher peaks of the San Rafael Mountains and the Sierra Madre in the eastern part of the county, but not in amounts sufficient to influence stream runoff greatly.

At any particular station the precipitation also varies widely from year to year. At Santa Barbara, for example, where rainfall has been measured since 1868, the least yearly amount of record was 4.49 inches in 1877, the greatest was 45.25 inches in 1941, and the 77-year average is 18.40 inches. In other words, the range has been between 24 and 246 percent of the average. Between these extremes the yearly rainfall fluctuates in rude cycles with a period of about 30 years each. The record available is long enough to cover only about two and one-half periods and does not permit any mathematical analysis. The irregular and somewhat indeterminate character of the so-called cycles is explained by the occasional wet years during the times of low average rainfall and likewise by the occasional dry years during the times of high average rainfall. It appears true, however, that periodic variations in rainfall do exist and that they exert a profound influence upon the hydrology of the area.

In any single year the depth of precipitation differs greatly from place to place in Santa Barbara County, owing largely to the alinement of the several mountain ranges with respect to storm tracks. In terms of average yearly precipitation, the spread is about from 10 inches in the upper Cuyama Valley to 40 inches locally on the highland in the southeastern part of the county. With respect to the Santa Ynez River basin in particular, the low-pressure storm centers usually move in from the northwest or west. The warm moist air moving from the southeast into these centers is deflected upward by the 3,000- to 4,000-foot Santa Ynez Mountains, which form the southern boundary of the basin. The resulting precipitation is fairly heavy along the crest and for some distance down the north slope of the mountains.

Specifically, studies by the United States Engineer Office at Los Angeles, have resulted in the conclusion that the average yearly precipitation is from 28 to 30 inches along the crest of the mountains eastward from Gaviota Pass but at the northern foot of the mountains is only from about 14 inches at the coast to 18 inches at San Lucas Bridge on the Santa Ynez River. However, the area between the divide and the river channel at the foot of the mountains is only 2 to 6 miles wide, and the total volume of water that falls there is fairly small. On the low plains and rolling hills north of the river and downstream from San Lucas Bridge, the average yearly precipitation also is between about 14 and 18 inches.

Upstream from San Lucas Bridge, however, the Santa Ynez Mountains merge northward into the San Rafael Mountains and form a rugged headwater area. Here, the higher peaks along the east and north boundaries of the Santa Ynez River basin are from 5,000 to 6,000 feet above sea level. Here any warm moist air moving toward a low-pressure storm center at levels above the crest of the Santa Ynez Mountains precipitates rain (or snow, occasionally) over the highland. The study by the Engineer Office suggests that the average yearly precipitation is extensively 30 inches or more and increases to as much as 34 inches in the vicinity of Big Pine Mountain (in the San Rafael Mountains, nearly due north of Santa Barbara) and to 40 inches at the eastern boundary of the river basin. Thus, of the total volume of precipitation on all the river basin, about half falls on this area upstream from San Lucas Bridge north of the river; possibly as much as two-thirds falls on the total area upstream from San Lucas Bridge north and south of the river.

For the Santa Ynez River basin, these features of rainfall distribution are established fairly well except for the mountainous headwater area upstream from San Lucas Bridge. Along or near the Santa Ynez River, rain gages are distributed from Jameson Lake, 5 miles from the eastern divide, to Surf at the coast on the extreme west. Elsewhere west of San Lucas Bridge, sufficient additional gages are maintained by private ranches to define the rainfall distribution. However, the higher mountains surrounding the basin east of San Lucas Bridge (part of the so-called back country) are rough and uninhabited and in winter are accessible only by saddle horses. There, existing rain gages are too few to determine adequately the distribution of precipitation. However, to abate this deficiency in basic data a program of rainfall measurement is now in preparation by various agencies concerned; it is hoped that within a few years this program will yield much valuable information on quantities and intensities of precipitation in this "wettest" part of the basin.

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TABLE 1.—*Climatologic data at five stations in and near Santa Barbara County, Calif.*

[From publications of U. S. Weather Bureau]

	Period (years)	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Year
Santa Barbara (altitude 130 feet)														
Average maximum temperature, through 1940	44	74.8	72.0	67.2	64.5	65.1	66.9	69.0	69.6	72.5	76.2	77.0	76.8	71.0
Average minimum temperature, through 1940	44	50.9	45.8	42.8	42.2	43.9	45.3	47.6	49.8	53.1	56.4	56.9	54.9	49.1
Average temperature, through 1940	56	62.9	59.0	55.0	53.3	54.5	56.0	58.1	59.8	62.6	66.0	67.0	65.9	60.0
Absolute maximum temperature, through 1944	48	100	98	91	90	94	95	98	101	115	108	98	108	115
Absolute minimum temperature, through 1944	48	34	28	23	25	27	32	34	38	40	45	45	43	23
Average precipitation, through 1940	73	.74	1.36	3.31	4.03	3.78	2.85	1.11	.43	.10	.02	.03	.34	18.10
Greatest 24-hour precipitation, through 1944	77	2.45	3.90	4.01	6.95	4.25	3.59	3.14	1.43	.99	.25	.70	4.50	6.95
Average number of days with 0.01 inch or more of precipitation, to 1940	40	2	2	6	7	7	6	3	2	1	(1)	1	1	38
Prevailing wind direction, through 1944	38	W.	W.	W.	W.	W.	SE.	W.	W.	W.	W.	W.	W.	W.
Frost data, 33-year period ending 1940:														
Average date of last killing frost before July 1														Jan. 21
Average date of first killing frost after July 1														Dec. 20
Average length of growing season														333 days
Santa Maria (altitude 217 feet)														
Average maximum temperature, through 1940	37	74.3	70.5	65.3	63.9	64.4	66.8	68.9	70.4	72.8	74.5	74.6	75.5	70.2
Average minimum temperature, through 1940	37	47.4	42.5	39.9	38.9	40.9	42.8	44.6	46.9	49.7	52.1	52.6	50.7	45.8
Average temperature, through 1940	48	61.3	56.8	52.7	50.1	51.4	53.6	55.8	58.9	61.6	63.5	63.9	63.3	57.7
Absolute maximum temperature, through 1944	43	104	92	90	85	89	91	98	101	109	103	95	106	109
Absolute minimum temperature, through 1944	43	29	24	26	24	25	28	28	32	35	41	31	32	24
Average precipitation, through 1940	49	.76	1.18	2.20	2.91	2.63	2.60	.95	.43	.08	.01	.03	.23	14.01
Greatest 24-hour precipitation, through 1944	53	2.80	1.70	2.39	3.10	3.55	2.24	1.80	1.15	1.73	.02	.85	1.30	3.55
Average number of days with 0.01 inch or more of precipitation, through 1940	23	3	3	7	8	8	8	5	2	1	1	1	2	49
Prevailing wind direction, through 1944	53	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.
Frost data, 34 year period ending 1940:														
Average date of last killing frost before July 1														Feb. 27
Average date of first killing frost after July 1														Nov. 27
Average length of growing season														273 days

San Luis Obispo (altitude 300 feet)														
Average maximum temperature, through 1940	44	75.1	70.7	64.3	62.2	63.6	65.3	67.8	69.2	73.6	77.0	77.1	77.4	70.3
Average minimum temperature, through 1940	44	49.6	45.5	42.3	41.5	43.7	44.7	45.8	47.6	50.0	51.7	52.4	51.8	47.2
Average temperature, through 1940	46	62.3	58.0	53.3	51.9	53.7	55.0	56.7	58.4	62.0	64.5	64.8	64.6	58.8
Absolute maximum temperature, through 1944	48	103	94	91	84	89	93	97	100	110	106	107	109	110
Absolute minimum temperature, through 1944	48	35	24	24	20	25	28	30	34	38	42	42	38	20
Average precipitation, through 1940	71	.88	1.65	3.93	4.91	4.20	3.32	1.40	.54	.13	(2)	.03	.23	21.22
Greatest 24-hour precipitation, through 1944	75	1.63	4.48	4.61	4.99	4.56	5.98	2.92	2.35	1.70	.09	.85	1.66	5.98
Average number of days with 0.01 inch or more of precipitation, through 1940	41	3	4	8	10	9	9	4	3	1	(1)	(1)	1	52
Prevailing wind direction through 1944	44	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.
Frost data 46 year period ending 1940:														
Average date of last killing frost before July 1														Feb. 3
Average date of first killing frost after July 1														Dec. 17
Average length of growing season														317 days
Ojai (altitude 750 feet)														
Average maximum temperature, through 1940	35	83.1	76.8	68.8	66.0	67.2	69.7	73.1	77.0	84.4	92.1	92.3	88.9	78.3
Average minimum temperature, through 1940	35	45.1	39.3	36.1	35.1	37.8	39.4	41.9	45.2	48.4	52.9	52.5	50.2	43.7
Average temperature, through 1940	35	64.1	58.1	52.4	50.7	52.4	54.5	57.5	61.1	66.4	72.5	72.4	69.6	61.0
Absolute maximum temperature. through 1944	39	108	100	93	91	92	95	100	105	119	117	115	114	119
Absolute minimum temperature, through 1944	39	27	23	21	13	23	25	27	31	36	41	40	37	13
Average precipitation, through 1940	35	.72	1.20	3.65	5.08	4.84	3.61	1.26	.54	.07	.01	.05	.38	21.41
Greatest 24-hour precipitation. through 1944	39	1.95	3.85	5.15	8.15	5.70	7.90	3.30	2.00	.48	.13	.60	4.10	8.15
Average number of days with 0.01 inch or more of precipitation, through 1940	26	2	2	5	6	6	5	3	2	1	(1)	(1)	1	33
Prevailing wind direction through 1944	30	SW.	SW.	SW.	SW.	SW.	SW.	SW.	SW.	SW.	SW.	SW.	SW.	SW.
Frost data, 35 year period ending 1940:														
Average date of last killing frost before July 1														Mar. 31
Average date of first killing frost after July 1														Nov. 17
Average length of growing season														231 days
Bakersfield (altitude 489 feet)														
Average maximum temperature, through 1930	29	81.8	71.1	60.2	58.4	65.8	70.3	76.4	82.9	94.1	100.2	98.8	91.3	79.3
Average minimum temperature, through 1930	29	48.5	40.8	35.2	36.2	39.3	42.4	47.0	52.8	59.4	63.6	62.4	55.7	48.6
Average temperature, through 1940	52	65.5	55.6	47.8	47.0	52.4	56.8	62.8	70.0	77.7	84.1	82.0	74.3	64.7
Absolute maximum temperature, through 1930	34	103	95	87	82	88	94	100	110	113	118	113	111	118
Absolute minimum temperature, through 1930	34	31	24	13	14	20	21	30	34	38	46	44	31	13
Average precipitation, through 1940	52	.29	.58	.77	1.02	1.01	.94	.58	.46	.06	.01	.01	.15	5.88
Average number of days with 0.01 inch or more of precipitation, through 1930	16	2	3	4	5	5	5	4	2	(1)	(1)	(1)	1	31
Prevailing wind direction through 1930	15	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.
Frost data, 27 year period ending 1930:														
Average date of last killing frost before July 1														Feb. 22
Average date of first killing frost after July 1														Nov. 23
Average length of growing season														274 days

[1] Less than 1 day.
[2] Less than 0.01 inch.

TABLE 2.—*Precipitation, in inches, in the 77 water years, 1867–1944 at stations in and adjacent to Santa Barbara County, Calif.*

Water-year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
Santa Barbara (altitude 130 feet) [1]													
1866–67										0.02	0.01	0	
1867–68	0	2.21	12.67	3.97	2.00	1.08	2.44	0.72	0	0	0	0	25.19
1868–69	0	1.25	4.26	3.26	2.12	4.22	.46	.20	0	0	0	0	15.77
1869–70	.30	.65	.57	.25	5.87	.83	.99	.74	.07	0	0	0	10.27
1870–71	1.04	.27	1.41	.86	2.92	.02	2.02	.37	0	0	0	0	8.91
1871–72	.09	1.83	6.56	2.53	1.81	.18	1.80	0	.14	0	.02	.05	15.01
1872–73	0	0	4.34	.58	5.48	.05	0	0	0	0	0	0	10.45
1873–74	0	.27	5.26	4.54	3.17	.78	.28	.14	0	0	0	0	14.44
1874–75	1.91	1.30	0	14.84	.18	.38	.10	0	0	0	0	0	18.71
1875–76	0	6.53	.31	7.56	5.67	2.73	.27	0	0	0	0	0	23.07
1876–77	.32	0	0	2.72	0	.82	.18	.45	0	0	0	0	4.49
1877–78	0	1.32	3.12	7.17	11.73	2.47	3.34	.29	.07	0	0	0	29.51
1878–79	.32	0	5.16	5.24	.71	.34	1.60	.21	0	0	0	0	13.58
1879–80	.41	1.62	4.57	1.30	10.86	1.15	5.73	0	0	0	0	0	25.64
1880–81	.25	.28	9.73	2.83	.30	1.25	.59	0	0	0	0	.44	15.67
1881–82	1.47	.33	.95	1.13	2.38	5.74	1.63	0	.20	0	0	0	13.83
1882–83	.37	.77	.10	2.18	2.92	3.64	.29	2.79	.35	0	0	0	13.41
1883–84	1.32	0	2.76	6.33	9.68	9.77	2.60	.39	1.62	0	0	0	34.47
1884–85	1.02	.79	6.62	1.23	.07	.35	3.00	0	0	0	0	0	13.08
1885–86	.19	9.84	2.47	5.12	1.19	2.03	3.40	0	0	0	0	0	24.24
1886–87	.39	.87	.86	.31	8.64	.13	1.43	.33	.03	0	0	.38	13.37
1887–88	.31	1.10	4.43	10.15	1.30	3.86	.16	.02	Tr	Tr	Tr	.03	21.36
1888–89	.07	5.62	5.59	.29	1.29	7.31	.49	.76	.13	0	0	0	21.55
1889–90	8.65	3.21	10.64	5.32	2.96	1.10	.31	.18	0	0	0	1.50	33.87
1890–91	.05	.48	3.53	.45	7.92	1.56	1.57	.30	0	0	0	.15	16.01
1891–92	0	0	2.43	1.10	2.55	2.95	.46	1.12	0	0	0	0	10.61
1892–93	.26	4.27	6.66	4.41	3.10	7.80	.38	.09	0	0	0	0	26.97
1893–94	.82	.07	2.94	.99	.76	.29	.24	.91	0	.12	Tr	1.36	8.50
1894–95	.68	.07	4.67	6.25	.67	1.99	.46	.02	.05	Tr	0	0	14.86
1895–96	.55	.77	.93	6.84	0	2.37	1.78	.08	.05	.40	0	0	13.77
1896–97	.92	3.51	2.92	4.35	3.65	2.73	.02	0	0	0	0	0	18.10
1897–98	1.44	0	0	.63	1.39	.28	Tr	1.25	0	Tr	0	3.17	8.16
1898–99	.14	0	.36	4.48	.02	2.78	.64	0	.78	0	0	0	9.20
1899–1900	2.06	1.97	2.35	2.32	.05	1.58	.42	1.90	.01	.02	Tr	.04	12.72
1900–1901	.15	3.99	.02	4.86	3.65	.16	2.07	.34	.10	.06	.09	.36	15.85
1901–2	2.42	1.16	Tr	1.36	4.40	2.89	1.40	.07	0	0	0	0	13.70
1902–3	1.48	4.01	2.24	2.06	1.63	6.12	2.91	.27	.02	0	0	Tr	20.74
1903–4	Tr	.05	Tr	.46	4.69	4.40	1.89	.09	0	0	.10	7.15	18.83

1904-5	.51	Tr	1.53	3.73	8.22	6.40	.51	1.44	.05	.18	0	.03	22.60
1905-6	.16	1.14	.07	4.26	3.67	9.96	.83	2.40	Tr	Tr	.04	0	22.53
1906-7	0	.35	6.46	12.46	2.34	5.64	.27	Tr	.16	0	.03	Tr	27.71
1907-8	6.23	Tr	1.80	4.29	5.96	.21	.49	.20	0	0	0	1.16	20.34
1908-9	.20	1.84	2.48	15.67	7.92	6.91	0	.03	.08	Tr	.01	.17	35.31
1909-10	.57	2.34	9.53	2.91	.08	3.62	.39	0	0	.02	Tr	2.56	22.02
1910-11	.29	.33	.75	14.21	4.92	7.76	1.02	.03	.05	Tr	0	.12	29.48
1911-12	.28	.02	2.33	.42	0	9.48	2.12	1.58	Tr	Tr	0	Tr	16.23
1912-13	.28	.21	Tr	3.14	6.58	.64	1.04	.19	.50	.09	.07	.17	12.91
1913-14	Tr	3.43	2.71	15.91	7.30	.95	.70	.03	.16	.05	0	0	31.24
1914-15	.12	.04	4.38	4.94	8.03	1.15	.97	1.57	Tr	0	0	.05	21.25
1915-16	0	.65	4.06	17.22	1.89	1.71	.30	Tr	0	0	.11	1.90	27.84
1916-17	2.82	.10	6.12	3.25	7.61	.28	.28	.09	0	Tr	.03	.05	20.63
1917-18	Tr	.17	.03	.51	10.47	10.37	.05	0	0	.25	.58	2.13	24.56
1918-19	.02	3.64	.83	1.20	1.95	2.62	.17	1.07	0	0	0	.84	12.34
1919-20	.27	.23	2.11	.33	5.81	4.20	.81	0	.08	0	Tr	0	13.84
1920-21	.40	.56	1.51	5.32	1.58	1.77	.38	2.69	.10	Tr	0	.24	14.55
1921-22	.32	.02	7.25	4.64	3.48	2.73	.09	.45	0	0	0	0	18.98
1922-23	.37	1.98	8.70	1.96	.91	Tr	3.29	0	.03	0	.03	.13	17.40
1923-24	.25	Tr	.08	1.63	.06	3.56	.62	0	Tr	0	0	0	6.20
1924-25	.85	1.20	1.20	.60	1.45	2.79	1.89	2.23	.05	.05	0	0	12.31
1925-26	.71	.80	2.57	2.08	4.28	.25	6.13	Tr	0	0	0	0	16.82
1926-27	.36	6.84	.62	1.94	9.86	2.28	.78	0	0	0	.05	.11	22.84
1927-28	3.48	1.49	3.28	Tr	1.95	2.46	.17	.50	.05	0	0	0	13.38
1928-29	.10	2.46	4.41	1.53	2.28	2.39	1.17	0	.20	0	0	.05	14.59
1929-30	0	0	0	5.82	1.21	4.93	.95	.63	.12	0	0	.01	13.67
1930-31	.04	2.64	Tr	4.25	4.07	Tr	1.43	2.11	0	0	.23	.01	14.78
1931-32	0	2.81	9.84	2.40	6.17	.23	.35	.09	0	0	0	.11	22.00
1932-33	.10	Tr	.67	6.42	0	.30	.20	.11	.75	0	Tr	Tr	8.55
1933-34	Tr	Tr	.88	.11	6.28	1.49	3.67	Tr	1.00	0	Tr	.04	13.47
1934-35	1.89	3.48	3.63	4.10	1.58	3.16	3.32	0	0	.07	.27	.02	21.52
1935-36	.78	.71	1.46	.73	10.49	1.97	.65	.01	.01	.01	.70	Tr	17.52
1936-37	1.86	0	6.93	3.09	7.99	4.79	.03	.11	0	0	0	Tr	24.80
1937-38	.16	.09	4.40	1.90	8.20	10.26	1.09	Tr	0	0	Tr	.19	26.29
1938-39	.14	.08	4.94	2.84	1.27	3.62	.17	.10	0	0	0	.26	13.42
1939-40	.09	.02	1.41	6.39	4.87	.82	1.06	.02	0	0	Tr	0	14.68
1940-41	.75	.43	8.92	9.68	8.21	11.71	5.50	.01	Tr	.03	.01	0	45.25
1941-42	.89	.44	5.00	.80	.75	1.76	3.19	Tr	0	0	Tr	.03	12.86
1942-43	1.44	.62	1.36	12.84	4.21	2.92	.92	.03	0	0	0	0	24.34
1943-44	.40	.12	5.53	1.44	7.05	1.74	1.57	.01	.06	0	0	Tr	17.92
77-year average	.74	1.32	3.26	4.12	3.88	2.96	1.25	.41	.09	.02	.03	.32	18.40
16-year average													19.10
16-year median													16.15

See footnotes at end of table.

TABLE 2.—*Precipitation, in inches, in the 77 water years, 1867–1944 at stations in and adjacent to Santa Barbara County, Calif.*—Continued

Water-year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
San Marcos Pass near Santa Barbara (altitude 2,200 feet) [2]													
1897–98	---	---	---	---	---	---	---	---	---	---	---	4.00	---
1898–99	0.25	0	0.50	4.25	0	5.75	1.50	0	1.00	0	0	0	13.25
1899–1900	3.06	3.00	3.32	4.50	0	2.25	1.00	3.00	0	0	0	0	20.13
1900–1	0	12.87	0	8.69	6.00	1.00	1.75	1.06	0	0	0	.25	31.62
1901–2	4.12	2.00	0	1.75	6.00	4.37	1.88	0	0	0	0	0	20.12
1902–3	3.50	5.56	3.75	6.25	1.62	6.94	4.25	0	0	0	0	0	31.87
1903–4	0	0	0	1.31	6.75	6.12	3.25	.69	0	0	0	11.56	29.68
1904–5	.75	0	2.63	5.75	12.69	10.38	0	3.62	0	0	0	0	35.82
1905–6	0	1.56	0	5.75	6.25	18.06	.81	4.88	0	0	0	0	37.31
1906–7	0	.63	11.50	12.32	3.75	9.96	.58	.11	.43	0	0	.24	44.52
1907–8	7.17	0	3.54	7.68	8.08	.45	.80	.42	0	0	0	1.54	29.68
1908–9	.20	1.78	4.13	22.25	15.28	10.59	0	0	.17	0	0	.25	54.65
1909–10	1.87	2.26	11.32	7.74	.14	5.74	.39	0	0	0	0	2.12	31.58
1910–11	.24	1.08	1.54	24.83	7.54	17.95	1.88	0	0	0	0	.20	55.26
1911–12	.27	.17	2.39	.88	0	11.85	4.01	3.01	.14	0	0	0	22.72
1912–13	.09	.34	0	4.49	9.53	.82	1.68	.41	.70	.11	0	.12	18.29
1913–14	0	6.35	3.95	28.21	12.70	1.64	.51	0	.46	0	0	0	53.82
1914–15	.14	0	7.70	7.23	14.68	2.57	2.27	2.04	0	0	0	.08	36.71
1915–16	0	.59	5.39	27.94	3.44	2.28	.35	0	0	---	---	---	---
1921–22	---	.09	17.44	3.60	11.20	4.35	.60	.68	0	0	0	0	---
1922–23	.50	3.46	13.48	3.63	1.33	.21	6.02	0	0	0	0	.45	29.08
1923–24	.12	.98	.12	1.94	.11	6.31	1.10	0	0	0	0	0	10.68
1924–25	1.85	1.20	2.07	.96	2.55	3.71	5.11	4.67	.12	0	0	0	22.24
1925–26	1.52	.84	3.26	3.16	9.31	.57	12.35	.13	0	0	0	0	31.14
1926–27	.24	13.07	1.11	4.54	15.61	4.18	1.61	0	0	0	0	.16	40.52
1927–28	4.93	3.58	3.99	.08	3.00	4.02	.68	.80	.19	0	0	0	21.27
1928–29	.42	4.89	7.71	2.35	5.49	3.91	2.95	0	.36	0	0	.15	28.23
1929–30	0	0	0	8.09	2.05	5.77	.76	2.41	1.00	0	0	0	20.08
1930–31	0	4.65	0	7.02	2.80	0	2.30	3.38	.26	0	.56	0	20.97
1931–32	.12	5.91	16.13	4.27	12.33	.88	.38	.17	0	0	0	.07	40.26
1932–33	.16	0	1.15	11.73	.04	.66	.28	.20	1.05	0	0	0	15.27
1933–34	2.10	.22	9.56	7.45	6.50	0	.02	0	1.68	0	0	.20	27.73
1934–35	2.25	4.58	5.90	7.58	2.08	5.64	6.61	.12	0	.33	.16	0	35.25
1935–36	1.02	1.38	2.16	1.04	18.46	2.98	1.67	.18	.10	.03	.42	0	29.44
1936–37	2.75	0	11.27	5.57	11.67	7.57	.10	.30	0	0	0	.02	39.25
1937–38	.10	.03	8.85	2.45	20.35	13.35	1.80	.20	.04	0	0	.34	47.51
1938–39	.21	.28	7.60	5.59	2.52	4.42	.30	.06		0	0	1.26	22.24

1939–40	.28	.27	2.37	10.34	8.35	1.57	1.82	.04	0	0	0	0	25.04
1940–41	1.43	.44	14.02	11.69	12.84	17.68	9.91	.35	0	.23	0	0	68.59
1941–42	1.28	.56	11.00	2.01	1.82	2.55	6.89	.11	0	0	.09	.17	26.48
1942–43	1.63	.92	1.88	19.43									[3] 41.21
1943–44													[3] 30.34
37-year average	1.16	2.27	4.81	7.04	6.76	5.47	2.41	.88	.21	.02	.03	.52	31.58
16-year average													32.37
16-year median													28.84

Rancho San Julian near Lompoc (altitude 650 feet) [4]

1879–80	1.00	2.50	4.75	1.75	8.50	1.75	7.25	0	0	0	0	0	27.50
1880–81	Tr	.25	15.50	2.00	.25	1.38	2.25	0	0	0	0	.06	21.69
1881–82	.50	.31	.25	.88	3.13	8.25	1.13	0	Tr	0	0	Tr	14.45
1882–83	.25	1.44	.06	1.38	2.25	6.00	.25	4.13	0	0	0	0	15.76
1883–84	1.07	.20	4.56	9.61	14.60	14.77	2.94	.37	1.91	0	Tr	0	50.03
1884–85	2.30	.64	9.08	.97	0	.72	4.05	.29	0	0	0	0	18.05
1885–86	.12	13.71	3.75	5.20	.83	4.44	5.07	.13	0	.02	.57	0	33.84
1886–87	.24	.58	.45	.24	10.75	.28	1.15	.22	0	0	0	.24	14.15
1887–88	.32	3.06	6.91	6.80	.72	4.66	.24						
1888–89		8.76	5.05	.52	2.58	7.38	1.60	1.88	.01	0	0	0	27.78
1889–90	12.71	2.88	13.62	8.41	5.83	1.30	.14	.20	0	0		.43	45.52
1890–91	.03	.44	4.48	.76	9.56	1.88	1.62	.45				Tr	
1891–92		.05	3.34	1.18	4.56	6.04	.37	1.31	.13				
1892–93	.18	3.94	8.31	3.50	2.60	8.32	.99	.07					
1893–94	.85	.04	4.19	1.52	2.94	.56	.22	1.88	1.02	.02	.17	1.91	15.32
1894–95	.65	.38	7.74	7.47	.97	1.11	0	0	0	0	0	0	18.32
1895–96	1.83	.96	.69	8.97	0	3.60	.72	0	0	.45			17.22
1896–97	1.14	2.65	3.58	2.99	6.82	3.52	.09	0	0	0	0	0	20.79
1897–98	1.29	0	.27	2.68	1.88	.75	0	1.25	0	0	0	1.40	9.52
1898–99	.14	0	.69	7.04	.24	3.63	.96	0	0	0	0	0	12.70
1899–1900	2.76	2.25	3.00	3.06	.02	1.96	1.14	1.49	0	0	.05	.48	16.21
1900–1901	.27	6.89	.16	6.49	3.95	.43	3.37	.51	0	0	.10	.04	22.21
1901–2	5.15	1.55	0	1.37	4.80	4.22	1.60	.12	0	0	0	0	18.81
1902–3	3.73	5.04	2.98	2.50	2.38	7.24	1.40	0	0	0	0	0	25.27
1903–4	.04	.08	.01	1.05	5.43	5.20	2.54	.19	0	0	.50	6.01	21.05
1904–5	2.00	.08	2.49	2.50	8.29	6.34	.21	3.69	.02	.03	0	.46	26.11
1905–6	.05	1.46	.14	6.78	4.95	15.40	.43	3.41	0	0	0	0	32.62
1906–7	0	.92	7.35	15.18	2.97	9.11	.05						
1907–8												1.67	
1908–9	.19	1.27	2.61	14.56	9.68	6.27						.22	

See footnotes at end of table.

TABLE 2.—*Precipitation, in inches, in the 77 water years, 1867–1944 at stations in and adjacent to Santa Barbara County, Calif.*—Continued

Water-year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
Rancho San Julian near Lompoc (altitude 650 feet) [4]—Continued													
1909–10	0.84	2.33	8.64	4.85	0.39	6.02	0.14					0.48	
1910–11		.26	1.33	21.32	6.14	12.93	2.26		0.03				
1911–12	.25	.37	1.96	9.81				1.57					
1912–13	.02	.13	.16	3.63	4.77	.69	1.54	.30	.13		0.65		
1913–14		2.85	6.31	20.23	6.99	1.24	1.15						
1918–19												.45	
1919–20	0	0	3.63	.46	5.46	5.05	.96	0	0	0	0	0	15.56
1920–21	1.29	2.39	2.88	9.53	1.68	3.14	.65	2.58	0	0	0	.66	24.80
1921–22	0	.35	12.42	6.05	6.20	3.89	.11	.57	0	0	0	0	29.59
1922–23	.59	3.35	9.36	3.07	1.93	.35	4.61	0	0	0	0	0	23.26
1923–24	0	1.09	.68	2.18	.13	5.25	1.59	0	0	0	0	0	10.92
1924–25	1.18	1.60	2.05	1.01	2.77	3.87	2.96	4.06	.09	0	0	0	19.59
1925–26	1.01	.15	4.07	3.02	7.47	.45	4.75	0	0	0	0	0	20.92
1926–27	.32	7.61	2.36	3.32	11.09	3.60	.98	.13	0	0	0	0	29.41
1927–28	5.52	2.41	6.75	.06	3.82	3.23	.25	0	0	0	0	0	22.04
1928–29	.15	3.75	5.79	1.74	4.74	2.67	2.15	0	.32	0	0	0	21.31
1929–30	0	0	0	7.78	2.03	3.88	.81	.95	0	0	0	0	15.45
1930–31	0	2.07	.16	7.79	3.84	.12	.83	2.41	0	0	.72	0	17.94
1931–32	0	4.68	16.60	6.48	5.86	.39	.61	.30	0	0	0	0	34.92
1932–33	.11	0	1.76	9.03	.40	.58	.42	.16	.91	0	0	0	13.37
1933–34	1.40	0	7.63	1.28	5.54	0	0	.22	.78	0	0	0	16.85
1934–35	1.70	3.65	2.59	8.96	1.41	6.86	4.75	0	0	0	0	.20	30.12
1935–36	.75	2.66	1.21	3.19	12.78	2.56	.99	.13	0	0	.90	.03	25.20
1936–37	1.80	0	9.35	5.80	11.00	5.34	0	0	0	0	0	0	33.29
1937–38	0	0	5.05	7.78	16.55	9.14	1.78	.12	0	0	0	.96	41.38
1938–39	.42	.25	5.39	4.15	2.49	5.60	0	0	0	0	0	3.00	21.30
1939–40	.32	1.03	1.82	8.16	4.94	1.52	1.34	0	0	0	0	0	19.13
1940–41	.82	0	14.40	14.81	16.39	15.08	5.33	0	0	0	0	0	66.83
1941–42	1.27	.81	10.66	2.29	1.52	3.50	4.70	0	0	0	0	0	24.75
1942–43	.91	.76	1.35	12.22	3.81	4.47	1.41	0	0	0	0	0	24.93
1943–44	1.29	0	6.31	3.64	10.18	1.21	2.18	0	0	0	[5] 0	[5] 0	24.81
52-year average	1.15	1.90	4.62	4.45	4.86	4.09	1.65	.64	.10	.01	.06	.30	23.83
16-year average													26.97
16-year median													24.87

Los Alamos (altitude 600 feet) [1]

1908–9	----	----	----	15.25	6.82	5.66	0	0	0.03	0	0	Tr	----
1909–10	0.95	1.69	7.10	3.58	.23	4.18	0.30	0	Tr	0	0	0.84	18.87
1910–11	.12	.58	.46	9.53	3.65	12.41	1.47	Tr	Tr	Tr	0	Tr	28.22
1911–12	0	.08	1.85	1.59	0	6.77	.85	1.12	0	0	0	0	12.26
1912–13	Tr	.30	.16	2.88	3.22	.75	.50	.15	.35	Tr	1.20	.10	9.61
1913–14	0	2.45	3.05	11.30	6.26	.97	.45	Tr	.08	Tr	0	0	24.56
1914–15	Tr	Tr	5.12	5.34	8.16	.61	2.14	1.65	Tr	0	0	0	23.02
1915–16	0	.72	3.48	8.62	1.47	1.35	.20	.04	0	0	Tr	1.90	17.78
1916–17	2.54	.27	7.79	2.03	4.17	.43	.19	.23	0	0	0	0	17.65
1917–18	0	0	.04	.41	11.86	7.18	0	0	0	Tr	Tr	.20	19.69
1918–19	.30	2.94	2.63	.46	2.75	1.65	.06	1.35	0	0	0	.58	12.72
1919–20	.18	.17	2.67	.39	2.97	3.75	.71	0	0	0	0	.03	10.87
1920–21	.58	1.33	1.29	3.77	1.80	1.06	.34	1.47	0	0	0	.84	12.48
1921–22	.32	.09	5.77	4.35	3.60	2.58	.28	.39	0	Tr	0	0	17.38
1922–23	.55	1.26	4.15	2.00	1.26	.36	3.60	0	.05	0	0	.15	13.38
1923–24	.05	.18	.36	.59	.19	3.15	.71	0	0	0	Tr	0	5.23
1924–25	.82	.85	1.43	.84	1.75	3.52	2.63	1.21	.08	0	Tr	Tr	13.13
1925–26	.82	.25	1.65	1.87	3.12	.32	4.09	.03	0	0	0	0	12.15
1926–27	.49	4.68	.81	1.91	6.02	2.16	1.43	.08	Tr	0	0	0	17.58
1927–28	3.41	.27	4.50	.12	2.99	2.54	.23	.92	0	0	0	0	14.98
1928–29	.23	2.79	2.18	1.70	1.02	1.16	1.21	0	.10	0	Tr	0	10.39
1929–30	0	0	.11	4.22	1.45	3.29	.59	.89	0	0	0	.29	10.84
1930–31	0	1.64	Tr	3.92	1.92	.12	.65	1.10	0	Tr	.14	0	9.49
1931–32	0	2.72	7.30	3.10	3.51	.18	.76	.12	0	0	0	.17	17.86
1932–33	.04	.01	1.38	6.95	.30	.55	.66	.28	1.26	0	0	0	11.43
1933–34	.27	.02	3.03	1.63	3.04	0	0	.34	.53	0	0	0	8.86
1934–35	1.42	3.00	1.70	4.18	1.66	3.37	2.58	.17	0	0	.15	Tr	18.23
1935–36	.56	1.21	1.66	.55	7.20	1.36	.61	.08	.05	0	.19	.07	13.54
1936–37	2.73	0	4.45	3.66	5.34	4.82	.25	0	0	0	0	0	21.25
1937–38	.06	0	2.18	2.56	7.67	5.79	1.43	.02	0	0	0	.89	20.60
1938–39	.16	.13	3.54	3.05	1.96	2.84	.10	.05	0	Tr	0	1.95	13.78
1939–40	.56	1.05	1.45	4.77	2.75	1.06	1.93	0	0	0	0	0	13.57
1940–41	.46	.10	6.04	6.44	8.15	10.13	3.83	.06	0	.05	.03	0	35.29
1941–42	1.05	.32	7.91	1.86	.70	1.95	3.63	.23	0	0	.07	0	17.72
1942–43	.80	.72	1.93	6.83	2.18	2.84	1.00	0	0	0	0	0	16.30
1943–44	.93	.17	4.22	1.93	7.36	1.04	1.65	.06	0	0	0	0	17.36
35-year average	.58	.92	2.95	3.40	3.48	2.75	1.17	.34	.07	0	.05	.23	15.94
16-year average	----	----	----	----	----	----	----	----	----	----	----	----	16.03
16-year median	----	----	----	----	----	----	----	----	----	----	----	----	15.04

See footnotes at end of table.

TABLE 2.—*Precipitation, in inches, in the 77 water years, 1867–1944 at stations in and adjacent to Santa Barbara County, Calif.*—Continued

Water-year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
Santa Maria (altitude 217 feet) [1]													
1884–85	------	------	------	------	------	------	------	------	------	0.01	0.04	0.30	------
1885–86	0	8.80	1.60	1.83	0.97	2.55	3.37	0	0	0	0	0	19.12
1886–87	.06	.59	.72	.50	5.95	.25	1.07	.22	Tr	0	0	.30	9.66
1887–88	.40	1.09	2.69	4.62	.43	1.98	.12	.14	Tr	Tr	0	Tr	11.47
1888–89	0	2.59	5.86	.42	1.35	4.20	.97	.60	.05	0	0	0	16.04
1889–90	7.53	1.80	6.71	7.02	3.64	.88	.10	.13	0	.06	0	.55	28.42
1890–91	.70	.70	3.40	.63	3.57	.71	1.58	.20	0	0	0	.03	11.52
1891–92	0	.33	2.77	.56	2.18	2.36	.45	1.15	Tr	0	0	0	9.80
1892–93	.35	1.95	2.52	2.08	3.10	6.84	.80	.05	0	0	0	0	17.69
1893–94	.65	.22	2.95	1.16	1.78	.62	.25	.73	.16	.06	Tr	1.05	9.63
1894–95	.68	.07	3.86	4.43	1.22	1.25	.53	.51	0	Tr	0	.01	12.56
1895–96	.65	1.26	.60	4.60	0.	2.59	1.77	.03	0	.11	.03	.02	11.66
1896–97	.60	1.82	2.34	3.55	4.00	2.52	.14	.01	0	.03	0	.10	15.11
1897–98	.67	.03	.55	1.44	1.06	.65	.02	1.14	0	0	0	.96	6.52
1898–99	.30	.05	.64	3.49	.46	4.88	.99	.75	0	0	0	0	11.56
1899–1900	1.86	1.21	.89	.87	.05	1.41	.97	1.97	Tr	Tr	Tr	Tr	9.23
1900–1901	.65	5.40	.35	4.51	3.17	.25	1.82	.13	Tr	0	0	.12	16.40
1901–2	1.60	.56	.01	1.73	4.03	2.37	1.70	.20	Tr	0	0	0	12.20
1902–3	1.02	2.59	.79	1.80	1.91	3.97	.71	Tr	0	0	0	0	12.79
1903–4	Tr	.19	.16	.55	5.39	3.06	1.73	.10	0	0	.86	2.55	14.59
1904–5	1.25	.03	1.55	1.85	5.83	4.46	.69	1.58	0	.02	Tr	.07	17.33
1905–6	.15	1.37	.31	2.64	3.40	6.94	.55	2.39	.02	Tr	.01	.01	17.79
1906–7	0	.63	4.35	7.78	1.02	3.95	.23	0	.04	0	0	.06	18.06
1907–8	3.57	0	1.80	3.98	3.76	.35	.26	.18	0	0	0	1.03	14.93
1908–9	.52	.97	.61	10.31	4.98	4.39	0	0	0	0	0	0	21.78
1909–10	.75	2.14	5.89	3.47	.50	3.82	.01	0	0	Tr	0	.65	17.23
1910–11	.72	.15	.45	6.42	3.80	6.68	1.82	0	0	Tr	0	Tr	20.04
1911–12	0	0	1.77	1.34	.10	4.13	.69	1.60	0	0	0	0	9.63
1912–13	0	.40	.20	2.20	1.27	.63	.42	0	.34	0	0	0	5.46
1913–14	1.00	2.45	2.95	9.36	2.20	.90	0	0	0	0	0	0	18.86
1914–15	0	0	5.40	4.05	6.31	.54	1.11	1.52	0	0	0	0	18.93
1915–16	0	.60	3.31	8.95	2.12	1.49	.19	0	0	0	0	2.51	19.17
1916–17	1.92	.52	4.15	2.53	2.01	.50	.11	.23	0	0	0	0	11.97
1917–18	.09	0	.31	.53	9.39	5.87	0	0	0	0	0	0	16.19
1918–19	.63	3.55	1.46	.68	2.36	1.57	0	.74	0	0	0	.41	11.40

1919-20	0	.15	1.88	.24	1.78	4.02	1.12	0	0	0	0	0	9.19
1920-21	.73	.94	1.24	3.13	1.65	1.57	.32	1.45	.01	0	0	.44	11.48
1921-22	.05	.13	5.32	4.90	2.97	2.50	.22	.35	0	0	0	0	16.44
1922-23	.32	1.34	3.59	1.91	1.06	.18	3.97	.05	.01	.01	0	.22	12.66
1923-24	.30	0	.62	.64	.46	3.01	1.00	.01	0	0	.03	.04	6.11
1924-25	.76	.78	1.85	2.56	1.67	3.28	2.34	1.71	.05	.02	.01	.01	15.04
1925-26	.16	.12	1.81	1.72	2.99	.41	2.68	.11	.01	.02	.01	.04	10.08
1926-27	.55	3.37	.91	1.88	5.21	2.10	1.26	.06	.20	.02	.01	.02	15.59
1927-28	3.08	.81	3.80	.22	2.51	3.99	.19	.71	0	Tr	.01	.02	15.34
1928-29	.04	2.31	2.16	2.28	1.22	1.61	.94	0	.16	Tr	Tr	.01	10.73
1929-30	.02	Tr	.15	3.42	1.18	2.70	.94	.68	.08	0	Tr	.16	9.33
1930-31	.02	1.55	Tr	4.16	1.13	.28	.42	.94	.06	.01	.31	.09	8.97
1931-32	.04	2.46	6.56	4.25	2.14	.31	.31	.26	.04	.02	.02	.07	16.48
1932-33	.09	.09	1.31	6.08	.30	.94	.18	.38	1.96	Tr	Tr	.02	11.35
1933-34	.32	.03	2.91	1.11	1.52	.20	Tr	.26	1.30	.01	.01	.01	7.68
1934-35	3.14	2.19	1.78	4.16	1.64	3.11	3.09	0	0	.01	.26	.17	19.55
1935-36	.50	2.02	1.71	1.31	5.32	1.23	1.06	.13	.03	.02	.01	.14	13.48
1936-37	1.83	Tr	5.69	3.59	4.83	4.65	.22	0	0	.01	0	0	20.82
1937-38	.16	.26	2.88	4.72	7.39	4.09	2.01	.04	.02	Tr	.02	.59	22.18
1938-39	.18	.23	1.53	3.25	2.18	2.39	.22	.03	0	0	0	1.50	11.51
1939-40	.46	1.03	1.30	5.41	2.67	1.98	1.74	0	0	0	Tr	.02	14.61
1940-41	.73	.12	5.25	5.04	6.83	8.72	3.86	.07	Tr	.09	.03	.01	30.75
1941-42	1.04	.32	7.50	1.78	1.30	2.04	2.82	.11	0	0	.02	.02	16.95
1942-43	.82	.84	2.94	7.23	1.27	3.04	1.06	.02	0	0	0	Tr	17.22
1943-44	1.05	.47	3.09	1.32	4.69	1.36	2.46	.11	.01	0	0	0	14.56
59-year average	.76	1.11	2.40	3.19	2.70	2.53	1.01	.40	.08	.01	.03	.24	14.46
16-year average													15.38
16-year median													14.58

Ozena, Ventura County (altitude 3,700 feet)[1]

1904				0.40	1.55	2.90	0.85	0.20	0	0	0.40	1.20	
1904-5	0	0	1.28	1.08	7.46	10.30	.05	1.61	0	0	0	.18	21.96
1905-6	.23	.97	.52	1.13	1.69	6.16	.57	.44	0	.63	0	0	12.34
1906-7	0	.37	4.22	11.59	.75	6.46	0	0	0	0	0	0	23.39
1907-8	2.83	0	1.05	4.80	5.30	.10	.35	.20	0	.10	.25	1.94	16.92
1908-9	.10	1.70	1.67	6.61	4.90	4.83	.10	0	.32	0	.67	0	20.80
1909-10	.10	1.60	8.83	2.52	.60	2.25	.55	0	0	.25	0	4.50	21.20
1910-11	.75	.45	1.00	10.63	5.75	7.25	.45	.28	.10	0	0	.50	27.16
1911-12	0	.70	1.33	.51	.10	5.93	.65	.77	0	0	0	0	9.99
1912-13	.15	.57	0	3.10	5.55	.12	0	0	.72	0	.32	0	10.53
1913-14	0	2.24	.86	10.08	9.47	.57	.39	.53	0	0	0	0	24.14

See footnotes at end of table.

TABLE 2.—*Precipitation, in inches, in the 77 water years, 1867–1944 at stations in and adjacent to Santa Barbara County, Calif.*—Continued

Water-year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
Ozena, Ventura County (altitude 3,700 feet)[1]—Continued													
1914–15	0.56	0	3.57	6.21	6.82	0.76	1.20	1.01	0	0	0	0.08	20.21
1915–16	0	.44	1.72	8.38	.64	2.19	.52	0	0	0	0	.83	14.72
1916–17	1.13	.12	3.05	2.88	1.63	.20	.52	.39	0	.26	0	0	10.18
1917–18	0	0	.10	.73	9.97	6.69	0	Tr	0	.14	0	.94	18.57
1918–19	0	1.86	1.50	.80	2.47	2.94	.09	2.19	0	0	0	.43	12.28
1919–20	.11	.36	1.62	.20	2.49	4.89	.42	0	0	0	0	0	10.09
1920–21	.32	.54	1.90	3.78	1.14	.52	.43	1.18	0	.08	0	.28	9.27
1921–22	.52	.22	5.99	2.86	3.01	1.98	0	.15	0	0	0	0	14.73
1922–23	.42	1.15	3.18	1.46	.33	0	1.51	0	.15	0	1.10	.25	9.55
1923–24	.40	.10	.40	.47	.18	2.61	.79	0	0	0	0	0	4.95
1924–25	.22	.30	.76	.61	.48	2.23	1.02	.97	1.10	.40	.94	0	9.03
1925–26	.95	.97	1.35	1.50	2.69	.38	6.51	0	0	0	0	0	14.35
1926–27	.19	2.62	1.31	.55	5.88	1.60	.65	.42	0	0	0	0	13.22
1927–28	.70	.46	1.63	.10	3.26	.68	.48	.54	0	0	0	0	7.85
1928–29	.09	1.16	1.34	1.20	.39	1.48	.82	.27	.06	0	.23	0	7.04
1929–30	.13	0	0	1.65	.92	2.55	.36	.45	0	0	0	.08	6.14
1930–31	.12	1.49	0	3.15	2.65	.09	1.46	.97	.17	.23	.84	.11	11.28
1931–32	0	1.92	5.72	1.40	5.33	.03	.26	0	.10	0	0	1.04	15.80
1932–33	0	.15	.57	5.92	.22	.06	.38	.38	0	0	0	0	7.68
1933–34	.20	.12	2.96	.26	1.88	.25	0	.19	.15	0	0	0	6.01
1934–35	2.38	1.54	2.16	3.82	.39	2.15	1.16	0	0	.06	.58	.13	14.37
1935–36	.44	.35	1.37	.48	5.47	.99	.54	.05	0	.06	.32	0	10.07
1936–37	2.70	.05	5.76	1.52	3.11	5.49	.12	.04	0	0	0	0	18.79
1937–38	.18	0	1.50	2.98	7.45	6.47	1.03	0	0	.53	.19	.06	20.39
1938–39	.21	.10	4.51	2.40	.68	2.28	.36	.72	0	0	.04	2.44	13.74
1939–40	.09	.02	.65	2.44	3.63	1.43	.46	0	0	0	0	0	8.72
1940–41	.96	.37	7.27	3.47	6.28	9.12	3.28	1.76	.09	0	.03	0	32.63
1941–42	.77	.34	4.15	.83	.54	.66	2.41	0	0	0	.24	0	9.94
1942–43	.25	.12	.57	8.19	2.53	3.00	1.64	0	0	0	0	0	16.30
1943–44	.16	.06	4.27	1.30	6.50	1.10	.36	.13	0	0	0	0	13.88
40-year average	.46	.64	2.27	3.09	3.26	2.72	1.80	.39	.07	.07	.14	.34	14.25
16-year average													13.30
16-year median													12.51

Pattiway (near), Kern County (altitude 3,700 feet) [1]

1915-16			2.10	3.21	0.49	2.16	0.53	Tr	0	0	0.30	0.72	
1916-17	1.07	0	2.92	2.39	Tr	.36	.87	.92	0	Tr	.05	0	8.58
1917-18	.05	.74	.08	1.41	6.56	3.32	Tr	Tr	Tr	Tr	Tr	1.08	13.24
1918-19	.50	2.27	2.06	Tr	3.26	2.95	.52	1.77	0	Tr	0	.26	13.59
1919-20	.10	.90	.85	.31	1.62	3.86	.35	0	Tr	0	.10	0	8.09
1920-21	.30	Tr	1.14	2.40	.96	.74	.66	2.08	.15	0	.15	0	8.58
1921-22	0	.60	2.51	4.00	1.76	2.89	.10	1.23	Tr	.10	0	0	13.19
1922-23	.40	.81	1.53	1.03	.72	.05	1.69	0	Tr	0	Tr	Tr	6.23
1923-24	.69	1.05	.64	.15	.74	1.90	1.58	0	0	0	0	Tr	6.75
1924-25	.35	.62	1.44	1.01	.58	2.00	1.20	.50	.10	0	.15	0	7.95
1925-26	.58	.75	.95	1.65	2.34	.48	3.60	.06	0	0	Tr	0	10.41
1926-27	.27	2.65	2.44	1.16	3.58	2.32	.46	.05	.65	0	0	0	13.58
1927-28	1.21	.73	.72	.81	2.11	.41	1.00	.78	0	0	0	0	7.77
1928-29	.10	1.59	1.14	.96	.66	1.73	.48	0	Tr	0	0	0	6.66
1929-30	0	0	.02	1.57	1.61	.22	.31	.83	0	Tr	Tr	.08	4.64
1930-31	.08	1.12	Tr	2.46	1.38	.39	.78	.22	.42	0	Tr	Tr	6.85
1931-32	.22	1.92	4.10	1.43	4.14	Tr	.84	.12	0	0	0	.33	13.10
1932-33	.05	.11	1.24	4.16	Tr	.08	.58	.60	1.00	0	Tr	0	7.82
1933-34	.47	.13	.84	.07	1.26	.26	0	.15	0	0	0	Tr	3.18
1934-35	1.63	1.78	1.42	2.84	1.72	1.94	.71	.16	0	0	.81	.72	13.73
1935-36	.55	.30	.81	.38	3.54	1.30	.20	.47	.42	0	.28	0	8.25
1936-37	2.11	.05	4.15	1.72	1.63	2.54	.50	.05	0	0	0	0	12.75
1937-38	.25	Tr	1.78	2.74	2.65	5.75	1.37	Tr	0	0	0	Tr	14.54
1938-39	.17	.16	2.09	2.30	1.03	1.63	.99	.23	0	0	Tr	1.26	9.86
1939-40	.39	.14	.66	1.87	2.33	.44	1.77	0	0	0	0	Tr	7.60
1940-41	1.10	.59	2.53	20.6	4.09	5.35	3.22	.08	0	0	0	0	19.02
1941-42	1.25	.30	4.27	.62	.05	.41	3.64	.15	0	0	.16	0	10.85
1942-43	.70	.58	.69	5.28	1.95	1.67	2.21	.18	0	0	0	0	13.26
1943-44	.55	.10	1.64	.59	5.29	1.36	1.01	.20	Tr	0	0	0	10.74
28-year average	.54	.71	1.60	1.69	2.06	1.66	1.09	.39	.10	(6)	.06	.13	10.03
16-year average													10.18
16-year median													10.30

[1] Data from publications of the U. S. Weather Bureau.
[2] Record furnished by Cyrus R. Marshall.
[3] Estimated on basis of 14-year relation (1928-29 to 1941-42) with record at Santa Barbara.
[4] Record of 1880-1919 furnished by Corps of Engineers, U. S. Army; record of 1920-44 furnished by Rancho San Julian.
[5] Estimated.
[6] Less than 0.01 inch.
Tr, 0.005 inch or less of rain or melted snow.

TABLE 3.—*Evaporation, in inches, at two stations in the Santa Ynez River basin, 1931–44*

[Standard land pan of U. S. Weather Bureau. Data from records of Montecito County Water District and the city of Santa Barbara Water Department]

Water-year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
Jameson Lake, near Montecito (altitude about 2,100 feet)													
1930–31	[1] 5.0	[1] 3.0	[1] 1.0	[1] 1.0	1.67	4.22	4.92	6.87	7.33	10.75	8.00	6.57	60.33
1931–32	4.35	2.15	.84	.90	1.66	4.46	5.29	6.32	8.92	10.16	10.28	9.14	64.47
1932–33	6.08	5.19	1.83	1.43	2.49	3.39	4.78	5.27	5.87	8.85	8.53	7.14	60.85
1933–34	5.31	2.49	.85	1.46	1.84	4.31	6.21	7.01	6.31	9.27	8.28	6.56	59.90
1934–35	3.99	1.85	.97	1.02	1.99	2.52	4.20	5.42	7.88	8.20	8.17	7.14	53.45
1935–36	4.70	1.91	1.37	1.53	1.31	3.90	5.25	7.02	7.76	9.02	8.38	7.30	59.45
1936–37	4.29	2.15	.92	.57	1.47	2.60	5.31	6.53	7.74	8.28	9.15	7.65	56.66
1937–38	6.11	2.45	1.16	1.07	.90	2.80	4.83	5.75	6.36	8.03	8.24	5.95	53.65
1938–39	3.87	2.11	1.52	1.31	1.67	3.00	4.95	6.01	6.63	7.23	7.80	5.63	51.73
1939–40	4.42	3.07	1.57	.94	1.31	3.50	4.34	6.14	6.89	7.75	8.52	6.63	55.08
1940–41	4.90	2.07	1.07	.95	.77	2.37	3.55	6.15	6.12	7.23	6.63	6.65	48.46
1941–42	3.97	2.03	.86	1.13	1.56	3.44	2.86	5.45	6.16	7.12	7.25	5.41	47.24
1942–43	3.58	1.66	1.09	.83	1.54	2.55	3.78	5.27	4.47	5.30	6.20	7.39	43.63
1943–44	4.75	2.03	1.13	1.22	1.42	3.95	4.73	5.41	5.21	5.92	7.09	6.69	49.55
Average	4.66	2.44	1.16	1.10	1.54	3.36	4.64	6.04	6.69	8.08	8.04	6.85	54.60
Median [2]	4.56	2.13	1.08	1.04	1.55	3.42	4.80	6.08	6.50	8.12	8.20	6.67	54.36
Gibraltar Reservoir, near Santa Barbara (altitude about 1,200 feet)													
1930–31	[3] 5.0	[3] 3.0	[3] 1.0	1.14	1.74	5.83	6.16	7.78	8.15	11.73	9.82	7.36	68.71
1931–32	4.96	2.64	1.07	1.46	1.90	5.25	6.49	7.14	8.81	10.19	9.77	7.23	66.91
1932–33	5.18	3.74	1.49	1.46	2.80	4.62	5.24	7.18	7.28	10.89	9.48	7.15	66.51
1933–34	5.72	3.37	1.36	1.57	1.50	4.90	6.66	8.40	7.13	10.34	9.92	7.78	68.65
1934–35	4.74	2.39	1.23	1.30	2.20	3.09	4.18	5.71	8.90	9.39	9.00	7.61	59.74
1935–36	5.26	2.36	1.49	1.75	1.60	4.46	5.80	7.91	9.05	10.26	9.25	8.14	67.33
1936–37	4.55	2.64	1.12	.87	1.77	3.31	6.07	6.64	8.55	10.13	9.78	7.43	62.86
1937–38	5.49	2.61	1.31	1.32	1.19	2.78	4.86	6.55	6.98	9.60	8.86	7.47	59.02
1938–39	4.43	2.77	1.28	.84	2.01	3.27	5.83	6.26	8.36	9.40	9.22	7.05	60.72
1939–40	5.39	2.96	1.50	1.11	1.56	4.08	4.99	7.12	8.64	9.99	9.52	7.23	64.09
1940–41	5.40	2.84	1.48	.96	1.05	2.66	3.89	6.24	7.58	8.71	7.70	6.66	55.17
1941–42	4.42	2.78	.76	1.18	2.15	3.91	3.60	6.48	7.87	9.44	8.76	6.81	58.16
1942–43	4.94	2.80	1.60	1.37	2.06	3.11	4.17	7.10	7.47	8.84	8.71	7.91	60.08
1943–44	5.73	3.51	1.45	1.57	1.84	3.89	4.79	6.01	6.59	8.34	9.15	7.17	60.04
Average	5.09	2.89	1.30	1.28	1.81	3.94	5.20	6.89	7.95	9.80	9.21	7.36	62.72
Median	5.09	2.79	1.34	1.31	1.80	3.90	5.12	6.87	8.01	9.80	9.24	7.30	61.79

[1] Estimated; reservoir dry, no record.
[2] Median is the value that divides the record into an equal number of greater and lesser quantities.
[3] Estimated.

TABLE 4.—*Average temperatures, in degrees Fahrenheit, at two stations in the Santa Ynez River basin, 1932–44*

[Data from records of Montecito County Water District and the city of Santa Barbara Water Department]

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
Jameson Lake near Montecito (altitude about 2,100 feet)													
1931–32	61	50	46	43	49	57	------	------	------	75	74	74	[1] 60
1932–33	64	61	46	44	44	55	57	58	64	72	74	67	59
1933–34	67	56	56	52	53	62	64	68	66	77	76	72	64
1934–35	65	56	52	49	53	50	59	62	72	74	76	74	62
1935–36	62	53	51	52	51	57	61	67	74	80	77	72	63
1936–37	64	57	50	39	49	53	59	66	72	79	79	72	62
1937–38	66	56	54	52	50	52	59	65	70	77	76	72	62
1938–39	61	54	53	49	47	54	63	64	71	77	78	72	62
1939–40	63	58	54	52	51	57	60	67	74	75	76	67	63
1940–41	64	54	54	50	53	54	56	67	67	76	71	64	61
1941–42	59	56	49	51	48	53	55	62	70	78	75	68	60
1942–43	63	56	51	50	53	56	60	66	65	74	72	71	61
1943–44	64	56	50	48	46	54	56	61	61	70	73	70	59
Average	63	56	51	48	50	55	59	64	69	76	75	70	61
Gibraltar Reservoir near Santa Barbara (altitude about 1,200 feet)													
1931–32	64	54	49	47	52	58	59	64	69	73	72	70	61
1932–33	68	63	58	48	51	57	58	60	67	75	75	67	62
1933–34	68	60	53	53	54	63	64	68	66	75	75	75	64
1934–35	65	58	50	51	54	51	59	61	69	73	76	71	62
1935–36	63	53	52	54	52	57	60	66	72	79	77	71	63
1936–37	64	58	50	40	51	53	58	64	70	76	76	71	61
1937–38	66	57	53	52	51	51	58	63	67	75	75	73	62
1938–39	63	54	54	49	45	53	61	62	68	73	74	72	61
1939–40	63	58	54	53	53	57	60	65	70	74	73	67	62
1940–41	65	57	56	52	55	55	56	65	66	74	71	67	62
1941–42	61	55	51	52	50	55	56	61	66	75	73	66	60
1942–43	64	58	53	51	54	56	58	64	65	72	71	72	62
1943–44	68	60	55	50	54	54	58	63	72	73	76	73	63
Average	65	57	53	50	52	55	59	64	68	74	74	70	62

[1] No record in April, May, or June; values for these 3 months assumed to be equal to those for Gibraltar Reservoir.

HYDROLOGIC AND GEOLOGIC SUBAREAS OF THE SANTA YNEZ RIVER BASIN

GENERAL FEATURES

The valley of the Santa Ynez River is a depression about 70 miles long and 15 miles in maximum width, partly structural and partly erosional in origin. (See pl. 1.) Its southern border is the crest of the narrow Santa Ynez Mountains. Its northern border is the San Rafael Mountains to the east and the lower Purisima Hills to the west. The San Rafael Mountains trend northwest and are as much as 15 miles from the southern border; the Purisima Hills trend nearly west and are between 5 and 10 miles from the southern border. In the western third of the valley, opposite the central part of the Purisima Hills, the Santa Rita Hills and the Santa Rosa Hills lie immediately north and south of the river, respectively. Geologically, both these hilly tracts are essentially foothills of the Santa Ynez Mountains.

With respect to topographic, geologic, and hydrologic features, the Santa Ynez River basin has five divisions. In downstream order they are designated the Headwater subarea, the Santa Ynez subarea, the Buellton subarea, the Santa Rita subarea, and the Lompoc subarea.

HEADWATER SUBAREA

From its source the Santa Ynez River flows westward for about 34 miles through a rugged terrain whose relief is somewhat more than 5,000 feet, which spans nearly half the length of the valley and which extends downstream to the San Lucas Bridge on State Highway No. 150. This upstream section of the valley has been called the hydrographic basin of the upper Santa Ynez River (Nelson, 1925, p. 327) but is designated herein the Headwater subarea. In this reach the Santa Ynez River receives several large tributaries, such as Mono, Santa Cruz, and Cachuma Creeks, which drain the rugged San Rafael Mountains to the north. Many smaller tributaries drain the Santa Ynez Mountains to the south. Two impounded water bodies in the upper part of this reach, Gibraltar Reservoir and Jameson Lake, supply water to the city of Santa Barbara and to Montecito, respectively.

The headwater subarea is underlain chiefly by folded consolidated rocks, although a thread of alluvial deposits lies along and beneath the river and broadens downstream to a sizable flood channel beginning about 12 miles above San Lucas Bridge. Similar deposits occur along the major tributaries. Isolated bodies of older alluvial deposits on benches and on certain hill summits testify to the former existence of streams at several altitudes above present stream grades. Although most of the subarea is underlain by consolidated rocks, in its western part a broad tongue of unconsolidated materials and alluvial terrace deposits floors a prominent structural depression north of the river. This tongue extends eastward to and nearly 6 miles beyond the valley of Santa Cruz Creek. On the south this tongue is separated from the river by a discontinuous ridge of the consolidated rocks, across which gaps have been cut by Santa Cruz Creek, Cachuma Creek, and other tributary streams to the west.

SANTA YNEZ SUBAREA

Westward from San Lucas Bridge the Santa Ynez River continues for about 6½ miles, or nearly to Solvang, in a fairly narrow but shallow inner valley in the consolidated rocks, but the dissected area north of the river broadens westward and contains a broad terraced upland, a part of the Santa Ynez River basin which will be designated the Santa Ynez upland in this report. This upland and the dissected foothills are composed largely of a thick body of unconsolidated deposits. This reach of the basin is the Santa Ynez subarea of this report. (See pl. 2.)

The Santa Ynez upland is from 150 to 200 feet above the river at its south edge and ascends gradually northward until it abuts against the dissected foothills east and north of Los Olivos. It is fairly extensively cultivated, and many wells take water from the underlying unconsolidated deposits. In the inner valley, on the other hand, shallow alluvial deposits cover the consolidated rocks. They form discontinuous tillable areas, but only a few wells draw water from them.

The Santa Ynez upland is bordered on the west by the valley of Alamo Pintado Creek, which skirts the rounded east end of the Purisima Hills. It is bordered on the east by the valley of Santa Agueda Creek. Several short stream courses drain the south edge of the upland and are all intermittent except Zanja Cota Creek, which is perennial near its mouth. All the streams cross a narrow barrier of consolidated rock near the river. From the south the main tributaries to the Santa Ynez River are San Lucas Creek, Quiota Creek, and Alisal Creek.

BUELLTON SUBAREA

Just west of Solvang the Santa Ynez River leaves the consolidated rocks and traverses a distinctive reach about 6 miles long. With the tributary areas, this reach constitutes the Buellton subarea. Here the inner valley is floored by an alluvial plain somewhat more than a mile wide, which lies against consolidated rocks of the Santa Ynez Mountains on the south but against unconsolidated deposits on the north. (See pl. 2.) About Buellton the alluvial plain is cultivated rather intensively, and a number of wells and pumps take water from the ground-water reservoir and from the river.

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From 2 to 3 miles north of the river the subarea includes a rather thoroughly dissected band of foothills, which flank the consolidated-rock core of the Purisima Hills.

La Zaca Creek, which is dry in its lower 2 miles except during and shortly after storms, enters the Santa Ynez River from the north near Buellton after crossing the Purisima Hills. Nojoqui Creek drains a fairly extensive area in the Santa Ynez Mountains south of the river.

SANTA RITA SUBAREA

About 2½ miles west of Buellton the river swerves abruptly southward across a prominent ridge of consolidated rocks, and then flows generally westward in a deep, winding, broad valley that passes between the Santa Rita Hills on the north and the Santa Rosa Hills on the south. Throughout this reach the course of the river lies in consolidated rocks; the structural depression, whose end the river crosses in the Buellton subarea, passes north of the Santa Rita Hills and there is floored by unconsolidated deposits but contains no through east-west drainage. Instead, the dry courses of Santa Rita Creek and Santa Rosa Creek cross the structural trough and drain the south flank of the Purisima Hills through narrow cuts across the main part of the Santa Rita Hills. On the south the subarea includes the fairly large drainage basin of Salsipuedes Creek, which enters the Santa Ynez River above The Narrows. This broad valley reach extends through the narrow gap known as The Narrows and with its tributary areas constitutes the Santa Rita subarea.

Geologic features of this subarea are shown on plates 2 and 3.

LOMPOC SUBAREA

Beyond The Narrows the river enters the Lompoc subarea at the southeast corner of the Lompoc plain, flows northwestward for about 2 miles, and then flows westward along the somewhat irregular north border of the plain for about 10 miles to the ocean.

The Lompoc plain is the principal agricultural area of the Santa Ynez River basin. It is an alluvial plain about 12 miles long and nearly 3 miles in maximum width. It is underlain by the most productive water-bearing zones of all the valley and is irrigated extensively from about 110 irrigation wells. The plain is bordered on the the south by the steep-fronted foothills of the Santa Ynez Mountains, which farther west give way to the broad but steeply sloping Lompoc Terrace. (See pl. 3.) This terrace rises southeastward to the summit of the mountains. Across the plain to the north the broad rolling Burton Mesa is from 300 to 400 feet above the sea and rises gently northeastward to the Purisima Hills. Between these two terraces and within a mile of the ocean the Lompoc plain is barely half a mile wide. East of Burton Mesa a hilly and terraced terrain stands from 90 to 100 feet above the north border of the plain, rises gradually northward to the Purisima Hills, and merges eastward into the trough that lies between the Santa Rita Hills and the Purisima Hills.

The Lompoc plain, the terraced terrain to the north and northeast, and certain foothills to the east and south are composed of unconsolidated deposits. However, the Lompoc Terrace, the Burton Mesa, the foothills of the Santa Ynez Mountains, and the westernmost part of the Santa Rita Hills are composed of non-water-bearing consolidated deposits.

Several intermittent streams drain the south flank of the Purisima Hills, chiefly those in Santa Lucia, Purisima, and Cebada Canyons. On the south the three streams in San Miguelito, San Pascual, Rodeo, and Lompoc Canyons drain the flank of the Santa Ynez Mountains; of these, all except the stream in Lompoc Canyon flow perennially to or nearly to the south edge of the Lompoc plain.

Stratigraphic units distinguished in the Santa Ynez River basin and adjoining areas

	Geologic age	Formation and symbol on plates 2 and 3	Thickness (feet)	General character	Water-bearing properties
Quaternary.	Recent.	River-channel deposits (*Qrc*).	0–70	Coarse sand and gravel of fluvial origin lying in the flood channel of the Santa Ynez River. Predominantly gravel above Robinson Bridge, but predominantly sand downstream.	Loose and unconsolidated; permeability 425 to 4,320, as determined by laboratory tests; carries some underflow of the Santa Ynez River. Tapped by a few wells in and upstream from the Buellton subarea, which are capable of yielding 500 to 1,000 gallons a minute.
		— — — Unconformity. — — —			
	Recent.	Younger alluvium (*Qyal*).	0–200	Gravel, sand, silt, and clay of fluvial origin underlying the alluvial plains of the Santa Ynez River outside the flood channel and of the tributary streams. Includes channel deposits of the tributaries. Locally comprises two members, of which the lower is of gravel and extends from the ocean upstream about to San Lucas Bridge.	Unconsolidated and largely saturated with water. Lower member is principal source of water in the valley and constitutes the main water-bearing zone beneath the Lompoc plain. Permeability 1,000 to 4,500 as determined by discharging well tests. Between Robinson Bridge and Solvang it carries most of the Santa Ynez River underflow.
		— — — Unconformity. — — —			
	Pleistocene.	Terrace deposits (*Qt*).	0–150	Gravel, sand, silt, and clay of fluvial origin capping terraces and flat hill summits along the Santa Ynez River and tributary streams. Includes some marine beach deposits along the ocean, also an extensive body underlying the Santa Ynez upland.	Generally above the zone of saturation. Locally can transmit some rainfall to underlying permeable deposits. The body in the Santa Ynez upland contains water, and yields moderate supplies to wells.
		— — — Unconformity. — — —			
	Pleistocene.	Orcutt sand (*Qo*).	0–300	Unconsolidated sand and clay with some gravel, mainly non-marine. Underlies hills and terraces bordering the Lompoc plain, and locally extends beneath the plain. Includes local indurated caps of reddish eolian and marine beach sand, which are genetically distinct but nearly coextensive with rest of the formation.	Saturated only near and beneath the Lompoc plain, where it is tapped by a few wells. Generally of low permeability, but some gravel beds locally yield water readily.
	— — ? — — —	— — — Unconformity. — — —			
— — ? — —	Pleistocene (?) and Pliocene.	Paso Robles formation (*Tpr*).	0–2,800±	Fluvial clay, silt, sand, and gravel; poorly assorted and compact, in lenticular beds. Underlies the entire valley; crops out along the flanks of the Purisima and Santa Rita Hills, and of the San Rafael Mountains. Lower part largely clay and silt; upper part composed of alluvial-fan deposits.	Generally less permeable than the younger alluvium. Sand and gravel beds yield water to numerous wells of moderate capacity in Santa Ynez upland. In the Lompoc subarea, lenses of sand and gravel in the lower part supply water to a few wells of fair yield.
Tertiary.	Pliocene.	Careaga sand (*Tc*).	450–1,000±	Fine-grained to medium-grained, uniform, massive, marine sand with some gravel and limestone. Locally fossiliferous. Crops out in flanks of Purisima and Santa Rita Hills and San Rafael Mountains.	Generally not tapped by wells. Permeability 70 as determined by laboratory tests. Rain infiltrating on outcrop areas transmitted in considerable amounts to main water-bearing zone in Lompoc subarea.
		— — Local unconformity. — —			

	Pliocene to Eocene.	Undifferentiated Tertiary rocks (*Tu*) which include Foxen, Sisquoc, Monterey, Rincon, Vaqueros, Sespe, and Tejon formations.		Predominantly consolidated mudstone and shale, in part diatomaceous and siliceous, with some limestone, sandstone, conglomerate, and volcanic rocks. Mostly marine in origin but in part continental.	Essentially not water-bearing except for local beds of sand and fractures. Not tapped by water wells.
		— — — Unconformity. — — —			
Cretaceous and Jurassic (?)		Knoxville and Franciscan formations (*JK*).		Consolidated dark sandstone and shale; also serpentine and other metamorphic and igneous rocks.	Essentially not water-bearing except for fractures. Not tapped by water wells.

GEOLOGY

By J. E. Upson

EARLIER WORK

Considerable geologic work has been done in the Santa Ynez River basin, nearly all of it by petroleum geologists employed by private companies and nearly all of it unpublished. The main features of the geology are shown on the geologic map of California by Jenkins (1938), and many minor features are described in the comprehensive book by Reed (1933). Fairly detailed studies of older consolidated rocks were made by Arnold and Anderson (1907) in their so-called Santa Maria district, which included all the area shown on plates 2 and 3. Recently Woodring and others (Woodring, Bramlette, Lohman, and Bryson, 1944) have completed a detailed map of the Santa Maria valley and adjoining areas, which includes some of the western and northern parts of the Santa Ynez River basin. A summary of this work has been published. A small part of the Santa Ynez River valley has recently been mapped by the Geological Survey as part of its investigation of petroleum resources (Woodring, Loofbourow, and Bramlette, 1945). Kew (1919) described the consolidated rocks in part of the upper Santa Ynez River district in 1919; that area, together with the extreme eastern part of the Santa Ynez subarea as here defined, has been mapped in some detail by Nelson (1925, pp. 327–396).

DESCRIPTIONS AND WATER-BEARING CHARACTERISTICS OF THE ROCKS

GENERAL FEATURES AND SUCCESSION

On the basis of their capacity to contain and yield ground water, the rock units of the Santa Ynez River basin are divided into two classes—those that are consolidated and can yield appreciable quantities of water only from cracks and fractures, and those that are unconsolidated and have continuous interstices which may yield appreciable quantities of water. In upward succession the unconsolidated water-bearing deposits are the Careaga sand of Pliocene age, the Paso Robles formation of Pliocene and Pleistocene (?) age, the Orcutt sand of Pleistocene age, and alluvial deposits of Pleistocene and Recent age. The Careaga sand is marine, but all the other formations are essentially continental. The consolidated non-water-bearing rocks underlie the Careaga sand and are Tertiary and Mesozoic in age. These older rocks were not mapped in any detail but were examined briefly because the younger formations contain materials derived from them.

The chart (pp. 28–29) summarizes the stratigraphic units. The distribution and relations of the units are shown in detail on the geologic maps, plates 2 and 3, and in the geologic cross sections, plates 2 and 4.

JURASSIC (?) AND CRETACEOUS ROCKS

Rocks of the Franciscan formation occur in a few small isolated bodies in the central part of the Santa Ynez Mountains, but they form nearly all the south front of the San Rafael Mountains. There they consist chiefly of altered basic volcanic rocks, with some jasper, quartz, and dense greenish chert. Considerable serpentine is associated with them. At the range front these rocks are upfaulted against the Careaga sand and Paso Robles formation.

Upper Cretaceous marine sandstone and shale occur in several bodies north of the crest of the Santa Ynez Mountains. A few bodies of sedimentary rocks assigned to the Knoxville formation have been mapped in the broad west-central part of the range.

A small body of old marine deposits, not studied thoroughly, occurs near the head of Happy Canyon on the south flank of the San Rafael Mountains. It consists of layers of dark-brown evenly bedded shale in alternation with thin beds of massive sandstone. The body is upfaulted against the Paso Robles formation on the south and is downfaulted against chert of the Franciscan formation and associated serpentine on the north. It is overlain probably unconformably, by a small body of Careaga sand. These rocks were called Knoxville, by Nelson (1925, p. 339 and geologic map) and are shown as Lower Cretaceous on the geologic map of California (1938).

CONSOLIDATED TERTIARY ROCKS

Consolidated Tertiary rocks predominantly of marine origin make up the main part of the Santa Ynez Mountains and occur locally in its foothills; also they occur in the central part of the Purisima Hills and of the Santa Rita Hills. At most places they include the Monterey, Sisquoc, and Foxen formations as defined by Woodring (Woodring, Bramlette, and Lohman, 1943, pp. 1345–1355), although in some small areas they include the older Rincon, Vaqueros, Sespe, and Tejon formations.

The Monterey shale, of Miocene age, underlies large areas in the lower foothills of the Santa Ynez Mountains, the Santa Rita Hills, the Purisima Hills, the Burton Mesa, and the Lompoc Terrace. It consists predominantly of white porcelaneous chert and banded silicified mudstone and diatomite. Most of the formation is silicified and very tough, but some parts are only moderately compact. A body of altered volcanic rocks occurs locally at the base of the formation.

The Sisquoc and Foxen formations occur throughout the Purisima Hills and the Santa Rita Hills; also locally in the foothills of the Santa Ynez Mountains. Neither formation is silicified. Characteristically, the Sisquoc formation is massive to very thin bedded, white diatomaceous mudstone, and the Foxen is gray or tan massive mudstone. Both formations are very fine grained and quite compact.

These several consolidated rocks of Tertiary age are not water-bearing at most places, but contain some water in fractures. Such as is obtainable is small in amount and uncertain in location. No wells derive water exclusively from them; and a few wells obtain water of a chemical quality unsuitable for some agricultural uses. Essentially, these rocks constitute relatively impermeable sides and bottoms for overlying bodies of water-bearing deposits.

UNCONSOLIDATED DEPOSITS OF TERTIARY AGE

CAREAGA SAND

CHARACTER, EXTENT, AND STRATIGRAPHIC RELATIONS

The Careaga sand is a body of fine- to coarse-grained massive marine sand that ranges in thickness from 450 to 1,000 feet, overlies the Sisquoc and Foxen formations, and underlies the Paso Robles formation. It can be traced into the Santa Ynez River basin from the type locality on the north flank of the Purisima Hills, where it has been defined recently by Woodring (Woodring, Bramlette, and Lohman, 1943, pp. 1355–1358), and assigned to the upper Pliocene. Two members distinguished by Woodring in the Santa Maria oil district also seem to be distinct throughout the Santa Ynez River basin but were not mapped separately there. The Careaga is distinguished from the underlying formations by its coarser grain and by its lesser degree of consolidation. It is distinguished from the overlying Paso Robles formation by uniformity of its grain size and by its contained marine fossil shells.

The Careaga sand was deposited in an arm of the sea that extended eastward and southeastward to and beyond Santa Cruz Creek. It crops out along the south flank of the Purisima Hills, along the north flank of the Santa Rita Hills, in a few hills along the south side of the Lompoc plain, and in a large area north of Buellton. At the east end of the Purisima Hills north of Solvang, a large body of coarse and apparently unfossiliferous sand is assigned to the Careaga. In the Santa Ynez and Headwater subareas it crops out discontinuously in a narrow band along the flank of the San Rafael Mountains and in another narrow belt north of the Santa Ynez River from the valley of Santa Agueda Creek eastward.

The formation rests with slight unconformity on the underlying Sisquoc and Foxen formations, is locally faulted against the Monterey formation, and is in fault contact with the Franciscan and Knoxville formations along the south flank of the San Rafael Mountains. It is conformable with and occurs everywhere beneath the Paso Robles formation. Where the Paso Robles formation is eroded through, the Careaga sand is overlain directly by alluvial deposits of Recent age. Most extensive of such areas is beneath the east half of the Lompoc plain where the alluvial deposits rest directly on the Careaga sand over several square miles. (See pl. 5.) Locally it is overlain uncomformably by the Orcutt sand and by terrace deposits.

The Careaga sand consists almost entirely of uniform massive sand, white to light yellow or cream in color. The sand grains range in size from coarse to fine, and at most places they are coarser in the upper part of the formation. Beds of clay and silt are characteristically absent, but the formation contains thin lenses of pebbles, which are chiefly quartzite but of which some are porcelaneous chert, volcanic rocks, or the banded silica characteristic of the Monterey formation. Locally the formation contains scattered shells or lenses of shells. In many places the sand is only faintly stratified although locally it is cross-bedded, and the pebbles and fossil shells are mostly in distinct lenses. Although surficially indurated in most exposures, in very fresh cuts and as encountered in wells, the Careaga sand seems quite unconsolidated except for a few zones cemented by calcium carbonate. Individual grains are somewhat rounded and consist mainly of quartz, but many are of diatomaceous and siliceous shale derived from the Monterey and Sisquoc formations. The pebbles are mostly well-rounded and less than 2 inches in diameter.

About 100 feet below the top of the formation a persistent zone of cobbles, pebbles, coarse sand, and numerous fossil shells is nearly continuous along the north side of the Santa Rita Hills and at some places consists entirely of shell fragments. This zone, or another similar zone, occurs far to the east between Santa Agueda Creek and Cachuma Creek. There, the zone is from a few feet to a few tens of feet thick and at most places is cemented by calcium carbonate. In some outcrops only a few "ghosts" of the original shells remain.

WATER-BEARING PROPERTIES

The Careaga sand is penetrated by wells mainly beneath the Lompoc plain. There, almost invariably it has been cemented off by the well driller, both because the loose, fine sand tends to enter the wells when pumped and because the overlying younger alluvium yields water much more readily. Accordingly, data regarding its water-bearing properties are lacking in the well logs. However, laboratory tests of permeability were made on 12 samples collected from outcrops of the Careaga sand in the area bordering the Lompoc plain. When tested with a variable-head apparatus, similar to that described in Water-Supply Paper 887, the permeability was found to range from 7 to 89 gallons per day per square foot. Of the samples collected some are considered not typical of the formation and others were indurated and doubtless yielded abnormally low values of permeability. Table 5 summarizes the test data on four samples thought to be typical of the nonindurated formation.

TABLE 5.—*Permeability of samples of Careaga sand*

Number	Location	General character	Permeability (g. p. d. per sq. ft.)
CS–8	East fork Purisima Canyon near head of valley plain. NW¼NE¼ sec. 12, T. 7 N., R. 34 W.	Uniform medium sand, somewhat iron stained.	73
CS–9	Cebada Canyon near crest of Purisima Hills. NE¼SE¼ sec. 6, T. 7 N., R. 33 W.	Fine yellow sand	89
CS–13	East fork Purisima Canyon above valley plain. NW¼-SW¼ sec. 6, T. 7 N., R. 33 W.	Loose massive yellow sand with scattered pebbles.	23
CS–14	West fork Purisima Canyon near head of valley plain. SW¼SW¼ sec. 1, T. 7 N. R. 34 W.	Loose medium sand; white and cross-bedded.	88

It is believed the average of the four values in the table, about 70 gallons per day per square foot represents approximately the order of magnitude of the permeability of the formation. This means that 70 gallons of water a day would pass through a section of the Careaga sand 1 mile wide and 1 foot thick under a hydraulic gradient of 1 foot per mile. (Wenzel, 1942, p. 7).

PASO ROBLES FORMATION

CHARACTER AND SUBDIVISIONS

The term "Paso Robles" was applied by Fairbanks (1898, pp. 565–566) in 1898 to extensive upper Tertiary continental deposits in San Luis Obispo County, Calif. It has come to be applied to similar late Tertiary continental deposits in Santa Barbara County, although the deposits have not been traced to the original Paso Robles area. The Paso Robles of the Santa Ynez River basin, however, is continuous with deposits so identified by Woodring and others (Woodring, Bramlette, and Lohman, 1943), in the Santa Maria oil district and is herein defined accordingly. It conformably overlies the Careaga sand and is considered to be upper Pliocene and lower Pleistocene(?) in age. It is overlain by the Orcutt sand and locally by terrace deposits and the younger alluvium.

At most places the Paso Robles formation is distinguished from the underlying Careaga sand by its heterogeneity and by the absence of marine fossils. However, in the area 3 to 4 miles northwest of Buellton the lower part of the Paso Robles consists mainly of sand that closely resembles the Careaga sand. Lithologically some strata of the Paso Robles formation are very similar to parts of the overlying Orcutt sand, but the Paso Robles is distinguished from most overlying formations, all of which are unconformable upon it, by its greater degree of deformation.

The Paso Robles formation is composed of coalescing alluvial fans laid down by streams flowing from the Santa Ynez and San Rafael Mountains. Probably early in the deposition, a continuous, westward-flowing stream occupied the axial part of the basin of deposition, but evidence that it continued during all the deposition is not at hand. The formation now occurs throughout the Santa Ynez River basin where it lies in general within the outcrop of the Careaga sand. (See pls. 2 and 3.) It crops out on the south flank of the Purisima Hills and the north flank of the Santa Rita Hills. It underlies a large area north of the Santa Ynez upland in the Santa Ynez subarea and in the Headwater subarea, where it has been dissected into a fairly rugged terrane. In the Santa Ynez upland and in the Buellton subarea the formation is concealed by terrace deposits and by the younger alluvium; and in the Lompoc subarea much of it is covered by the Orcutt sand. The top of the Paso Robles is eroded everywhere, so its original thickness is unknown. The existing thickness ranges from a feather edge to about 2,800 feet. It is thickest in the northeastern part of the Santa Ynez subarea near the fault contact with the older consolidated rocks. (See pl. 2, section *A–A′*.) In the Lompoc subarea it pinches out to the west beneath the younger formations. (See pl. 4.)

The detailed characteristics of the Paso Robles formation differ considerably in different parts of the valley. In general the lower part consists of clay, silt, and sand, whereas the upper part consists of sand and gravel with minor amounts of clay and silt. In the Lompoc and Santa Rita subareas the lower part of the Paso Robles is composed of beds of dark greenish clay interbedded with strata of massive and cross-bedded coarse white to light-yellow sand, thin fresh-water limestone, and locally coarse fairly clean gravel. (See following sections.) This part of the formation is probably not more than about 100 feet thick. Massive clay and lenses of fresh-water limestone nearly everywhere mark the base of the Paso Robles formation. The limestone, indicated by scattered nodules on the land surface, occurs eastward as far as Buellton, and at a few places in the easternmost part of the Purisima Hills near Los Olivos.

Section of strata in lower part of Paso Robles formation, exposed in SE¼SW¼ sec. 16, T. 7 N., R. 33 W.

	Feet
Clay	1
Gravel, lenticular; pebbles of chert, sandstone, quartzite, and granite	3
Sand, massive, somewhat compact, reddish buff; discontinuously exposed	30
Clay, massive, olive green	2
Sand, as above	5
Clay, massive, olive green	2
Sand, massive, compact, light yellow	20
Total	63

Section of strata in lower part of Paso Robles formation, exposed in SE¼SW¼ sec. 29, T. 7 N., R. 33 W.

	Feet
Clay, dark greenish brown, massive	2
Gravel, clayey; large rounded pebbles and cobbles	2
Sand, fine, white to light yellow, massive, compact	10
Clay, sandy; dark olive green, massive, compact	2
Sand, fine; white to light yellow; locally streaked with limonite	3
Total	19

In the Buellton, Santa Ynez, and Headwater subareas the lower part of the Paso Robles is generally somewhat finer grained than in the Lompoc and Santa Rita subareas. It is best exposed in the hills east of Santa Agueda Creek north of the Santa Ynez River, but it also crops out in the vicinity of Buellton. There it is several hundred feet thick, is predominantly red to orange buff, and consists mainly of massive clay and silty clay, with some scattered pebbles and lenses of cross-bedded pebble gravel. Most of the pebbles are of diatomaceous and siliceous shale derived from the Monterey formation, but some are of jasper, chert, and basic volcanic rocks derived from the Franciscan formation.

The upper part of the Paso Robles formation overlies all the lower part here described and occurs throughout the area. It is composed of typical alluvial-fan deposits and is relatively coarse grained near the mountains. Also, it differs somewhat in composition from place to place according to the source rock. Typically it is light cream to light orange buff and is composed of clayey sand with scattered pebbles and lenses of pebble gravel and cobble gravel. Certain beds of clayey silt are several feet thick, massive, and distinctively orange buff. The sand and gravel are in massive to crudely stratified and locally cross-bedded lenses. At the land surface they are moderately compact. The gravel lenses are fairly coarse grained and contain pebbles, cobbles, and boulders which average about 2 inches in diameter and most of which are rounded or flattish fragments of diatomaceous and siliceous Monterey shale. Commonly a few of the pebbles are of jasper, serpentine, and basic volcanic rocks derived from the Franciscan formation and associated rocks, and some are of sandstone from the Eocene or Cretaceous rocks. All these source rocks are exposed in the San Rafael Mountains and in the upper drainage basin of the Santa Ynez River. In exposures near the south flank of the San Rafael Mountains, the deposits are much coarser, as the gravel beds contain rounded and angular boulders as much as 2 feet in diameter, and the fine-grained beds are nearly all sand. Nearly all the boulders are of altered basic volcanic rocks, serpentine, and some jasper; the sands consist of smaller grains of the same materials. Therefore the Paso Robles formation here is dark gray or black, whereas elsewhere it is almost white because it is composed largely of particles from the Miocene and Pliocene rocks.

In the western part of the Santa Rita Hills the upper part of the Paso Robles formation contains thick lenses of gravel that are cross-bedded and that include rounded cobbles and boulders as much as 1 foot in diameter. Here, most of the included boulders are of sandstone or banded chert; however, some are of volcanic rocks, jasper, or quartzite and a very few are of grantic rock. In these features, this part of the Paso Robles resembles channel deposits of the Santa Ynez River. Similar deposits are exposed nearly 25 miles to the east. In a belt of prominent hills which is about 2 miles north of the Santa Ynez River and which trends nearly eastward across the valley of Santa Agueda Creek, another coarse-grained zone about 100 feet thick occurs just above the lower part of the Paso Robles. It is mainly of gravel but contains some thin strata of buff silt. The gravel beds are somewhat consolidated in exposures and consist of coarse sand, pebbles, and boulders as much as 1 foot in diameter. About 40 percent of the pebbles and boulders are of siliceous shale; the remainder are of jasper, serpentine, and basic volcanic rocks. These coarse-grained deposits also resemble the modern river-channel deposits and, with those in the Santa Rita Hills to the west, probably were laid down by some through-flowing stream in the Paso Robles basin of deposition.

Thus, the deposits that compose the Paso Robles formation reveal a varied history. The lower part of the formation probably was deposited in ponds and swamps in the western part of the valley, but on the flood plains of sluggish creeks in the eastern part. For a time thereafter the basin was probably occupied by a large master stream flowing to the ocean. However, with increased uplift of the adjacent highlands this river probably was disrupted as fans of coarse alluvium were built by side streams which flowed from the mountains.

WATER-BEARING PROPERTIES

As indicated in the foregoing description, the Paso Robles formation contains a large proportion of fine-grained material and is composed chiefly of discontinuous, lenticular, and poorly assorted alluvial-fan deposits. Of these, the clay, silt, and pebbly silt are too fine grained to yield water readily. Even the lenses of gravel contain enough clay and silt to impede the flow of water. However, beneath the easternmost part of the Lompoc plain the massive sand and coarse gravel that are interbedded with clay in the basal part of the formation yield water to drilled wells at rates up to 200 to 300 gallons a minute. (See pl. 5, section *F–F'*, logs of wells 7/34–24N1, 7/34–25D1, and 7/34–26F2.[1])

Most of the wells that tap the formation in the eastern part of the area (see table 26, logs of wells 6/31–1B2 and 7/30–32H1) penetrate considerable clay or "clay and gravel" and yield less than 200 gallons a minute. The most productive well, No. 6/30–2N1, is in the lower valley of Santa Águeda Creek and penetrates about 1,300 feet into inclined strata of the Paso Robles formation (the stratigraphic thickness penetrated is about 1,000 feet). By report, its casing is perforated opposite all the gravel bodies, and its pumping yield is about 1,300 gallons of water per minute at a drawdown of about 90 feet. These figures indicate its specific capacity to be about 15 gallons a minute per foot of drawdown. In contrast, some wells drilled in clayey parts of the formation yield only a few gallons a minute and are inadequate even for supplying water to stock.

Thus, the Paso Robles formation at most places is much less permeable than some of the younger alluvium (p. 45), but where it contains considerable gravel it can sustain wells of a yield adequate for moderate

[1] In this report the numbers or symbols ascribed to wells show locations according to the rectangular system for subdivision of public land. For example, in the symbol for well 7/34–24N1, the part that precedes the dash indicates the township and range (T. 7 N., R. 34 W.), the digits following the dash indicate the section (sec. 24), the letter indicates the 40-acre subdivision of the section as shown in the accompanying diagram, and the final digit is the serial number in the particular 40-acre tract. Thus, well 7/34–24N1 is the first well to be listed in the SW¼SW¼ sec. 24, T. 7 N., R. 34 W. Inasmuch as the maps show the townships, ranges, and sections, ordinarily the well symbols given on the maps include only the elements after the hyphen; and on small-scale maps they include only the letter and serial number.

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

irrigation. Furthermore, the formation underlies the large foothill area north of the Santa Ynez upland, there receives infiltrate from rain, and there constitutes a large ground-water reservoir.

PLEISTOCENE AND RECENT DEPOSITS

ORCUTT SAND

The Orcutt sand is a body of unconsolidated sand and clayey sand with scattered pebbles or stringers of pebbles. It occurs discontinuously in the western part of the Santa Ynez River basin, was first named by Hoots and Herold (1935, p. 156) and more recently has been studied and defined by Woodring (Woodring, Bramlette, and Lohman, 1943, p. 1359). The type locality is near the town of Orcutt, on the south side of the Santa Maria Valley.

In the Santa Ynez River basin the Orcutt sand occupies the central part of the trough between the Santa Rita Hills and the Purisima Hills and extends east to the divide between Santa Rita Creek and Santa Rosa Creek. To the west it caps the broad Burton Mesa north of the Lompoc plain, also underlies much of the corresponding Lompoc terrace to the south. Along the southwest side of the Lompoc plain the formation dips northward at a low angle and passes beneath the alluvium forming the plain.

The Orcutt sand rests on an erosion surface cut on the deformed Paso Robles and older formations and in turn is overlain unconformably by terrace deposits and the younger alluvium. It is itself somewhat warped, dips as great as 5° being known. Its greatest known thickness is about 200 feet in the central part of its area where, between depths of 199 and 398 feet, well 7/35–25P1 penetrates deposits assigned to the Orcutt sand. From there it thins to feather edges at the margins of its outcrop. (See pl. 3.) Woodring (Woodring, Bramlette, and Lohman, 1943, p. 1359) considers the Orcutt sand to be of upper Pleistocene age.

The Orcutt sand generally is poorly exposed and is difficult to distinguish from much of the Paso Robles formation, which it resembles lithologically. In general, the Orcutt is the less deformed but as mapped may include some Paso Robles beds where dips are low.

Although the Orcutt sand consists almost entirely of sand and clayey sand with scattered pebbles and stringers of pebbles, locally it contains lenses of clay and of gravel. For example, wells in the central part of the Lompoc plain, such as 7/35–35C2 and 7/35–24B2 penetrate gravel strata assigned to the formation (pl. 5). In most outcrops the sand is moderately coarse and consists of rounded to subangular grains of quartz and rounded grains of diatomaceous and siliceous shale. Contained pebbles are mostly rounded and of diatomaceous shale or porcelaneous chert, but a few are of quartzite. Their average diameter is about 1 inch. These several materials occur commonly in massive or indistinctly bedded lenses, though locally the sand is somewhat cross-bedded. In color, the beds are generally almost white to very light yellow, but the upper 10 to 20 feet are stained a dark brownish red by coatings of iron oxide on the grains.

At most places the beds contain sufficient clay so that in road cuts and stream cuts they stand at fairly steep slopes. On these, rain-wash develops a characteristic rilled or fluted form mentioned by Woodring (Woodring, Bramlette, and Lohman, 1943, 1359).

Like the Paso Robles formation, the bulk of the Orcutt sand is irregularly and indistinctly stratified and is considered to be essentially of continental origin. However, north and northeast of the Lompoc plain its uppermost part, a zone from 5 to 10 feet thick, is massive sand that contains rounded and angular fragments of jasper, quartzite, and chert. Nearly everywhere it is indurated and iron-stained, evidently as a result of weathering. Many of the pebbles are darkly stained, and the surfaces of nearly all the pebbles and cobbles are highly polished and minutely pitted, presumably by the action of wind-blown sand. The lack of stratification, and the haphazard scattering of pebbles throughout, suggest that this uppermost part of the Orcutt is a beach deposit. If so, it would seem that after the deposition of most of the Orcutt the sea advanced briefly and then retreated at least locally.

Because the Orcutt sand is unconsolidated and contains considerable loose, coarse sand, it can hold a relatively large quantity of water. However, many of its lenses contain silt or clay, so that the formation probably can neither transmit water rapidly nor yield water copiously to wells. Nonetheless, a number of wells on the southwestern part of the Lompoc plain derive water from the formation.

Because it occurs chiefly in hills and terraced areas which are undeveloped agriculturally, the Orcutt sand is not tapped widely by wells, and, with respect to ground water, it serves chiefly as a large catchment area for rain. Specifically, most of the outcrop area is mantled with coarse, loose sand which has washed down the hill slopes from the upper part of the formation. This mantle presumably absorbs rain readily, as there is virtually no runoff from the outcrop area during ordinary storms. Rain so absorbed passes in part beyond the reach of plant roots, is stored in the Orcutt sand, and ultimately is probably transmitted to the underlying Paso Robles formation.

TERRACE DEPOSITS

The terrace deposits include numerous isolated bodies of clay, sand, and gravel that cap hilltops, benches, and upland areas along the Santa Ynez River and its larger tributaries. They occur at several altitudes above present sea level and present stream grades. Several other bodies of terrace deposits are believed to lie beneath the southern part of the Lompoc plain. All these deposits rest with angular unconformity on the older rocks and deposits. Mainly they are thin, of small extent, and only locally conceal the underlying formations. However, one large and rather complex body forms and underlies the Santa Ynez upland. Along the river and its main tributaries the terrace-forming materials are remnants of former river-channel and flood-plain deposits; elsewhere, they are alluvial-fan deposits.

These terrace deposits consist largely of clay, silt, and gravel. Where deposited as local alluvial fans by small streams they are rather poorly assorted, but where deposited by the perennial Santa Ynez River they are generally well-sorted and contain much coarse clean gravel. They range in thickness from a feather edge to as much as 150 feet. Their lower part is mostly coarse gravel, and their upper part is sand and silt. Usually they are unfossiliferous, but at a locality about 3 miles west of Buellton, in the deposits on the lowest of the river terraces, the writer found the lower two-thirds of the thigh-bone of an extinct camel, which has been identified by C. W. Gilmore [2] of the National Museum as belonging to the genus *Camelops* and which is considered to be of Pleistocene age. As the containing deposits are those of the lowest, or youngest terrace, all the terrace deposits are at least as old as Pleistocene.

In the southeastern part of the Lompoc plain a number of wells pass through the younger alluvium, then penetrate bodies of gravel 10 to 20 feet thick immediately above the Careaga sand. (See pl. 5, sections *G–G'* and *H–H'*; also logs of wells 7/34–31J1, 7/34–31Q2, 7/34–33L1, and 7/34–33D1, and others.) These bodies seem to occur at a common horizon and are believed to belong to a common stratigraphic unit. Their inferred extent is shown on plate 5. Possibly these particular bodies of gravel are basal beds of the Orcutt sand, offset by faulting from the rest of the formation, but it seems more likely that they are remnants of a separate body of younger terrace deposits as here described. The well logs show them to consist almost entirely of coarse gravel with some sand. The casings of numerous wells are perforated in the gravel; and the wells derive considerable water from the deposits. Accordingly, they are here called the secondary water-bearing zone in the Lompoc subarea of the Santa Ynez River basin.

The most extensive bodies of terrace deposits underlie and in part compose the Santa Ynez upland of the Santa Ynez subarea (pl. 2). There the terrace deposits were laid down by short streams flowing

[2] Reeside, J. B., written communication, Dec. 2, 1943.

south or southwest and graded to several successively lower levels of the Santa Ynez River. Their deposition in the early stages may have been in part induced by late minor warping of the Tequepis syncline. These deposits occur at several levels and are genetically different from each other but are lithologically indistinguishable and are mapped as a single body. They rest unconformably upon the upturned and eroded edges of the Paso Robles, Careaga, and older formations. They are largely separated by the consolidated rock barrier from the lower terrace deposits along the river; but a tongue appears to extend through a gap in the barrier at Zanja Cota Creek, and there the deposits extend almost to the river.

The terrace deposits of the Santa Ynez upland are not well-exposed, but as indicated by the few exposures and by logs of wells they consist of lenses of poorly assorted gravel, sand, and silt with some clay or fine silt. Some logs report a large proportion of clay. In this area the terrace deposits very much resemble the Paso Robles formation but are deformed only slightly if at all. Their fine-grained materials are stained orange buff, and on the higher hills are somewhat indurated like the upper part of the Orcutt sand. The pebbles are chiefly white flattish but rounded fragments of porcelaneous chert and diatomaceous shale. However, some are of jasper, serpentine, and basic volcanic rocks derived from the Franciscan formation and associated rocks. Most of the pebbles are from 1 inch to 2 inches in diameter. The deposits are moderately compact at the land surface.

The terrace deposits are at least 30 feet thick, as stream valleys of that depth do not cut the underlying material. Locally, they are probably much thicker. At one well drilled recently near the center of the upland the driller reported a change in character of gravel about 100 feet below the land surface. Although a lithologic break was not obvious from the cuttings, it is possible that the drill passed from terrace material into the underlying Paso Robles formation at that depth. The record of well 7/30-32H1 (table 26) reveals a change in general lithologic character at 156 feet; and other wells show changes at comparable depths. Hence it is inferred that the maximum thickness of the terrace deposits beneath the northern part of the upland is about 150 feet.

Because they have a considerable proportion of fine-grained material, also because their beds of gravel are unassorted and lenticular, the terrace deposits are inferred to be only moderately permeable. Probably they are about as permeable as the underlying Paso Robles formation. The wells drilled on the Santa Ynez upland derive water in large part from the terrace deposits but also from the Paso Robles formation. (See logs of representative wells, table 26.) As discussed in later paragraphs on the ground water of the Santa Ynez subarea, there is some evidence that the beds of clay in this body of older alluvial fill greatly retard the downward percolation of water that infiltrates below the land surface.

YOUNGER ALLUVIUM

General character.—The younger alluvium of this report includes the several bodies of alluvial fill of Recent age that underlie and form the Lompoc plain and that extend upstream along the Santa Ynez River and into the valleys of tributary streams. It is termed younger alluvium because it is younger than the Orcutt and Paso Robles formations, which are largely of alluvial origin. The deposits that constitute the younger alluvium are known chiefly from well logs and consist of unconsolidated clay, silt, sand, and gravel. They range in thickness from a feather edge to a maximum of about 200 feet, and they rest unconformably on all the older formations heretofore described.

The younger alluvium was deposited in valleys carved by former streams that flowed toward a shoreline at least 200 feet below present sea level. Evidence for this conclusion is drawn mainly from well logs, which show that for a distance of 5 miles back from the present shore the base of the alluvial deposits rests on consolidated rocks of Tertiary age at depths of from nearly 200 to 150 feet below sea level. (See pl. 5.) According to local residents, corresponding deposits in the south coastal valleys of the county locally have been deposited to thicknesses of 10 to 20 feet. Hence the deposition of this alluvium is considered nearly if not quite the most recent geologic event in this region; and the cutting of the older terraces is considered to occupy much of the middle and late Pleistocene. Therefore, the younger alluvium was probably deposited during the rise of sea level that accompanied the retreat of the last, or Wisconsin, glaciers elsewhere on the continent and is considered to be of Recent age. This age determination is corroborated elsewhere in southern California, particularly in the Long Beach-Santa Ana area, where analogous bodies of alluvium were deposited in former valleys that had been cut in deposits of latest Pleistocene age. (Poland and Piper, in preparation.)

The thickest and most extensive body of the younger alluvium is that which forms and underlies the Lompoc plain in the western part of the valley. (See pl. 3.) This body is nearly continuous but becomes progressively thinner along the Santa Ynez River upstream to about San Lucas Bridge. In these areas the younger alluvium contains the most productive water-bearing beds in the valley. However, at most places along the river upstream from San Lucas Bridge the younger alluvium forms veneers of silt and sand on the bedrock surface, is only a few feet thick, and probably is largely cut out and replaced by the river-channel deposits. Contiguous tongues also lie along the perennial tributary streams such as Santa Agueda, Santa

Cruz, and Alisal Creeks. Other thick bodies form the valley floors of intermittent tributary streams such as those which drain the Purisima Hills. In those areas it is not highly productive of water.

The younger alluvium rests on and is flanked on each side by consolidated rocks through almost its entire extent. For a few miles in the vicinity of Buellton it rests in part on the Paso Robles and Careaga formations; and beneath about the eastern two-thirds of the Lompoc plain it rests on and against the Orcutt, Paso Robles, and Careaga formations. (See pl. 5.) In the part of the valley below San Lucas Bridge the younger alluvium is made up by two fairly distinct members —a lower member predominantly of coarse sand and gravel, and an upper member chiefly of fine sand, silt, and clay. (See pl. 5; also logs of wells along the river given in tables on p. 168 and p. 189.)

Lower Member.—The lower member, which is known only from well logs, occurs throughout the reach downstream from San Lucas Bridge, and downstream from the vicinity of Solvang it is continuous and fairly thick. Its thickness ranges from a feather edge along its margin to about 45 feet near Solvang and about 110 feet beneath the Lompoc plain. The increase in thickness of the lower member is progressive downstream. For example, in the Santa Ynez subarea at well 6/30–30A1 (pl. 2), the younger alluvium is 62 feet thick, and its lower member is 44 feet thick. At well 6/30–30B1 the corresponding thicknesses are 75 feet and 55 feet, respectively. Downstream in the Buellton subarea the thickness of the whole formation ranges from 32 to 86 feet, and that of the lower gravel member is from 10 to about 60 feet. (See log of well 6/32–11L1, table 27.) In the succeeding Santa Rita subarea, well 6/33–12L1 (table 28) penetrates 78 feet of younger alluvium, of which the lower 72 feet is reported to be gravel. At The Narrows, well 6/34–2A1 (table 28) penetrates 184 feet of alluvial deposits, of which all the lower 79 feet is reported to be gravel.

Beneath the Lompoc plain the lower member is even thicker and more extensive. It lies beneath about the northern two-thirds of the plain except on the east, where it is constricted sharply to a tongue that extends into and through The Narrows; also except on the west, where it seems to lie beneath about the south half of the plain. (See pl. 5.) Near the ocean it is about 75 feet thick.

Thus, the lower member of gravel occurs nearly everywhere throughout the river course. However, in a few places it is thin, and locally it may be absent. For example, in secs. 14 and 15, T. 6 N., R. 33 W., several wells penetrate only 10 to 15 feet of the gravel. Also, beneath the southern third of the Lompoc plain it probably exists only as separate tongues that extend to and into the several tributary canyons.

From the logs and yields of wells, also because well-rounded cobbles from 3 to 6 inches in diameter have been obtained in drilling certain wells, it is evident that the lower member of the younger alluvium consists of coarse gravel containing cobbles and boulders, doubtless some sand, but very little silt or clay. This seems to be true throughout its reach downstream from San Lucas Bridge.

Along the Santa Ynez River, from San Lucas Bridge downstream to the Lompoc plain, the lower member of the younger alluvium supplies water to numerous irrigation wells of which some have large capacities. For example, about 3 miles downstream from San Lucas Bridge, well 6/30–30A1, 16 inches in diameter, penetrates 44 feet of gravel and reportedly yields 1,350 gallons a minute; and well 6/30–30B1 reportedly yields 1,800 gallons a minute from 53 feet of gravel. (See pl. 2.) Downstream, in the reach between Buellton and The Narrows, the yield of well 6/33–12L1 has been measured as 790 gallons a minute, of well 6/33–9J1 as 730 gallons a minute, of well 6/33–16A1 as 485 gallons a minute, and of well 6/34–2A1 as 650 and 700 gallons a minute, respectively, on each of two dates. As determined by well-discharge tests, the permeability of the lower member ranges from about 1,000 to 4,500 gallons per day per square foot (see p. 76).

Along most of this reach from San Lucas Bridge downstream nearly to the Lompoc plain the upper member of the younger alluvium has been cut through, and the lower member is overlain directly by river-channel deposits. Still farther downstream, and beneath the entire Lompoc plain, the upper member intervenes between the lower member and the channel deposits, but as far downstream as about 3,000 feet beyond Robinson Bridge the intervening part of the upper member is coarse-grained. (See pl. 5, cross section *E–F–E′*.) Thus, throughout its reach from San Lucas Bridge downstream to about 3,000 feet beyond Robinson Bridge, no thick impermeable strata intervene between the bed of the Santa Ynez River and the lower member of the younger alluvium. Accordingly, throughout that reach there is free interchange of water between the river and the lower member of the younger alluvium. Therefore the lower member contains and transmits river underflow. Also, as its cross-sectional area is much greater than that of the river-channel deposits, the lower member transmits the bulk of that underflow. In a later section of this report the quantities of underflow transmitted are estimated.

Beneath the Lompoc plain, the lower member of the younger alluvium supplies water copiously to about 75 irrigation wells whose yields range from 500 to 1,000 gallons a minute. Thus, it is highly permeable and, because it supplies the bulk of the water withdrawn from wells, is termed the "main water-bearing zone." The water is confined throughout nearly all the plain (p. 147), but only at the extreme west end of the plain and in the middle of the plain opposite Rodeo Canyon is the head sufficient to cause flowing wells.

Upper member.—The upper member of the younger alluvium underlies and forms the alluvial plain about Lompoc, here called the Lompoc plain; it also forms the separate alluvial flats upstream along the Santa Ynez River at least as far as San Lucas Bridge and in the canyons of tributary streams that enter the Lompoc plain from the south. It overlies the lower member everywhere except within the actual channel of the river along the reach from San Lucas Bridge downstream nearly to Robinson Bridge.

The upper member of the younger alluvium is exposed only in the fronts of the low terraces along the river channel and locally along the tributary streams. In these exposures it consists of unstratified or faintly stratified clay, silt, and sand with enclosed stringers of pebbles at a few places. Elsewhere, especially in the Lompoc subarea where the member is thickest and most extensive, well logs indicate that extensively it is composed largely of clay and silt, with some strata of sand. (See pl. 5 and table 29.) Sand or gravel is the principal constituent of the member only near the mouths of the foothill streams along the south margin of the Lompoc plain such as San Miguelito Canyon; along the Santa Ynez River in the easternmost part of that plain; and along the north edge of the plain, about opposite Rodeo Canyon. The distribution of fine-grained and coarse-grained materials, here summarized so briefly, is critical with respect to the occurrence and movement of ground water and, accordingly, is developed more fully in several following paragraphs.

In most drillers' logs the topmost 30 to 40 feet of the upper member is reported as "soil," a nondescriptive term. However, some descriptive data are available from 15 observation wells, some as much as 45 feet deep, bored by the Geological Survey in the easternmost part of the Lompoc plain, and from 6 observation wells bored in the central and western parts of the plain. Logs of these wells are given in table 30. In wells drilled in the easternmost part of the plain the dry material above the water table was found to consist very largely of alternating beds of loose sand and silt but in some part of compact clay. The material penetrated by the wells in the western part of the plain is not markedly finer grained but seems to consist of somewhat more clay and silt and less sand. At least beneath the easternmost part of the Lompoc plain nearly all these materials, which form the topmost part of the upper member, are slightly to moderately permeable from the land surface to and below the water table. Similar conditions doubtless prevail over most of the Lompoc plain, although the average permeability of the materials probably diminishes westward, or toward the coast, except in the area near the north edge of the plain opposite Rodeo Canyon. Locally, as at one of the bored observation wells just described, compact clay occurs above and confines the shallow ground water; however, it is believed that such conditions do not occur extensively.

At greater depths the upper member of the younger alluvium contains beds of clay which are from 10 to 60 feet thick, and which are probably continuous over fairly broad areas beneath the central and western parts of the Lompoc plain—for example, at well 7/35–16N1 in cross section *J–J′* (pl. 5), at well 7/34–31A2 in cross section *H–H′*, and at wells 7/35–18J1 and 7/34–30L1 in cross section *E–E′*. As reported by drillers, some of the clay is "tough" or "compact." Similarly, "clay and sand" or "sandy clay" (drillers' terms thought to signify loose clay or silt with some sand) occurs in locally thick bodies, especially beneath the central part of the plain. Thus, although some sand is reported in nearly all well logs (see pl. 5) and in all areas except one rather small area to be described, silt and clay seem to predominate in the upper member across the full width of the Lompoc plain from the coast inland (eastward) about to Rodeo Canyon; also, across the northern two-thirds of the plain from Rodeo Canyon eastward to and possibly somewhat beyond the H Street Bridge across the Santa Ynez River, due north of Lompoc. Thus, the clay and silt predominate beneath about half the total extent of the plain.

Under hydraulic gradients of ordinary magnitude silt transmits water slowly, but compact clay transmits essentially none. Therefore, within the area just described, which spans roughly half the Lompoc plain, these fine-grained materials are essentially non-water-bearing. Even though the thin beds of sand that are enclosed have been tapped by a few domestic wells of small capacity, in the particular area the upper member of the younger alluvium has a very low average permeability, effectively retards the downward movement of water from the land surface, and under natural conditions generally confines the water in the permeable lower member under relatively low head. Likewise it confines water locally in the buried terrace deposits and in the Orcutt sand.

Beyond the thick and extensive beds of clay or silt—that is, beneath the southern third of the Lompoc plain from Rodeo Canyon eastward to Lompoc, and beneath the full width of the plain east of the H Street Bridge—the upper member of the younger alluvium consists extensively of silt, sandy silt, and sand, These deposits are somewhat permeable, sufficiently so to afford some hydraulic continuity between the unconfined water at shallow depth and the water of the highly permeable lower member. Thus, wherever and whenever the water table is higher than the static level of the water in underlying permeable zones, some water doubtless can percolate downward through the upper member. Such percolation doubtless is greatest when the pressure level of the deeper water body is drawn down by pumping from wells.

Locally within these areas—in particular, opposite the tributary canyons along the south margin of the Lompoc plain and along the Santa Ynez River—the upper member of the younger alluvium is predominantly sand and gravel and contains only thin, discontinuous beds of clay or silt. (See table 29, logs of wells 7/34–33L1 and 7/34–31J1.) The coarsest deposits of all are those penetrated by wells along the river within a few thousand feet downstream from Robinson Bridge, where very little silt or clay intervenes between the river-channel deposits and the lower member of the younger alluvium. (See pl. 5, cross section *E–F–E′*, wells 7/34–27K1, 7/34–34H1, and 7/34–35F5; also well 6/34–2A1.) These local coarse-grained deposits of the upper member absorb and transmit water fairly readily and probably do not effectively confine any underlying water-bearing zone. Along the south margin of the Lompoc plain they absorb all the low-water flow of the streams in San Miguelito Canyon, Rodeo Canyon, and other canyons; there, doubtless they transmit some water downward and laterally to the deeper-lying lower member of the younger alluvium. Along the Santa Ynez River, in the 3,000-foot reach downstream from Robinson Bridge, they likewise afford continuously permeable material from the channel deposits of that major stream downward to the lower member or "main water-bearing zone."

In the area at the north edge of the Lompoc plain opposite Rodeo Canyon, in secs. 23 and 24, T. 7 N., R.35 W., the upper member seems to be largely sand, as at wells 7/35–23B1, 7/35–24H1, and 7/35–24K2 (see pl. 5′, cross section *I–I′*), although the log of a shallow well bored by the Survey, 7/35–24K3 adjacent to 7/35–24K2, shows a high proportion of clay and silt in the uppermost 24 feet. There also the local coarse-grained deposits of the upper member probably afford some continuously permeable conduits between channel deposits of the river and the lower member of the younger alluvium.

Along the south flank of the Purisima Hills east of the Lompoc plain and north of the Santa Ynez River (see pls. 2 and 3), relatively broad tongues of younger alluvium floor the valleys of the several intermittent streams. In the main these tongues are essentially alluvial-fan deposits. As exposed in the fairly deep trenches reportedly cut in large part during the prolonged and heavy rains in the winter of 1940–41, the deposits appear to consist mainly of indistinctly bedded or lenticular strata of clayey or silty sand, which encloses scattered pebbles and small lenses of pebbles. Sand is the dominant ingredient, as the deposits were derived mainly from the Careaga sand, Paso Robles formation, and the Orcutt sand. The contained pebbles are in part reworked from those older formations and in part derived from the Foxen, Sisquoc, and Monterey formations. They consist chiefly of diatomaceous and siliceous shale, but some are of sandstone, quartzite, jasper, or other rocks.

These alluvial-fan deposits are loose and absorb the flashy runoff of their respective intermittent streams in winters of average or less-than-average rainfall. At most places they are too thin and of insufficient extent to contain much water, but at least locally in the Santa Rita Valley they are believed to be relatively thick and may store a fairly large volume of water. However, because they are unassorted, lack thick and continuous strata of gravel, and are predominantly of sand and silt these particular bodies of younger alluvium are not highly permeable, even though porous. They are penetrated by only a few wells for domestic and stock use. With respect to ground-water resources, probably they serve chiefly to absorb rainfall and runoff and to transmit the water to underlying formations.

RIVER-CHANNEL DEPOSITS

The river-channel deposits comprise the materials intermittently transported by the present river and form the lowest alluvial plain, which is at times completely covered during floods and hence called the flood chaunel. They occur in a shallow valley carved in the younger alluvium and locally rest unconformably on the terrace deposits and older formations. They are the youngest deposits of the area and hence late Recent in age. Channel deposits also exist along the smaller streams but are generally only a few feet wide and thick and are not distinguished from the younger alluvium.

Along the Santa Ynez River the river-channel deposits range in width from 300 feet to about 3,000 feet. At most places there is no information as to the thickness, but a few wells penetrate the deposits, and drill cores have been made at the Santa Rosa dam site. In the Santa Ynez subarea wells 6/30–20H1 and 6/30–20H2 probably were drilled to bedrock and have measured depths of 48 feet. In the vicinity of Buellton wells 6/32–11L1 (table 27) and 6/32–11R2 encountered shale about 55 feet and 65 feet, respectively, below the surface of the deposits. Drill cores at the Santa Rosa dam site penetrated 70 feet of deposits above the shale. If all this material belongs to the river-channel deposits, they are therefore at least 70 feet in maximum thickness. This figure seems excessive, however, and it is likely that the lowermost strata belong to the younger alluvium, although distinguishing features have not been recognized. The channel deposits are probably 30 to 40 feet in maximum thickness.

The river-channel deposits are mostly sand and gravel on the surface and at depth are inferred to consist of cross-bedded, lenticular, coarse sand and gravel with only thin and discontinuous lenses of clay and silt. The logs of Geological Survey test holes, compiled from samples of the material penetrated and brought up in the drilling auger, show that at least the uppermost 15 to 20 feet of deposits within the first 3 miles downstream from The Narrows consist mainly of sand with some silt and clay and a few thin lenses of pebble gravel and cobble gravel. (See table 30.) Above Robinson Bridge, as seen at the land surface, they contain a large proportion of rounded pebbles and cobbles of which many are as much as 5 to 6 inches in diameter. The coarseness decreases rapidly near The Narrows, and within the Lompoc plain the deposits consist largely of coarse sand with some stringers of pebble gravel and cobble gravel. At the lower end of the channel, near the ocean, the deposits are mainly of sand. They are loose and porous; and the permeability, as derived from laboratory tests, ranges from 425 to 4,320 gallons per day per square foot. (See p. 79.) The average permeability is about 1,000.

The deposits are neither thick nor extensive and do not contain a large quantity of ground water. They are tapped by a few irrigation wells which have large yields. The deposits contain and transmit a small part of the underflow of the Santa Ynez River. Nevertheless, where the hydraulic gradient is favorable they readily transmit the water of the Santa Ynez River to the underlying lower member of of the younger alluvium.

EOLIAN DEPOSITS

Eolian deposits, consisting of wind-blown sand, occur along the coast near the mouth of the Santa Ynez River. They lie on the coastal slopes and terraces at altitudes of 500 feet or less; and a small body lies immediately inland from the beach at the west end of the Lompoc plain. (See pl. 3.) The deposits are not extensive and comparatively thin. Generally they form poor soil or underlie nonagricultural areas and hence are not tapped by water wells.

GEOLOGIC STRUCTURE

The main structural features of the Santa Ynez River basin are the large synclines and anticlines. These large folds are expressed in the distribution of the rocks and deposits in the lowland between the folded and faulted Santa Ynez Mountains on the south and the faulted San Rafael Mountains on the north. These structures determined the areas in which the unconsolidated water-bearing formations could accumulate, and thus they determined the position and extent of the major bodies of ground water. As brought out under the next topic of this report, late geologic and geomorphic events have determined the relation of the Santa Ynez River to the main ground-water bodies. The structures are shown on the geologic cross sections, plates 2 and 4, and for the most part have been mapped by other geologists and are well known in the area.

The Santa Ynez Mountains are essentially a single high anticlinal fold in their eastern part but a complexly folded and faulted mass in the western part. Locally the north limb of the anticline is faulted, as a large fault extends along the Santa Ynez River from the vicinity of Solvang to about the east end of the Santa Rita Hills. The rocks may be faulted locally along the south edge of the Lompoc plain south and southwest of Lompoc, but evidence therefor is inconclusive and no faults are shown on plate 3. The San Rafael Mountains, which border the eastern part of the valley on the north, were uplifted along a fault zone that trends northwest and that has a displacement of several thousand feet.

In the lowland intervening between the Santa Ynez Mountains, and the San Rafael Mountains the rocks are folded into a series of anticlines and synclines whose axes trend toward west-northwest, and westward they diverge slightly northward from the general course of the Santa Ynez River. The consolidated nonwater-bearing rocks of the Sisquoc and Monterey formations are exposed in the central parts of the anticlines; the unconsolidated water-bearing Careaga sand and Paso Robles formation, and the younger alluvium lie in the synclines. In order northward and eastward the main folds are: A minor anticlinal fold in the western part of the Santa Rita Hills; a long curving syncline, called the Santa Rita syncline, north of the Santa Rita Hills; a longer sinuous anticline, which forms the Purisima Hills and which locally is called the Purisima anticline; a still longer sinuous syncline, called the Los Alamos syncline, which is north of the Purisima Hills, whose axis passes about through the town of Los Olivos, and which appears to continue eastward into the Tequepis syncline of Nelson (1925, p. 390) and finally a short anticlinal fold expressed in the Paso Robles formation and called by Nelson (1925, p. 390) the San Marcos anticline. These folds are shown but not named on plates 2 to 4.

The main bodies of unconsolidated water-bearing deposits occur in the Santa Rita syncline and the Los Alamos-Tequepis syncline. The Santa Rita syncline lies immediately north of the Santa Rita Hills, begins a short distance west of Buellton where it abuts against the large fault south of the river, extends west-northwestward across the valleys of Santa Rosa Creek and Santa Rita Creek nearly to Cebada Canyon, and there swings first to the west and then probably to the west-southwest. At the Lompoc plain the axis of this syncline plunges gently eastward, but the fold is believed to extend beneath the

Lompoc plain as a very shallow trough and probably to die out beneath the Lompoc Terrace.

The Santa Ynez River does not occupy either of these main synclines. In the Headwater and Santa Ynez subareas the river is south of the Tequepis syncline. In the Buellton subarea it crosses the east end of the Santa Rita syncline but shortly abandons that structural trough to enter its broad valley across the upfolded consolidated rocks of the Santa Rita subarea. Below The Narrows the river leaves the upfolded area, and in the Lompoc subarea swings across the west end of the Santa Rita syncline. Thus, only near Buellton and in the Lompoc subarea, where it crosses the two ends of the Santa Rita syncline—that is, for only about 18 miles of its entire course—is the Santa Ynez River in direct contact with the major bodies of water-bearing deposits in its valley. These seemingly anomalous features are explained in the following treatment of geomorphic history.

GEOLOGIC AND GEOMORPHIC HISTORY

The early events that bear on the development of the ground-water basins in southern Santa Barbara County took place in the early and middle parts of the Tertiary period of geologic time. In the Eocene, Oligocene, and Miocene epochs there accumulated over the area the marine and continental deposits of mud, sand, and gravel that have become the consolidated Tejon, Sespe, Vaqueros, Rincon, and Monterey formations. With the end of the Miocene this long period of nearly continuous deposition ended and in the ensuing early Pliocene the area of the Santa Ynez Mountains began to rise in a great anticlinal fold. Thus began the first stage in delimitation of the present ground-water areas.

North of the rising arch, over the area of the present Santa Ynez River basin, the sea remained as a broad shallow inlet whose south edge lay beyond the present course of the Santa Ynez River and whose north edge lay well beyond the present San Rafael Mountains. In this trough fine mud, in part diatomaceous, accumulated throughout early and middle Pliocene time to form the Sisquoc and Foxen formations. As brought out by Woodring and others (Woodring, Bramlette, and Lohman (1943, pp. 1353–1356), the site of the Purisima Hills apparently began to develop as a small anticlinal fold but evidently did not rise above the sea.

In the late Pliocene, however, the sea became even more shallow and the bordering land masses rose higher, so that sand and a small amount of gravel accumulated in the trough to form the Careaga sand. Near the end of the Pliocene the sea retreated entirely. At first lime deposits accumulated in fresh- or brackish-water ponds on these plains but later, streams flowing from the rising land masses began to deposit predominantly silt and mud, with a small amount of sand and gravel on the low coastal plains. These fine-grained deposits became the lower part of the Paso Robles formation.

The early earth movements accompanying these events were slow and gradual, and probably deformation was mainly by folding. However, with the transition from marine to continental deposition the uplift of the San Rafael Mountains became localized along the fault system bordering its south side. With continued uplift, streams flowing from this range and others from the north slope of the Santa Ynez Mountains built extensive coalescing alluvial fans in the intervening depression. These fans merged westward into a broad coastal alluvial slope which extended westward and northwestward for many miles. The deposits thus accumulated, in places nearly 3,000 feet thick, are the widespread Paso Robles formation.

This epoch of deposition ended in early or early middle Pleistocene time with intensified crustal movements. The San Rafael Mountains rose essentially to their present altitude by movement along the bordering fault system, cutting and strongly tilting the upper beds of the Paso Robles formation. Concurrently, these beds were arched over the Purisima Hills and the Santa Rita Hills and downfolded between. The Santa Ynez Mountains were further arched, with some of the movement localized along faults so that the Paso Robles formation and the Careaga sand dipped steeply off its north flank. Thus, the Santa Ynez Valley was established about in its present structural form.

Following this strong deformation of early or middle Pleistocene time, a widespread erosion surface was developed over all the lowland trough and much of the mountainous area. This erosion surface covered at least the westernmost part of the Santa Ynez Mountains and probably extended up the ancestral Santa Ynez trough far into the present Headwater subarea. Late in the development of this surface, streams deposited on its lower 20 miles material worn largely from the exposed edges of the Paso Robles and Careaga formations. The material thus deposited—sand with some clay and pebbles—constitutes the bulk of the Orcutt sand. Subsequently the sea may have advanced briefly inland and then retreated, leaving on the Orcutt sand the veneer of massive sand and scattered pebbles which now forms the indurated upper layer. Perhaps at the same time, local streams deposited a thin blanket of alluvium over the area of the Santa Ynez upland farther inland. Thus, there was formed a broad surface, at least in part depositional, extending from the sea far up into the Santa Ynez Valley and probably fairly high onto the north flank of the Santa Ynez Mountains. Before through drainage was established this surface evidently was tilted slightly southward, probably owing to renewed uplift of the San Rafael Mountains. Accordingly, when through drainage did develop (essentially in the present pattern) the ancestral Santa Ynez River was established far to the south close against the Santa Ynez Mountains and without regard to the major synclines.

Probably with renewed general uplift the river began to incise itself through the veneer of terrace deposits and the Orcutt sand; and except in the 5-mile reach across the present Buellton subarea and in the eastern part of the Lompoc subarea it became superimposed on the consolidated rocks underlying the north flank of the Santa Ynez Mountains. Correspondingly, its tributaries from the north were superimposed on the consolidated rocks in their lower reaches.

In subsequent downcutting the Santa Ynez River and its tributaries have developed the present valleys. The process was interrupted by several stages of relative stability, during which the inner valley was widened somewhat and narrow plains of alluvial sand and gravel were deposited along the river and less extensively along the tributary streams. With downcutting renewed after each period of stability these alluvial plains were dissected, and remnants were formed at successively lower levels along the deepening valleys. These remnants, the terrace deposits of today, include those buried beneath the south side of the Lompoc plain. In general, the successive sets of river terraces correspond to two prominent marine-cut terraces along the coast—one formed at a stand of the sea 60 to 90 feet above present level and the other about 300 feet above present level. The lower marine terrace probably corresponds to the lowest river terrace, in the deposits of which the fossil camel bone was found near Buellton.

Near the close of Pleistocene time the crustal movements died out almost completely. Also, probably concurrently with the advance of the latest continental glaciers, the sea withdrew along the entire coast and stood at least 200 feet below its present level. The Santa Ynez River and its tributaries cut sharp valleys into the underlying formations, but, as this low stand of the sea was relatively brief, those valleys were broad only in the unconsolidated deposits. Across the consolidated rocks only rather narrow canyons were incised.

As the sea returned about to its present level, the river and tributaries then aggraded their courses. The first deposits of aggradation were entirely coarse gravel, which now constitutes the lower member of the younger alluvium, but the material laid down subsequently was sand, silt, and clay. During this later stage of aggradation, the sea may have invaded the Lompoc subarea briefly and intermittently to form a shallow lagoon or tidal swamp in which the deposits were mainly clay but most of the upper member is considered continental.

So were deposited the predominantly fine-grained materials that make up the greater part of the upper member of the younger alluvium in the Lompoc subarea. At the same time, the side streams were depositing sand, gravel, and some clay to form the marginal alluvial fans. Ultimately a broad alluvial plain was formed in the previously carved valley, of which the chief remnants are the Lompoc plain and the corresponding cultivated benches upstream along the Santa Ynez River.

In recent years the Santa Ynez River has incised its course as much as 45 feet below that plain. Along that entrenched course, in its flood channel, the river intermittently deposits and transports the coarse sand and gravel which are distinguished as river-channel deposits. The transport of this material is the latest event of the region except for the local accumulation of dune sand blown in from the beach.

SURFACE-WATER RESOURCES

By H. G. Thomasson, Jr.

RUNOFF IN THE SANTA YNEZ RIVER BASIN

GENERAL CHARACTERISTICS

Because its land forms range from a ruggedly mountainous headwater terrane to relatively extensive lowland plains, because the water-holding capacity of its surficial materials and underlyiug rocks ranges greatly, and because its rainfall occurs largely in a few storms during a rainy season that extends about from December through the following April, runoff within the basin of the Santa Ynez River varies greatly among its several subareas (pl. 1) and fluctuates exceedingly each year. Flash runoff concurrent with storms and progressive depletion through the dry season of summer and autumn are characteristic. From year to year, runoff varies even more widely than rainfall (pp. 7–9). Based on computed virgin flow, the greatest yearly runoff in the Santa Ynez River near Lompoc (at Robinson Bridge) has been at least 120 times the least yearly runoff—the known extremes are those for 1930–31 and for 1940–41, respectively. At the same station, measured monthly runoff has been as great as 309,000 acre-feet (March 1911) and as little as 72 acre-feet (December 1929).

MEASURED STREAM FLOW

Table 6 identifies the stations at which measurements of stream flow have been made along the main stem of the Santa Ynez River; also, table 7 shows the scope of the records obtained at continuing gaging stations, both on the main stem and on tributaries. As table 7 shows, on the main stem of the river gaging stations have been maintained discontinuously from 1904 through 1920 and continuously thereafter at Gibraltar Dam; discontinuously from 1906 to 1918 and continuously since May 1925 near Lompoc (at Robinson Bridge); and for shorter terms at four additional stations. Also, continuous gaging stations have been maintained for terms of a few years on four principal tributaries, and miscellaneous measurements have been made at main-stem stations and at stations on tributaries. The records of measured flow at the six main-stem stations are presented in table 8 and for the four stations of longest term are summarized in table 9, in terms of both monthly and yearly runoff.

In addition to the records obtained from continuing gaging stations, numerous miscellaneous measurements have been made at several sites along the river and its tributaries (see table 6 and pl. 1). A few were made in 1914 and 1915, but thereafter none were made until 1928 when the city of Santa Barbara started an intensive stream-gaging program in connection with litigation concerning its diversion of water from the basin. Between 1928 and 1934 many measurements were made at points along the river from the headwaters to the mouth and on all tributaries of any size. During the period 1935 to 1938 the measurements were continued on the river above Gibraltar Dam and on tributaries, but the program of measuring on the lower river was discontinued. From the summer of 1938 to 1941 some measurements were made along the river below San Lucas Bridge in addition to those on the upper river and tributaries. Beginning in the summer of 1942 the Geological Survey has made numerous and periodic measurements at selected sites along the river below San Lucas Bridge and on tributaries entering below that bridge. All these miscellaneous measurements are published in water-supply papers of the Geological Survey (see table 7, footnote); they are not reprinted in this report.

TABLE 6.—*Stations along the main stem of the Santa Ynez River at which flow has been measured*

Station	Drainage area (square miles)	Distance above mouth (river miles)[1]
Above North Fork		85
Jameson Lake (Juncal Dam)	18	[2] 84.5
One half mile above Mono Creek		75
One half mile below Mono Creek		74
Gibraltar Dam	219	[2] 71.0
Paradise Camp		61
Above Santa Cruz Creek		51.2
Below Santa Cruz Creek		[3] 51.1
Near Santa Ynez (San Lucas Bridge)	435	[2, 3] 44.5
Near Solvang (Mission Bridge)	585	[2, 3] 37.5
Buellton bridge (U. S. Highway No. 101)		[3] 33.9
Associated pipe-line crossing		27.8
Donovan's		27.3
Santa Rosa dam site	704	[3] 25.3
Site E (gravel plant)		23.5
Falls (solid rock channel above Site D)		21.0
Site D (Greco crossing)		[3] 20.3
Site C (foot of Chalk Rock Hill)		18.8
Solid rock channel above Site B		17.9
Site B		17.4
Above Salsipuedes Creek		15.7
Site A		14.3
The Narrows		13.6
Near Lompoc (Robinson Bridge)	790	[2, 3] 13.1
Between Robinson Bridge and Rucker crossing		12.4
Rucker crossing (A Street)		11.4
H Street		10.4
Pine Canyon (Dyer Bridge) near Lompoc	844	[2] 7.5
Renwick crossing		3.0
Barrier bridge		1.1
Southern Pacific R. R. bridge		.2
Pacific Ocean	900	0

[1] Computed from map No. 443/111 and from table 7 in unpublished report by the Corps of Engineers, U. S. Army on Santa Ynez River basin, dated April 15, 1942; also, from aerial photographs correlated with this map and table.
[2] Continuing gaging station. Records summarized in tables 7 and 8.
[3] Mileage correlated with data from survey by the U. S. Bur. Reclamation in 1941. Mileage to other stations balanced between these key points, generally within tolerance of 0.1 mile.

TABLE 7.—*Available records of stream flow in the basin of the Santa Ynez River*

Station	Term of record
Santa Ynez River at Jameson Lake, near Montecito, Calif., formerly Santa Ynez River at Juncal Dam, near Montecito, Calif.	December 1930 to September 1944 (Prior to October 1941, monthly discharge only).
Santa Ynez River above Mono Creek, near Santa Barbara, Calif.	January 1903 to June 1903.
Santa Ynez River near Santa Barbara, Calif	February 1904 to April 1907. October 1907 to January 1908. October 1911 to March 1915. June 1916 to September 1917. January 1918 to September 1918. April 1920 to September 1944 (April 1920 to September 1941, monthly discharge only).
Santa Ynez River below Gibraltar Dam, near Santa Barbara, Calif.	April 1920 to September 1944 (Prior to October 1941, monthly discharge only).
Santa Ynez River near Santa Ynez, Calif. (at San Lucas Bridge).	December 1928 to September 1931. October 1932 to September 1944.
Santa Ynez River near Solvang, Calif	October 1928 to November 1940 (June 1937 to November 1940, irrigation seasons only).
Santa Ynez River near Lompoc, Calif. (at Robinson Bridge).	December 1906. October 1907 to December 1918 (1909, gage heights only). May 1925 to September 1944.
Santa Ynez River at Pine Canyon, near Lompoc, Calif.	May 1941 to September 1944.
Mono Creek near Santa Barbara, Calif	January 1903 to June 1903. December 1903 to June 1904.
Santa Cruz Creek near Santa Ynez, Calif	October 1941 to December 1942. July 1943 to September 1944.
Santa Agueda Creek near Santa Ynez, Calif	January 1941 to September 1944.
La Zaca Creek at Buellton, Calif	Do.
Salsipuedes Creek near Lompoc, Calif	Do.

NOTE.—Records here listed have been published by Geological Survey as follows:

Year ending Sept. 30	Water-Supply Paper	Year ending Sept. 30	Water-Supply Paper	Year ending Sept. 30	Water-Supply Paper
1918	447	1931	721	1939	881
1919	511	1932	736	1940	901
1920	511	1933	751	1941	931
1925	611	1934	766	1942	961
1926	631	1935	791	1943	981
1927	651	1936	811	1944	1011
1928	671	1937	831	1945	1041
1929	691	1938	861	1946	1061
1930	706				

TABLE 8.—*Measured runoff, in acre-feet, of the Santa Ynez River at six gaging stations, 1904–44*

[Data from water-supply papers of the Geological Survey]

Water-year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
Santa Ynez River at Jameson Lake (Juncal Dam) near Montecito [1]													
1930–31	(2)	(2)	[2] 4	21	52	47	46	41	26	15	11	9	272
1931–32	6	16	738	226	3,790	310	195	116	73	34	22	22	5,550
1932–33	11	23	11	1,240	158	97	73	62	36	17	11	8	1,750
1933–34	8	6	311	1,520	294	143	53	42	43	18	8	6	2,450
1934–35	68	48	273	857	140	441	490	185	55	27	29	21	2,630
1935–36	22	23	24	24	1,220	273	161	65	31	33	22	21	1,920
1936–37	34	22	721	401	2,780	3,550	1,110	697	437	58	30	28	9,870
1937–38	38	34	88	63	3,420	9,500	1,540	775	504	256	59	49	16,330
1938–39	43	48	214	385	234	520	145	66	30	17	13	31	1,750
1939–40	22	23	31	63	411	174	105	61	33	12	22	12	969
1940–41	11	12	317	1,070	4,390	7,730	5,580	1,560	891	546	291	151	22,550
1941–42	117	183	429	252	191	269	592	305	77	30	22	21	2,490
1942–43	21	23	27	4,780	1,720	3,290	712	417	191	65	34	39	11,320
1943–44	30	21	125	124	1,970	2,300	329	164	116	37	10	7	5,230
Median [3]	22	23	170	318	816	376	262	140	64	32	22	21	2,560
Average	31	34	237	788	1,480	2,050	795	325	182	83	42	30	6,080
Percentage of the year	0.5	0.5	3.9	13.0	24.4	33.7	13.1	5.3	3.0	1.4	0.7	0.5	100
Santa Ynez River at Gibraltar Dam, near Santa Barbara [4]													
1903–4	----	----	----	----	690	1,882	1,137	424	42	2	0	11,425	----
1904–5	541	381	430	4,544	50,260	49,010	8,509	3,148	946	234	160	83	118,000
1905–6	61	125	246	916	1,520	64,600	9,400	4,140	1,420	357	86	60	82,900
1906–7	61	83	3,210	90,400	27,200	93,500	14,100	----	----	----	----	----	----
1907–8	885	161	344	16,400	----	----	----	----	----	----	----	----	----
1911–12	357	619	812	916	684	7,190	3,910	1,690	553	160	40	18	16,900
1912–13	20	33	49	503	8,720	4,760	1,550	769	449	76	85	15	17,000
1913–14	6	1,070	486	49,000	57,000	18,200	5,840	3,040	1,430	585	213	121	137,000
1914–15	140	159	1,080	3,950	28,200	10,400	----	----	----	----	----	----	----
1915–16	----	----	----	----	----	----	----	----	690	181	65	12	----
1916–17	400	357	7,560	6,760	16,700	7,930	2,740	1,450	472	82	34	15	44,500
1917–18	[5] 20	[5] 20	[5] 20	41	21,900	57,200	9,520	3,460	1,230	343	183	316	94,300

See footnotes at end of table.

TABLE 8.—*Measured runoff, in acre-feet, of the Santa Ynez River at six gaging stations, 1904–44*—Continued

Water-year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
Santa Ynez River at Gibraltar Dam, near Santa Barbara—Continued													
1919–20							2,680	924	179	60	27	21	
1920–21	18	21	25	1,146	1,517	2,136	657	631	192	74	47	36	6,500
1921–22	33	27	11,310	7,561	28,205	12,306	5,294	2,477	899	258	48	19	68,400
1922–23	24	96	3,424	1,025	1,488	914	776	597	218	67	37	28	8,690
1923–24	20	56	202	178	140	1,178	381	117	44	35	31	45	2,430
1924–25	53	43	81	92	95	653	1,626	303	99	20	13	20	3,100
1925–26	18	85	266	204	8,402	976	36,215	1,057	369	100	50	35	47,800
1926–27	20	4,566	1,230	926	31,633	9,435	3,493	504	242	137	63	67	52,300
1927–28	60	155	355	290	4,691	1,902	670	266	100	40	20	20	8,570
1928–29	17	102	307	192	780	1,375	799	68	47	11	0	0	3,700
1929–30	0	0	0	187	64	2,186	353	224	55	13	2	3	3,090
1930–31	2	15	4	63	515	127	130	105	34	22	11	2	1,030
1931–32	8	92	6,640	2,450	29,900	2,770	1,330	638	192	36	10	1	44,000
1932–33	0	0	0	4,310	2,020	994	488	249	109	12	1	0	8,180
1933–34	0	0	1,160	8,590	2,090	1,090	272	52	78	1	0	0	13,330
1934–35	370	692	1,690	7,390	1,460	3,200	6,870	1,540	296	35	0	0	23,540
1935–36	0	0	0	6	10,400	2,510	2,040	433	61	3	2	0	15,450
1936–37	0	0	2,980	3,130	29,240	28,360	11,360	3,170	899	41	0	0	79,180
1937–38	0	0	674	385	26,980	79,090	9,480	5,070	1,620	386	40	0	123,700
1938–39	16	80	1,340	2,270	2,460	5,130	1,160	489	111	6	0	507	13,570
1939–40	0	0	0	1,010	3,660	2,150	975	309	47	0	0	0	8,150
1940–41	0	0	4,700	11,100	34,630	72,400	46,510	11,130	4,580	1,740	700	262	187,800
1941–42	343	462	3,280	3,440	2,360	2,900	5,740	2,200	444[4]	16	0	0	21,180
1942–43	0	0	0	33,940	15,110	29,300	7,430	2,780	952	133	0	0	89,640
1943–44	0	0	571	714	16,510	21,210	7,430	3,610	885	95	0	0	51,020
Over-all median	18	43	430	1,010	4,690	3,200	2,740	769	296	67	20	15	21,180
Over-all average	78	293	1,610	4,940	13,240	15,860	6,180	1,760	608	165	60	54	44,480
16-year median [6]	0	0	622	2,360	3,060	2,840	1,680	564	152	19	0	0	18,320
16-year average [6]	47	90	1,460	4,950	11,090	15,830	6,310	1,920	636	159	48	48	42,600
Percentage of the year	0.1	0.2	3.4	11.6	26.1	37.2	14.8	4.5	1.5	0.4	0.1	0.1	100

Santa Ynez River below Gibraltar Dam, near Santa Barbara [7]

1903-4	----	----	----	----	690	1,882	1,137	424	42	2	0	11,425	----
1904-5	541	381	430	4,544	50,260	49,010	8,509	3,148	946	234	160	83	118,000
1906-5	61	125	246	916	1,520	64,600	9,400	4,140	1,420	357	86	60	82,900
1906-7	61	83	3,210	90,400	27,200	93,500	14,100	----	----	----	----	----	----
1907-8	885	161	344	16,400	----	----	----	----	----	----	----	----	----
1911-12	357	619	812	916	684	7,190	3,910	1,690	553	160	40	18	16,900
1912-13	20	33	49	503	8,720	4,760	1,550	769	449	76	85	15	17,000
1913-14	6	1,070	486	49,000	57,000	18,200	5,840	3,040	1,430	585	213	121	137,000
1914-15	140	159	1,080	3,950	28,200	10,400	----	----	----	----	----	----	----
1915-16	----	----	----	----	----	----	----	----	690	181	65	12	----
1916-17	400	357	7,560	6,760	16,700	7,930	2,740	1,450	472	82	34	15	44,500
1917-18	----	----	----	41	21,900	57,200	9,520	3,460	1,230	343	183	316	----
1919-20	----	----	----	----	----	----	0	0	78	48	73	82	----
1920-21	115	5	78	83	74	31	30	34	268	98	61	48	925
1921-22	49	57	8,130	7,555	28,500	12,400	5,450	3,110	10	45	57	32	65,400
1922-23	31	42	1,950	818	1,250	513	541	166	56	138	49	48	5,600
1923-24	80	77	80	80	57	80	62	61	.58	31	31	30	727
1924-25	31	30	28	31	14	0	0	0	57	51	30	30	302
1925-26	31	30	31	31	354	654	36,200	682	79	62	62	60	38,300
1926-27	62	1,560	946	649	31,600	9,190	3,170	133	60	62	62	60	47,550
1927-28	58	0	0	0	1,660	1,626	282	68	66	68	68	66	3,960
1928-29	68	40	18	0	0	0	0	86	73	54	55	54	448
1929-30	55	54	28	5	0	0	12	61	60	61	47	24	407
1930-31	25	24	24	20	7	7	48	56	42	16	15	14	297
1931-32	15	15	13	0	27,600	2,400	900	314	185	34	15	15	31,500
1932-33	38	116	40	1,160	1,850	692	71	53	86	21	23	30	4,180
1933-34	30	30	14	6,560	2,020	889	6	42	52	31	31	30	9,730
1934-35	43	82	53	6,400	1,330	2,780	6,530	1,140	338	53	31	30	18,810
1935-36	31	30	31	31	7,270	2,270	1,760	93	120	31	31	30	11,730
1936-37	31	30	27	2,280	29,340	28,410	11,290	2,670	448	39	31	30	74,630
1937-38	31	30	12	0	25,220	79,430	9,400	4,760	1,000	75	31	30	120,000
1938-39	31	30	14	1,700	2,370	5,070	885	137	32	31	31	29	10,360
1939-40	31	30	31	4	1,430	1,930	647	0	10	31	31	30	4,200
1940-41	31	28	1,130	11,110	34,230	73,200	46,700	11,110	3,920	1,280	320	108	183,200
1941-42	109	101	3,060	3,440	2,240	2,740	5,620	1,660	107	37	31	25	19,170
1042-43	27	26	3	31,210	15,220	29,400	7,390	2,430	527	31	31	30	86,330
1943-44	29	1	0	0	14,880	21,630	7,130	3,160	364	30	31	30	47,280

See footnotes at end of table.

TABLE 8.—*Measured runoff, in acre-feet, of the Santa Ynez River at six gaging stations, 1904–44*—Continued

Water-year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
Santa Ynez River at San Lucas Bridge, near Santa Ynez [8]													
1928–29	[9] 0	[9] 50	[5] 150	180	811	1, 110	875	357	56	8	0	0	[9] 3, 597
1929–30	0	0	0	0	0	2, 580	286	200	47	1	0	0	3, 110
1030–31	0	0	0	0	0	1	0	0	0	0	0	0	1
1931–32	[9] 0	[9] 0	[9] 13, 000	[9] 6, 300	[9] 55, 000	[9] 8, 400	[9] 2, 300	[9] 1, 200	[9] 300	[9] 100	[9] 0	[9] 0	[9] 86, 600
1932–33	0	0	0	6, 210	3, 340	1, 290	503	164	57	6	0	0	11, 600
1933–34	0	0	6	11, 150	3, 930	1, 870	190	19	0	0	0	0	17, 170
1934–35	0	0	0	11, 430	3, 420	8, 210	15, 260	3, 090	615	144	52	2	42, 220
1935–36	0	0	0	0	21, 230	4, 740	4, 070	534	137	32	0	0	30, 740
1936–37	0	0	3, 260	4, 920	62, 250	59, 180	19, 930	5, 200	1, 480	244	94	68	156, 600
1937–38	16	0	363	198	59, 240	184, 100	18, 950	6, 560	2, 680	893	182	80	273, 300
1938–39	43	19	659	3, 000	4, 230	7, 800	2, 180	662	108	2	0	0	18, 700
1939–40	20	14	33	959	3, 750	3, 600	1, 520	367	109	46	32	14	10, 460
1940–41	12	7	4, 380	25, 870	98, 710	190, 500	121, 000	22, 370	7, 240	3, 180	1, 260	569	475, 100
1941–42	534	594	6, 370	5, 540	3, 200	4, 310	8, 010	3, 000	740	181	75	11	32, 560
1942–43	0	3	27	68, 910	28, 920	66, 260	13, 150	4, 290	1, 490	388	116	73	188, 600
1943–44	75	56	362	845	40, 620	36, 680	7, 310	3, 470	987	277	75	72	90, 830
Median	0	0	92	3, 960	4, 080	6, 270	3, 180	931	218	73	16	1	31, 650
16-year average	44	46	1, 790	9, 090	24, 290	36, 290	13, 470	3, 220	1, 000	344	118	56	89, 760
Percentage of the year	0. 05	0. 05	2. 0	10. 1	27. 1	40. 4	15. 0	3. 6	1. 1	0. 4	0. 1	0. 1	100
Santa Ynez River at Solvang [8]													
1928–29	261	361	424	421	1, 530	2, 010	1, 550	382	310	232	111	108	7, 700
1929–30	136	143	258	520	365	3, 450	533	504	296	205	96	103	6, 610
1930–31	218	381	406	452	506	389	209	240	207	21	58	76	3, 160
1931–32	236	318	15, 800	7, 380	71, 300	9, 840	2, 840	1, 570	460	295	193	223	110, 000
1932–33	315	345	403	7, 690	4, 400	1, 870	845	471	387	220	135	157	17, 200
1933–34	226	296	458	11, 430	4, 820	2, 750	586	290	219	152	96	145	21, 470
1934–35	257	401	331	13, 000	3, 680	10, 080	22, 290	3, 650	690	261	193	211	55, 040
1935–36	265	316	381	356	28, 020	5, 380	3, 910	726	339	323	283	193	40, 490
1936–37	369	381	------	------	------	------	------	------	1, 720	397	250	266	------
1937–38	292	363	------	------	------	------	------	------	2, 190	1, 040	391	339	------
1938–39	412	454	------	------	------	------	------	------	553	289	220	250	------
1939–40	345	337	------	------	------	------	------	------	290	226	195	188	------
1940–41	196	305	------	------	------	------	------	------	------	------	------	------	------
8-year median	246	332	404	3, 950	4, 040	3, 100	1, 200	488	324	226	123	151	19, 340
8-year average [10]	239	320	2, 308	5, 160	14, 330	4, 470	4, 100	979	364	214	146	152	32, 710
Percentage of the year	0. 7	1. 0	7. 0	15. 7	43. 8	13. 7	12. 5	3. 0	1. 1	0. 6	0. 4	0. 5	100

Santa Ynez River near Lompoc (at Robinson Bridge) [6]

1906-7	----	----	10,400	----	----	----	----	----	----	----	----	----	----
1907-8	7,010	5,390	4,720	42,200	108,000	37,700	14,000	8,920	5,360	3,280	1,180	1,370	239,000
1908-9	1,110	1,070	2,370	----	----	----	----	----	----	----	----	----	----
1909-10	----	----	----	53,600	8,940	16,700	11,200	4,720	2,330	1,480	1,290	1,370	----
1910-11	1,410	1,730	1,910	65,200	55,500	309,000	49,700	23,000	12,100	7,010	4,250	2,670	533,000
1911-12	2,310	2,200	3,760	4,290	2,380	12,400	9,640	6,270	2,900	1,630	1,320	1,250	50,400
1912-13	1,330	1,430	1,710	2,930	20,300	10,100	3,770	2,230	1,390	842	756	655	47,400
1913-14	547	2,960	1,860	222,000	217,000	58,500	21,400	9,900	4,920	2,640	2,120	1,930	546,000
1914-15	1,650	1,820	5,330	21,200	263,000	42,400	17,400	24,900	7,800	4,790	2,840	2,120	395,000
1915-16	2,160	2,360	5,200	143,000	46,400	28,600	13,400	7,560	3,460	2,130	1,910	1,560	258,000
1916-17	3,500	2,360	16,400	21,000	45,600	25,300	10,500	5,820	2,860	1,510	1,360	1,130	137,000
1917-18	1,190	1,470	1,410	1,430	100,000	161,000	27,200	12,500	6,010	3,860	2,100	2,250	320,000
1924-25	----	----	----	----	----	----	----	1,110	202	60	44	22	----
1925-26	65	374	769	928	11,100	4,040	64,900	6,150	1,210	374	132	68	90,100
1926-27	38	6,490	2,920	3,110	84,400	22,900	9,640	3,180	1,150	283	34	21	134,000
1927-28	596	1,610	7,320	2,950	8,970	5,500	2,450	978	204	105	55	78	30,800
1928-29	52	302	1,010	842	2,550	2,590	1,860	463	89	12	0	0	9,770
1929-30	0	0	0	621	589	3,370	881	247	61	14	0	0	5,780
1930-31	0	0	14	477	1,160	588	112	36	4	0	0	0	2,390
1931-32	0	0	17,000	13,500	93,800	12,500	3,340	1,660	337	51	32	25	142,000
1932-33	40	38	188	8,180	5,490	2,310	910	261	151	47	27	19	17,700
1933-34	23	20	134	15,440	4,250	3,610	601	61	20	6	0	0	24,170
1934-35	3	28	13	17,410	4,730	10,440	19,500	3,910	682	81	16	20	56,830
1935-36	22	30	228	633	27,260	7,050	4,740	813	42	5	0	0	40,820
1936-37	0	0	383	6,530	85,670	78,610	27,890	7,140	2,240	437	60	72	209,000
1937-38	44	59	405	1,120	93,110	215,300	25,960	11,030	3,500	1,240	395	259	352,400
1938-39	455	396	1,490	4,470	7,880	13,030	3,860	1,200	166	8	0	5	32,960
1939-40	14	29	121	3,190	6,200	7,170	2,950	834	93	11	0	0	20,610
1940-41	0	0	8,260	59,380	135,000	250,700	145,300	32,410	11,520	5,570	2,480	1,710	652,300
1941-42	1,950	2,300	13,380	13,140	6,930	10,140	11,560	5,240	1,640	461	276	289	67,310
1942-43	413	797	1,180	80,540	40,480	81,320	17,530	6,040	2,280	760	319	213	231,900
1943-44	355	479	1,510	2,770	50,750	45,550	10,420	5,180	1,580	499	148	117	119,400
Over-all median	210	438	1,460	5,500	33,870	12,760	10,460	5,210	1,480	449	140	98	104,800
Over-all average	899	1,240	3,520	27,090	54,590	52,200	18,620	6,710	2,640	1,340	779	637	170,200
16-year median	22	30	394	5,500	7,400	10,290	4,300	1,430	252	49	22	20	48,820
16-year average	211	280	2,830	14,260	35,360	46,520	17,340	4,780	1,520	575	235	170	124,100
Percentage of the year	0.2	0.2	2.3	11.5	28.5	37.5	14.0	3.8	1.2	0.5	0.2	0.1	100

[1] Runoff computed from reservoir records and equals change in storage plus diversion to Montecito, plus release to river plus spillway overflow plus evaporation minus rainfall.

[2] Measurement began December 12, 1930; runoff from October 1 through December 11 estimated as probably not more than 20 acre-feet and disregarded in total for the year. (See following record of runoff at Gibraltar Dam, downstream.)

[3] Median is the value that divides the record into an equal number of greater and lesser quantities.

[4] Through November 1920, runoff measured at site of Gibraltar Dam; subsequently, runoff computed from reservoir records for Gibraltar Lake and equals change in storage plus diversion plus release to river plus spillway overflow plus evaporation minus rainfall. Inflow regulated upstream by operation of Jameson Lake (Juncal Dam) beginning in December 1930.

[5] Estimated to complete the year.

[6] For the period 1928-29 through 1943-44, in common for the stations at Gibraltar Dam, at San Lucas Bridge, and at Robinson Bridge.

[7] Flow regulated upstream by operation of Gibraltar Dam beginning in April 1920 and of Jameson Lake (Juncal Dam) beginning in December 1930. Beginning with April 1920, runoff here shown is spillway overflow plus release to river.

[8] Flow regulated upstream at Gibraltar Dam beginning in April 1920 and at Jameson Lake (Juncal Dam) beginning in December 1930.

[9] Estimated, to complete 16-year record.

[10] During the 8-year period ending with 1935-36, the average yearly runoff at San Lucas Bridge was 27 percent of the average for the 16-year period ending with 1943-44.

TABLE 9.—*Median and average values measured runoff of the Santa Ynez River in the 16 water years 1929–44*

Station	Drainage area (square miles)	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
Median runoff, in acre-feet														
Jameson Lake [1]	18	22	23	170	318	816	376	262	140	64	32	22	21	2,560
Gibraltar Dam	219	0	0	622	2,360	3,060	2,840	1,680	564	152	19	0	0	18,320
Intervening area	216	−26	−24	78	1,700	2,200	2,660	1,500	706	107	40	−7	−16	16,210
San Lucas Bridge	435	0	0	92	3,960	4,080	6,270	3,180	931	218	73	16	1	31,650
Intervening area	355	22	29	208	1,950	3,670	3,840	1,550	502	62	9	0	12	14,410
Robinson Bridge	790	22	30	394	5,500	7,400	10,290	4,300	1,430	252	49	22	20	48,820
Average runoff, in acre-feet														
Jameson Lake [1]	18	31	34	237	788	1,480	2,050	795	325	182	83	42	30	6,080
Gibraltar Dam	219	47	90	1,460	4,950	11,090	15,830	6,310	1,920	636	159	48	48	42,600
Intervening area	216	5	5	1,510	5,100	14,010	20,730	7,410	1,560	557	228	69	22	51,200
San Lucas Bridge	435	44	46	1,790	9,090	24,290	36,290	13,470	3,220	1,000	344	118	56	89,760
Intervening area	355	167	233	1,040	5,170	11,070	10,230	3,870	1,570	522	226	117	115	34,330
Robinson Bridge	790	211	280	2,830	14,260	35,370	46,520	17,340	4,780	1,520	575	235	170	124,100
Average runoff, in percentage of the year														
Jameson Lake [1]	18	0.5	0.5	3.9	13.0	24.4	33.7	13.1	5.3	3.0	1.4	0.7	0.5	100
Gibraltar Dam	219	.1	.2	3.4	11.6	26.1	37.2	14.8	4.5	1.5	.4	.1	.1	100
Intervening area	216	.01	.01	2.9	10.0	27.4	40.5	14.5	3.1	1.1	.4	.1	.01	100
San Lucas Bridge	435	.05	.05	2.0	10.1	27.1	40.4	15.0	3.6	1.1	.4	.1	.1	100
Intervening area	355	.5	.7	3.0	15.1	32.2	29.8	11.3	4.6	1.5	.7	.3	.3	100
Robinson Bridge	790	.2	.2	2.3	11.5	28.5	37.5	14.0	3.8	1.2	.5	.2	.1	100

[1] For 14-year period ending Sept. 30, 1944.

NATURAL OR "VIRGIN" STREAM FLOW

In the Santa Ynez basin the natural stream-flow regimen now is disturbed substantially by storage and diversion of water at the Juncal and Gibraltar Dams, for use by the Montecito County Water District and the city of Santa Barbara, respectively; also by pumpage of water for irrigating flood-plain lands below the San Lucas Bridge and especially below Solvang. By water-years beginning with October 1920, these uses have ranged about from 2,800 to 20,700 acre-feet. Thus, the values of measured runoff in tables 7 and 8 do not present the quantities of water originating on the watershed above the several gaging stations.

To show the actual surface-water resources of the Santa Ynez River basin, table 10 contains computed natural or "virgin" runoff, by years, for four main-stem gaging stations. Natural runoff is identical with the measured runoff of table 8 for the station at Jameson Lake (Juncal Dam) throughout the term of its record. For the remaining three stations, however, it is derived from the measured values by corrections for depletions as follows: at Gibraltar Dam and the two stations downstream, for depletion involved in the operation of Jameson Lake, which began in December 1930; for the stations at San Lucas Bridge and at Robinson Bridge, for the further depletion caused by the operation of the Gibraltar Dam, which began in April 1920; and for the station at Robinson Bridge, for the additional depletion due to the pumpage for irrigation in the reach upstream to San Lucas Bridge. For the two reservoirs, the offset for depletion is the algebraic sum of increase (+) or decrease (—) in storage, diversion (+), evaporation (+), and rainfall (—). Depletion by pumpage was assumed to have been inconsequential through 1918, to have increased uniformly each year from 1,500 acre-feet in 1926 to 3,000 acre-feet in 1934, and subsequently to have been on the order of the quantities given in tables 21, 22, and 23.

As explained on page 107, and elsewhere in the chapters on ground water, the water pumped for irrigation of flood-plain lands between San Lucas Bridge and Robinson Bridge is drawn largely from a ground-water body that essentially is in hydraulic continuity with the river and which seems not to have been depleted appreciably up to 1944–45. Thus, for the purposes of this treatment it is assumed arbitrarily that in each year the runoff has been depleted by an amount equal to the pumpage. This assumption doubtless introduces appreciable error in the computed values for natural runoff at Robinson Bridge during dry years, because in those years the ground-water storage probably has been drawn down temporarily. However, this error is substantially compensated in the computed values for wet years, during which ground-water storage appears to have been replenished.

TABLE 10.—*Computed yearly natural runoff, in acre-feet, of the Santa Ynez River at four gaging stations, and from the intervening areas, 1905–44*

Water-year	Gaging station, and drainage area in square miles					
	Jameson Lake	Gibraltar Dam	Intervening area	San Lucas Bridge	Intervening area	Robinson Bridge
	18	219	216	435	355	790
1904–05		118,000				
1905–06		82,900				
1907–08						239,000
1910–11						533,000
1911–12		16,900				50,400
1912–13		17,000				47,400
1913–14		137,000				546,000
1914–15						395,000
1915–16						258,000
1916–17		44,500				137,000
1917–18						320,000
1920–21		6,500				
1921–22		68,400				
1922–23		8,690				
1923–24		2,430				
1924–25		3,100				
1925–26		47,800				101,100
1926–27		52,300				140,400
1927–28		8,570				37,210
1928–29		3,700	3,150	6,850	8,170	15,020
1929–30		3,090	2,700	5,790	4,870	10,660
1930–31	272	1,300	−290	1,010	4,780	5,790
1931–32	5,550	49,620	55,080	104,700	58,000	162,700
1932–33	1,750	9,930	7,390	17,320	8,930	26,250
1933–34	2,450	15,780	7,440	23,220	10,000	33,220
1934–35	2,630	25,350	23,410	48,760	18,310	67,070
1935–36	1,920	16,930	19,020	35,950	14,870	50,820
1936–37	9,870	81,320	81,080	163,300	57,100	220,400
1937–38	16,330	124,900	153,200	278,100	83,600	361,700
1938–39	1,750	14,430	8,370	22,770	19,560	42,330
1939–40	969	9,120	6,260	15,380	16,550	31,930
1940–41	22,550	190,430	291,970	482,400	181,800	664,200
1941–42	2,490	21,540	13,390	34,930	40,650	75,580
1942–43	11,320	91,270	97,330	188,600	54,000	242,600
1943–44	5,230	52,270	43,540	95,810	37,590	133,400
Over-all median	2,560	19,270				117,200
Over-all average	6,080	44,170				176,700
16-year median [1]		19,230	16,200	35,440	18,920	58,940
16-year average [1]		44,430	50,820	95,300	38,670	134,000

[1] For the period 1928–29 through 1943–44.

Table 10 (also tables 8 and 9) gives both median and average values for runoff at the several main-stem stations. Of these two values, the average obviously prorates the aggregate runoff over the period of record but, with respect to the quantities of water available for utilization, may be somewhat misleading because in considerable part its magnitude is determined by excessive runoff during only about one-sixth of the period. Under such conditions, commonly it is economically impracticable to conserve and to utilize all runoff indicated by average values. On the other hand, the median value (see definition in table 8) indicates the extent to which the water resources could have been utilized with shortages in only half the years. For the common 16-year period of record, at Gibraltar Dam, San Lucas Bridge, and Robinson Bridge, the median values of yearly natural runoff are from 32 to 44 percent of the corresponding average values; for the two tributary areas that intervene between these gaging stations the median values are 44 and 49 percent of the average values. In other words, assuming for the moment that the 16-year period of common record is representative, only from one-third to one-half the gross runoff can be conserved for use unless reservoir capacity is sufficient for holdover storage in more than half the years.

In the foregoing three tables the 16-year average and median values for runoff at Gibraltar Dam, San Lucas Bridge, and Robinson Bridge have been derived for the longest possible common period of record—specifically for the period beginning with October 1928 and extending through September 1944. This common period begins with a succession of relatively dry years and extends through a succession of relatively wet years. During the 16 years, rainfall at Santa Barbara was 104 percent of the over-all average for the 77 years of record for that climatologic station; in other words, the 16-year median and 16-year average values for runoff in the Santa Ynez River may be about equal to the true long-term values. Average values of runoff for the 50-year period ending September 30, 1941, have been independently derived by the Corps of Engineers, United States Army,[3] and for the 75-year period ending September 30, 1942, have been computed by the Bureau of Reclamation;[4] of necessity, both agencies have estimated the runoff for years in which there was no record. From the data of table 11 it is concluded that the particular 16-year values of this report afford reasonable approximations of long-term average and median runoff for purposes of fixing the scope of programs to conserve and fully to utilize the water resources—more precise values seem not to be afforded by data now available.

TABLE 11.—*Average yearly runoff of the Santa Ynez River at three gaging stations for the 16 water years 1929–44*

Gaging station	Acre-feet	Percentage of 50-year average	Percentage of 75-year average
Gibraltar Dam	44, 430	100. 5	103
San Lucas Bridge	95, 300	99	98
Robinson Bridge	134, 000	99	84

Prior to the period spanned by the 16-year average and median values of runoff, stream-gaging stations had been maintained discontinuously at Gibraltar Dam and at Robinson Bridge and have afforded values for yearly runoff beginning with 1904–5 and 1907–8, respec-

[3] Unpublished computations by Corps of Engineers, U. S. Army, 1942.
[4] Unpublished computations by Bureau of Reclamation, U. S. Dept. Interior, 1945.

tively. However, the records for these early periods are somewhat misleading with respect to long-term averages because they span 4 years in which runoff was only about 12 percent of average but was measured only at Gibraltar Dam, and 5 years in which runoff apparently was about 250 percent of average but was measured only at Robinson Bridge. Accordingly, the over-all median and average values of table 10 for these two stations are inserted for information only; they are believed to be inadequate as a basis for any critical appraisal of water resources.

RUNOFF AS A FUNCTION OF RAINFALL

Unlike that from humid areas, the runoff from the basin of the Santa Ynez River is neither a simple nor a constant function of the rainfall. Rather, the runoff caused by a storm of any particular magnitude ranges widely and in accord with the amount, distribution, and intensity of the antecedent rainfall in that year; also, for a given amount of rainfall, the yearly runoff is determined in part by the wetness of the previous year or few years. This influence of antecedent rainfall is a factor in all years and in dry years commonly involves a large percentage of the total runoff. It is related to certain physical features of the basin, which have been described on pages 24–27 and which on pages 81–99 are treated with specific reference to runoff characteristics.

The short rainy season concentrates all the flood runoff into a short period each year. Prolonged recession in runoff characterizes each summer and autumn and depletes the shallow ground-water storage to the extent that the runoff early in the ensuing rainy season depends as much on the intensity as on the amount of rainfall in the particular storm. Infiltration rates are high so that the first 6 to 8 inches of precipitation each winter, if in the form of intermittent gentle rains, may produce no runoff from most of the basin. On the other hand, a single intense storm of considerably less precipitation can produce flash runoff from almost the entire basin early in the season. This flash runoff, however, is of short duration, and the streams soon recede to the low base-flow or no-flow condition.

Evapotranspiration losses are fairly high and from year to year are much less variable than rainfall. Available records of evaporation, as measured in type-A land pans, and of temperature at Jameson Lake (Juncal Dam) and at Gibraltar Dam, have been summarized in tables 3 and 4, respectively, for the period beginning October 1930 (see pp. 22–23). No records of wind movement are available. Table 12 gives median, average, and extreme values for yearly evaporation and temperature in the 14-year period ending September 30, 1944.

TABLE 12.—*Mean and extreme values of yearly evaporation and temperature at two stations in the Santa Ynez River basin, in the 14 water years 1931–44*

Station	Median	Average	Maximum	Minimum
Jameson Lake (Juncal Dam):				
Evaporation, in inches	54. 36	54. 60	64. 47	43. 63
Average temperature, in ° F	62	61	64	59
Gibraltar Dam:				
Evaporation, in inches	61. 79	62. 72	68. 65	55. 17
Average temperature, in ° F	62	62	64	60

Subtraction of the nearly uniform yearly loss by evapotranspiration from the widely variable yearly rainfall causes the yearly runoff to vary much more than the yearly rainfall. This effect is modified somewhat by any hold-over ground-water storage in the basin. During a succession of dry years, shallow ground-water storage may become so depleted that in a given year the natural losses plus the replenishment of storage may dispose of nearly all the rainfall so that very little water runs off. On the other hand, another year having the same aggregate rainfall but occurring within a wet period may produce considerable runoff. Three years have been selected to illustrate the range of this rainfall-runoff relationship, as summarized in table 13 and as developed more fully in following paragraphs.

TABLE 13.—*Relation of rainfall to runoff in the Santa Ynez River in 3 extreme years*

[Quantities in percent of average for the 16 water years 1929–44]

Water year (ending Sept. 30)	Rainfall	Runoff above gaging station at—		
		Gibraltar Dam	San Lucas Bridge	Robinson Bridge
1930–31	75	3	0. 001	4
1935–36	95	38	38	38
1940–41	250	430	510	490

The water year September 30, 1931, had about 75 percent of average rainfall but followed 3 consecutive dry years. (See table 2.) The very small runoff at successive stations along the river shows the extreme effect of local absorption of precipitation. At Gibraltar Dam the rainfall was 17.34 inches and the virgin runoff was 1,300 acre-feet (table 10) from the 219 square miles of drainage area; the average depth of runoff was 0.11 inch. Of this amount, 297 acre-feet was released downstream and the remainder was detained in reservoir storage. At San Lucas Bridge, 26.5 miles downstream, only 1 acre-foot of surface flow was recorded during the year. Not only was there virtually no runoff in the channel from the 216 square miles of intervening drainage area but also the 297 acre-feet released at Gibraltar

Dam was dissipated within the reach. Only a small part of this loss is accountable as increased underflow at San Lucas Bridge (p. 80). At Solvang, 7 miles downstream from San Lucas Bridge, the surface runoff for the year was 3,160 acre-feet and the underflow is estimated to have been as great as if not greater than at San Lucas Bridge. Accordingly, all but 1 acre-foot of the runoff at Solvang was derived from the 150 square miles of drainage area between Solvang and San Lucas Bridge. This runoff probably was ground-water overflow from the Santa Ynez upland to the north and bore little relation to the year's rainfall (p. 103). It was equivalent to a depth of 0.40 inch on the intervening drainage area. At Robinson Bridge the total surface runoff amounted to only 2,390 acre-feet, which was 770 acre-feet less than that at Solvang although the intervening drainage area is 205 square miles.

These data do not completely represent the runoff conditions in 1930–31 because accurate data are not available as to diversions downstream from Solvang, but they do illustrate the striking deficiency in surface runoff that can exist in a year having 75 percent of the long-term average rainfall.

The water year ending September 30, 1936, had about 95 percent of average rainfall and followed a year in which rainfall was slightly greater than average. For the same areas discussed in the preceding paragraph the figures for runoff were: Gibraltar Reservoir, inflow 16,900 acre-feet and outflow 11,700 acre-feet; San Lucas Bridge, runoff 30,700 acre-feet, or 19,000 acre-feet gain below Gibraltar Dam; Solvang, runoff 40,500 acre-feet, or 9,800 acre-feet gain below San Lucas Bridge; and Robinson Bridge, runoff 40,800 acre-feet, or only 300 acre-feet gain below Solvang. During the year it is estimated that 4,100 acre-feet were pumped for irrigation between San Lucas Bridge and Robinson Bridge so that runoff from this area may have been about 4,400 acre-feet. Thus, with rainfall only moderately greater than in 1930–31, the runoff above Robinson Bridge increased by more than 40,000 acre-feet.

At the other extreme was the year ending September 30, 1941, in which precipitation was 250 percent of normal and was distributed uniformly over 5 months. Runoff was recorded as follows: Gibraltar Reservoir, inflow 190,000 acre-feet, outflow 183,000 acre-feet; San Lucas Bridge, 475,000 acre-feet, or 292,000 acre-feet inflow below Gibraltar Dam; and Robinson Bridge, 652,000 acre-feet, or 177,000 acre-feet inflow below San Lucas Bridge. Based on computed natural yearly runoff, the 435 square miles above San Lucas Bridge yielded water at the rate of 1,110 acre-feet per square mile, or to a depth of 20.8 inches over the area, whereas the 355 square miles of drainage area between San Lucas Bridge and Robinson Bridge yielded only

512 acre-feet per square mile, or 9.6 inches over the area. The gaging station at Solvang had been discontinued previously. During this wettest year of record, rainfall on the basin ranged from about 40 inches on the west to more than 60 inches on the east. The difference between rainfall and runoff averaged between 30 and 40 inches in depth over the entire basin. Reservoir storage and diversion and pumpage from wells along the river accounted for only about 12,000 acre-feet, or for 0.28 inch depth of runoff above Robinson Bridge; accordingly, storage and diversion did not greatly modify the amount of runoff that would have occurred naturally. However, part of the natural hold-over storage of the water year 1940–41 has increased the runoff during succeeding years.

The 3 years just treated suggest the insurmountable difficulties involved in any attempt to establish a simple relation between the amounts of rainfall and of runoff. For years having more than about 25 inches of rainfall, a reasonably definite relation seems to exist; however, for years whose rainfall is average or less than average the runoff ranges very widely for any particular amount of concurrent rainfall. Not until local deficiencies in surficial ground-water storage have been completely satisfied in any season does a large percentage of the succeeding rain find its way to the stream channels as surface runoff. In the extremely dry water year of 1930–31 evidently the deficiencies never were satisfied, in that practically no runoff occurred.

UNDERFLOW OF THE SANTA YNEZ RIVER

GENERAL CONSIDERATIONS

Like most coastal streams in California, the Santa Ynez River flows on a filled channel throughout much of its length. Beginning several miles above San Lucas Bridge and continuing to the ocean there is no place along the river at which its inner valley is entirely devoid of unconsolidated deposits. It is true that at two places between Santa Rosa dam site and Robinson Bridge, and possibly elsewhere, the river flows across consolidated rock, but at each of those places the rock is skirted by an ancient channel filled with unconsolidated deposits. Figure 2 shows a low-water profile of the river and suggests the profile at the bottom of the unconsolidated deposits, for reaches in which the depth to the underlying consolidated rocks is known from well logs or from test borings at highway bridges and at dam sites.

The unconsolidated deposits beneath and adjacent to the river transmit a certain amount of underflow which is not measured at the successive gaging stations. Obviously, however, this underflow is an integral part of the water resources of the river valley.

The amount of this underflow at any point is governed by the slope of the water table in a downstream direction, by the cross-sectional

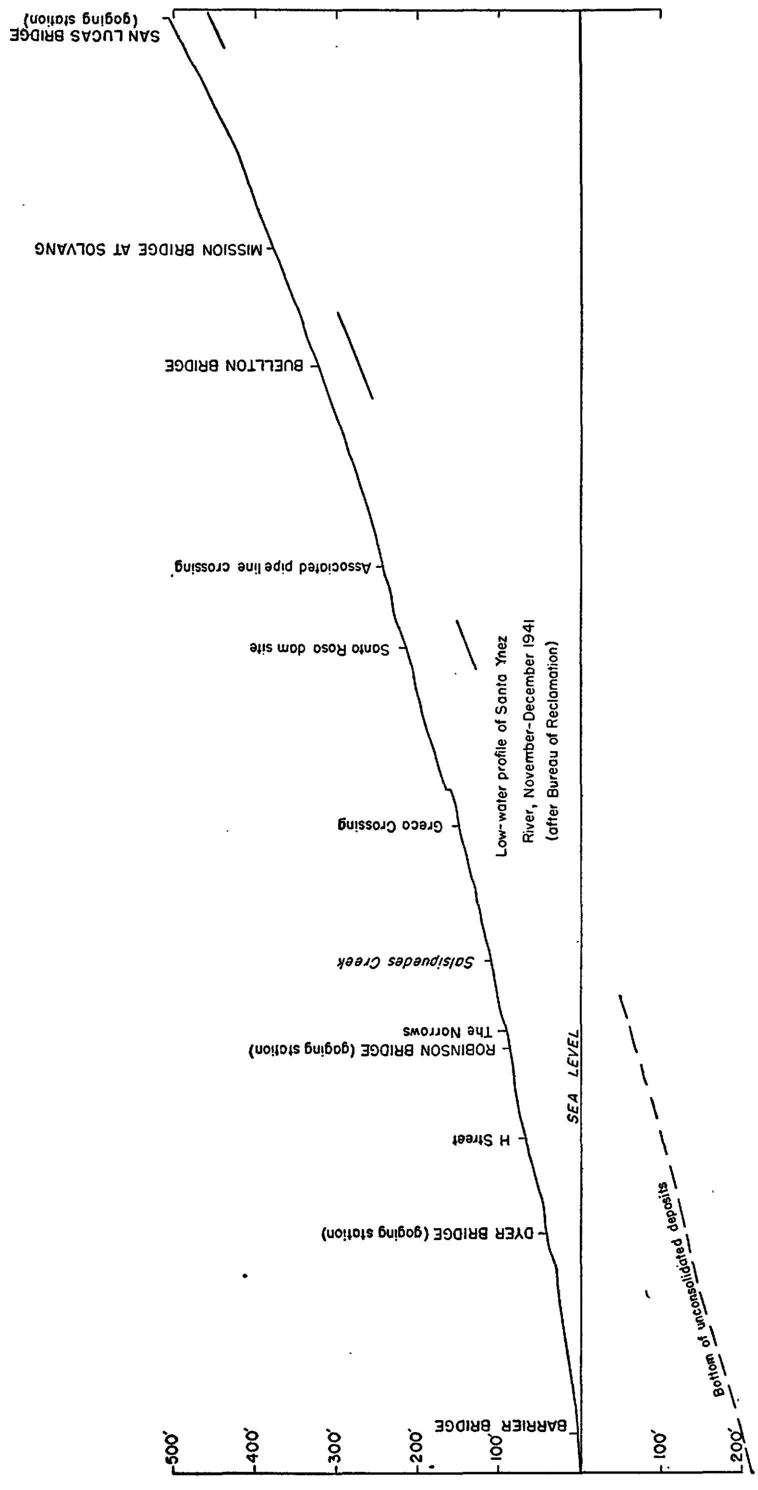

FIGURE 2.—Low-water profile and approximate depth to consolidated rock along the Santa Ynez River between San Lucas Bridge and the Pacific Ocean.

area of the saturated unconsolidated deposits, and by a constant which expresses the physical character of the material. These factors fit into an equation expressing Darcy's law of laminar flow, as follows:

$$Q=PIA,$$

in which Q is the quantity of water discharged in a unit of time, P is a coefficient of permeability for the material, I is the hydraulic gradient, and A is the cross-sectional area of the material through which water percolates (Wenzel, 1942, pp. 3–7). The quantity, Q, is expressed ordinarily in gallons per day. The coefficient of permeability, P, is expressed in gallons per day per square foot (g. p. d. per sq. ft.), and for laboratory use is defined as the rate of flow of water, in gallons per day, through a cross-sectional area of 1 square foot under a hydraulic gradient of 100 percent at a standard temperature of 60°F. This coefficient increases somewhat with temperature. The so-called field coefficient of permeability is defined as the rate of flow of water, in gallons per day, through a cross section 1 mile wide and 1 foot thick, under a hydraulic gradient of 1 foot per mile, at the field temperature. Numerically it differs from the laboratory coefficient only by a correction for the difference between standard and field temperatures. In laboratory usage the hydraulic gradient, I, is expressed as the percentage ratio of the drop of head to the length of the column of water-bearing material. In field usage, it is expressed in feet per mile. The remaining term in the equation is the cross-sectional area, A, which is expressed in square feet or in foot-miles according to the respective coefficients of permeability.

HYDRAULIC GRADIENT

With respect to underflow of the Santa Ynez River, the effective hydraulic gradient is taken to be the grade of the stream because, so long as there is surface flow, it is reasonable to assume that the water table is about level with the water surface in the stream. This is not strictly true throughout; for example, at the head of a riffle the water table commonly is below the water surface of the stream but at the foot of the riffle the water table commonly is somewhat the higher. In general, however, the average profile of the Santa Ynez River may be taken as identical with the average slope of the water table within the adjacent unconsolidated deposits. Table 14 gives values for the hydraulic gradient at selected points along the river, derived from the data of the low-water river profile shown on figure 2. With respect to these values, any fluctuations during the year probably are negligible.

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TABLE 14.—*Average gradient, in feet per mile, along the Santa Ynez River*

[Based on profile surveyed by U. S. Bureau of Reclamation, November-December 1941]

Reach, or station	Gradient
Tequepis dam site	23
San Lucas Bridge	19
San Lucas Bridge to Mission Bridge (near Solvang)	18. 3
Mission Bridge	16
Mission Bridge to Buellton bridge	15. 5
Buellton bridge	14
Associated Pipe Line crossing	12
Santa Rosa dam site	11
About 0.4 mile below Greco crossing	8
The Narrows	8

CROSS-SECTIONAL AREA OF THE UNCONSOLIDATED DEPOSITS

The cross-sectional area of the saturated unconsolidated deposits in a vertical plane normal to the direction of underflow is less easily determined than the hydraulic gradient because it is completely hidden from view. At only one point along the river below San Lucas Bridge, at the Santa Rosa dam site, is the cross section known fully from test holes bored to rock (by the Corps of Engineers, U. S. Army). However, because well logs indicate that the profile of the underlying bedrock is relatively uniform between San Lucas Bridge and Robinson Bridge (fig. 2), an approximate cross section can be drawn by projecting the consolidated-rock sides downward at a reasonable slope and then rounding off to the interpolated depth to rock at any particular place. A cross section so drawn is subject to considerable error, but in general it is believed that areas so derived are within about 25 percent of true values. In view of the approximate values of the other variables involved, accuracy of this order is considered adequate for the present purpose. Figure 3 shows six such cross sections along the river between San Lucas Bridge and the ocean.

PERMEABILITY OF THE UNCONSOLIDATED MATERIALS

FIELD TESTS

Theis (1935, p. 522) has developed a formula for determining permeability from the recovery of the water level in a well after discharge from that well has stopped. This "recovery formula" has been further elaborated by Wenzel (1942, p. 95–96). It derives a factor called the "coefficient of transmissibility," which is the product of the field coefficient of permeability times the saturated thickness of the aquifer; that is, it yields a value for the rate of flow of water, in gallons a day, through a section extending the full depth of the aquifer and

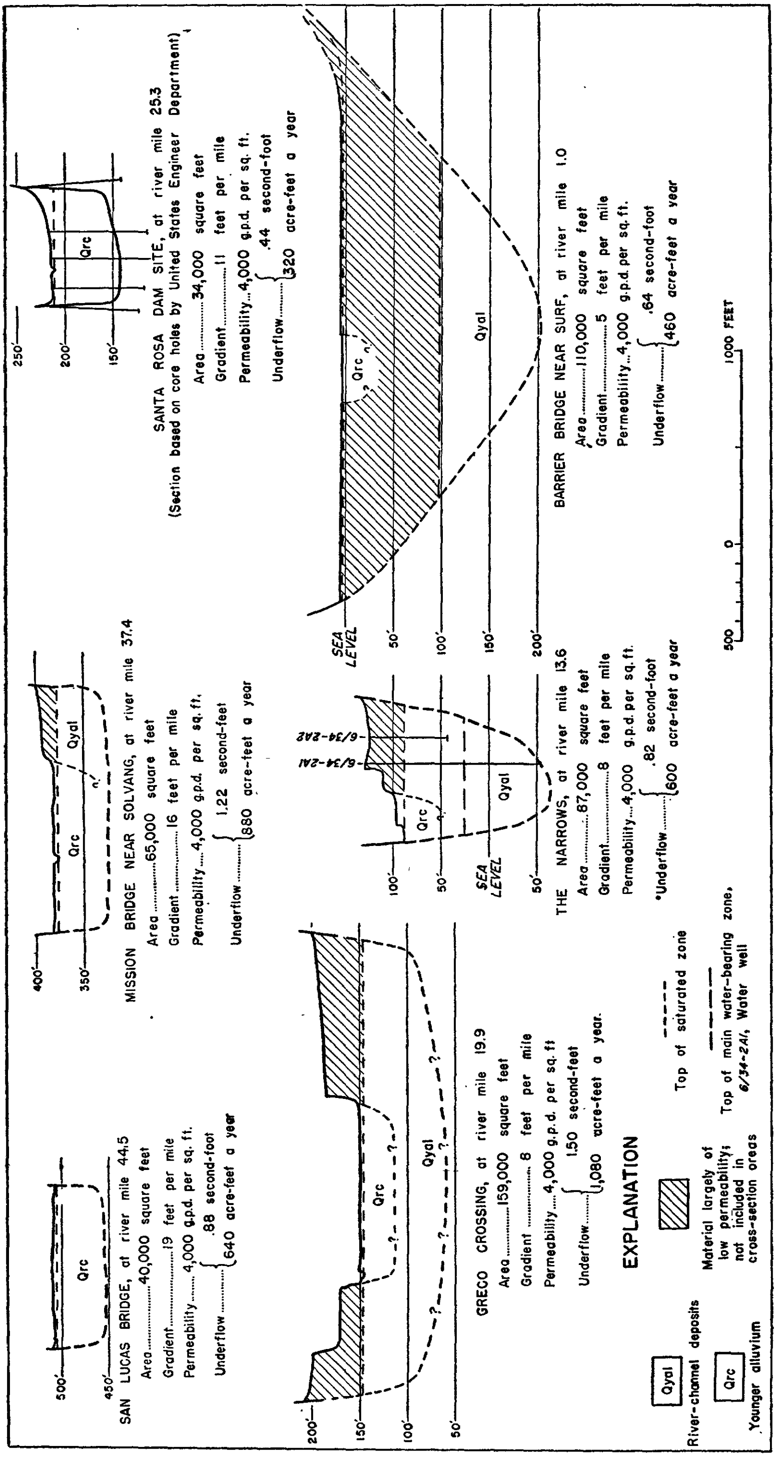

FIGURE 3.—Cross sections of unconsolidated deposits along the Santa Ynez River, at six places between San Lucas Bridge and the Pacific Ocean.

1 mile wide, under a hydraulic gradient of 1 foot per mile. The formula follows:

$$T=\frac{264}{s}q \log_{10} \frac{t}{t'}$$

in which T is the coefficient of transmissibility; q is the discharge of the pumped well in gallons a minute; s is the residual draw-down in feet; and t and t' are the times since pumping started and since pumping stopped, respectively, measured in any common unit. These several factors commonly are readily evaluated in the field so that under ideal conditions it is possible to obtain reliable values of transmissibility. If the saturated thickness also is known, values of permeability are then calculated.

Recovery tests were made on four wells on terraces bordering the river channel between the Santa Rosa dam site and Robinson Bridge. All four wells penetrate to the bottom of the younger alluvium, and their casings probably are perforated in the lower gravel member of that formation. Time of starting the pump was noted, discharge of the well was measured by a pitometer-type flowmeter, and, beginning as soon as the pump was stopped, measurements of the recovering water level were made with time of each measurement recorded. These measurements were continued for at least 12 hours and as much as 17½ hours, depending on whether the well was needed for irrigation on the following day. Table 15 summarizes the results of these tests; plates 2 and 3 show the locations of the wells.

TABLE 15.—*Results of recovery tests on four wells along the Santa Ynez River between Santa Rosa dam site and Robinson Bridge*

Number of well on plate 2 or 3	Date of test	Transmissibility (g. p. d. per ft.)	Thickness of saturated material tapped (feet)	Permeability (g. p. d. per sq. ft.)
6/33-12L1	June 17-18, 1944	290,000	61	4,800
6/33-9J1	June 15-16, 1944	150,000	49	3,000
6/33-16A1	June 16-17, 1944	50,000	41	1,200
6/34-2A1	July 30, 1943 May 31, 1944	400,000	79	5,100

The recovery formula is based on so-called ideal conditions—namely, that the aquifer is of infinite extent, that the initial water table is level, that the saturated material is uniform in thickness and homogeneous, and that the well casing penetrates the full thickness of the saturated beds and is perforated from the water surface to the bottom. Field conditions were far from ideal for the four wells tested between Santa Rosa dam site and Robinson Bridge. In each test, uncertainties were introduced by nearness of rock boundaries along the sides of the canyon, by the heterogeneous character of the water-bearing materials, and by indefinite information as to the location of perforations in the well casings; also because the river flowed across the cone of pumping depression, and because the rock floor beneath the saturated material probably was not level.

Of the four wells tested, well 6/33–12L1 is about 1,800 feet downstream from the Santa Rosa dam site; its log indicates merely 6 feet of soil overlying 72 feet of gravel. Being just below the constricted dam site, the material penetrated probably is coarse-grained, so that the relatively high value of transmissibility is not surprising. However, as the river was flowing across the cone of depression induced by pumping, the water level probably recovered more rapidly than otherwise; hence, the values of transmissibility and permeability may be too large.

Results of the test on well 6/33–9J1 are considered the least reliable, as only approximate limiting values for transmissibility could be fixed—a probable minimum of 150,000 and a probable maximum of 350,000. The smaller of these two limits is entered in table 15.

Well 6/33–16A1 is situated opposite well 6/33–9J1 but about one-half mile south of the river. In spite of low transmissibility, the thinness of saturated material at this well gives permeability values not inordinately small. A lower value of permeability here is not unreasonable as the well is in an alcove of the ancient river channel, where the materials probably are somewhat finer of grain.

The fourth well tested, No. 6/34–2A1, is on the right bank of the river about 3,000 feet upstream from Robinson Bridge and within The Narrows. As with the well just below the Santa Rosa dam site, relatively coarse material might be expected. According to the driller's log the well penetrates many thin strata of gravel, sand, silt, and blue clay to a depth of 105 feet, and only the lower 79 feet of the well penetrates continuous coarse gravel. Possibly because the river flows nearby, high values of transmissibility and of average permeability were obtained. Two tests were made on this well to minimize field errors: the two tests agreed very well.

LABORATORY TESTS

Disturbed samples of present river-bed material, part of the river-channel deposits as previously defined, were tested for permeability in a variable-head permeameter similar to one designed by S. F. Turner.[5] This instrument consists of two cylinders connected at the bottom by a tube through which water may pass freely. The sample of material is placed in one cylinder, called the permeameter, upon a suitable retaining screen. Water is admitted to the other cylinder, called the manometer, and allowed to percolate upward through the sample, and to spill over the top of the permeameter cylinder. For this apparatus the coefficient of permeability may be computed by the equation

$$P=\frac{48{,}815\ al}{At}\log\frac{h_0}{h},$$

in which P is the coefficient of permeability expressed in gallons per day per square foot, a is the cross-sectional area of the manometer in square centimeters, i is the length of the sample in centimeters, A is the cross-sectional area of the sample in square centimeters, t is the time of percolation in seconds, h_o is the initial head in any unit, and h is the head measured in the same unit as h_o at any time t (Wenzel, 1942, pp. 59–65).

Twenty-four samples of river-bed material were collected at 12 sites between San Lucas Bridge near Santa Ynez and the Barrier bridge near Surf. Of these, 14 samples were collected from the reach between San Lucas Bridge and Robinson Bridge, for which the quantity of underflow is sought. The samples were taken in pairs at each site—one sample of average coarse bar material and another of average fine bed material, with the view that the average permeability of the present channel deposits at the site would fall somewhere between the two values so obtained. Because the river-bed bars from which the samples were taken have been worked and reworked by recent floods, it is believed that the disturbed samples, packed under water in the permeameter, probably yield representative values of permeability. The results of the tests are given in table 16. Four additional samples were collected from tributaries of the Santa Ynez River; for these, results are given in table 17.

[5] Turner, S. F., personal communication, 1944.

TABLE 16.—*Results of permeability tests on 24 samples of bed materials along the Santa Ynez River*

[Locations listed in order downstream]

Location	Description	Permeability g. p. d. per sq. ft.
San Lucas Bridge	Coarse sand, fine gravel	2,390
	Medium sand, few extreme fines	760
Mission Bridge, near Solvang.	Coarse gravel and sand, no fines	4,200
	Gravel and coarse sand	750
Donovan's	Coarse sand and gravel, some fines	850
	Coarse sand gravel, few fines	1,240
Santa Rosa dam site	Coarse sand and gravel, few fines	940
	Coarse sand and gravel	1,050
Greco crossing	Sand and fine gravel	970
	Coarse sand and gravel	4,320
The Narrows, opposite well 6/34-2A1.	Fine gravel and coarse sand	1,300
	Fine gravel and sand	1,000
Robinson Bridge	do	1,080
	do	870
Rucker crossing	do	850
	do	1,260
H Street Bridge	Sand, lowest water channel	750
	Slightly higher bar	1,520
Dyer Bridge	Sand, very little gravel	1,080
	do	1,040
Lynden School crossing	Sand	850
	do	960
Barrier bridge, near Surf	Fine sand	425
	do	650

TABLE 17.—*Results of permeability tests on samples of bed materials along tributaries of the Santa Ynez River*

Location	Description and remarks	Permeability (g. p. d. per sq. ft.)
Santa Agueda Creek 100 feet above mouth.	Gravel, particles from 20 to 2 millimeters in diameter; very few fines.	3,280
La Zaca Creek, 25 feet upstream from gaging station.	Medium to coarse sand, some fines; dry and hard.	450
Santa Rosa Creek, 100 feet upstream from highway 150, in midchannel.	No gravel; fine sand with some silt; dry and hard.	30
Santa Rosa Creek near mouth, at edge of alluvial plain along Santa Ynez River.	Sand. Surface flow estimated 0.25 second-foot.	171

The determination of the average permeability of an aquifer by means of laboratory tests on samples of the material is subject to uncertainty. Although the values of permeability listed in tables 16 and 17 probably are reasonably correct for the particular samples, those samples are very small as compared to the cross-sectional area involved. Neither is there any assurance that the river-channel deposits are of the same mechanical composition as the underlying younger alluvium, which transmits most of the underflow. As a matter of fact, the logs of water wells consistently show a layer of gravel near the bottom of the younger alluvium, and it is quite possible that the permeability of this layer is much greater than that of present river bars. On the other hand, the well logs also indicate lenses of silt and clay, particularly in the upper part of the younger alluvium; it is quite probable that the permeability of these lenses is much less than that of the present river bars. No laboratory samples were taken from present overflow channels where considerable silt had been deposited, for it was evident from inspection that the permeability of such samples would be very small.

The laboratory values of permeability were fairly consistent from point to point along the river and on the average were lower than the values derived from the four recovery tests on wells. However, the largest of the laboratory values are in the same order of magnitude as the average of values from the well tests.

COMPUTATIONS OF UNDERFLOW

Table 18 summarizes computations of underflow at six cross sections along the river between San Lucas Bridge near Santa Ynez and the Barrier bridge near Surf. For these computations, hydraulic gradients are taken from table 14 and cross-sectional areas from the data shown on figure 3. Average permeability has been assumed as 4,000 for all six sections; that is, it is taken at a value about equal to the largest values from the laboratory tests and to the average from the well tests.

TABLE 18.—*Underflow in unconsolidated deposits beneath the Santa Ynez River, at sites between San Lucas Bridge and the Pacific Ocean*

Site	River miles above mouth	Gradient (feet per mile)	Cross-sectional area (square feet)	Underflow [1]		
				Second-feet	Gallons a day	Acre-feet a year
San Lucas Bridge	44. 5	19	40, 000	0. 88	576, 000	640
Mission Bridge, near Solvang	37. 4	16	65, 000	1. 22	788, 000	880
Santa Rosa dam site	25. 3	11	34, 000	. 44	284, 000	320
Greco crossing	19. 9	8	159, 000	1. 50	964, 000	1, 080
The Narrows	13. 6	8	87, 000	. 82	528, 000	600
Barrier bridge, near surf	1. 0	5	110, 000	. 64	416, 000	460

[1] Permeability of materials assumed uniform, and 4,000 g. p. d. per sq. ft.

These computed values of underflow along the Santa Ynez River admittedly are approximations and are about as large as can be justified with the data now available. Even so, at the six cross sections listed in the table the values range only from 460 to 1,080 acre-feet per year; obviously, they are very small in comparison with the average yearly runoff.

WATER-SUPPLY CHARACTERISTICS, BY SUBAREAS

GENERAL FEATURES

Between the extremely rugged terrain to the east and the Pacific Ocean to the west, the Santa Ynez River basin spans a wide range of rainfall and runoff characteristics. Because the underlying materials range from consolidated rocks to incoherent coarse alluvium, the several subareas (pl. 1) are quite unlike in their capacities to absorb and to yield water. Figure 4 shows average natural monthly runoff, in acre-feet, from three subdivisions of the basin for the 16-year period ending September 30, 1944. The areas represented are those above Gibraltar Dam, between Gibraltar Dam and San Lucas Bridge, and between San Lucas Bridge and Robinson Bridge.

Upstream from San Lucas Bridge the basin is mountainous and, except for diversions to irrigate a very few acres of land, its runoff is regulated only by Jameson Lake (Juncal Dam) and Gibraltar Reservoir. This upstream segment of the basin, the Headwater subarea, is the principal catchment area for water. Downstream from San Lucas Bridge the Santa Ynez Mountains flank the river on the south but to the north lie relatively extensive lowland plains with low rolling hills beyond. In this downstream segment of the basin, thousands of acre-feet of water are pumped each year from wells for agricultural uses. The effect of this pumpage on the stream regimen is not instantaneous, nor is it easily determined, but such withdrawal is believed ultimately to influence the flow at gaging stations downstream.

Four floods of sufficient magnitude to cause appreciable damage have occurred in the 16 years that discharge has been measured concurrently at San Lucas Bridge and at Robinson Bridge. Peak rates of flow during these floods have been about the same at the two places, as follows: In the year 1937–38, at San Lucas Bridge 43,700 second-feet on March 2 (from rating curve extended above float measurement of 34,100 second-feet), at Robinson Bridge 45,000 second-feet on March 3 (from rating curve extended above float measurement of 38,000 second-feet); in the year 1940–41, at San Lucas Bridge 21,200 second-feet on March 4, at Robinson Bridge 20,200 second-feet on March 5; in the year 1942–43, at San Lucas Bridge 33,000 second-feet on January 23, at Robinson Bridge 32,000 second-feet on January 23; and in the year 1943–44, at San Lucas Bridge 16,000 second-feet on February 22, at Robinson Bridge 15,000 second-feet on February 22. Heavier rainfall on and flashier runoff from the area above San Lucas Bridge combine with channel storage and

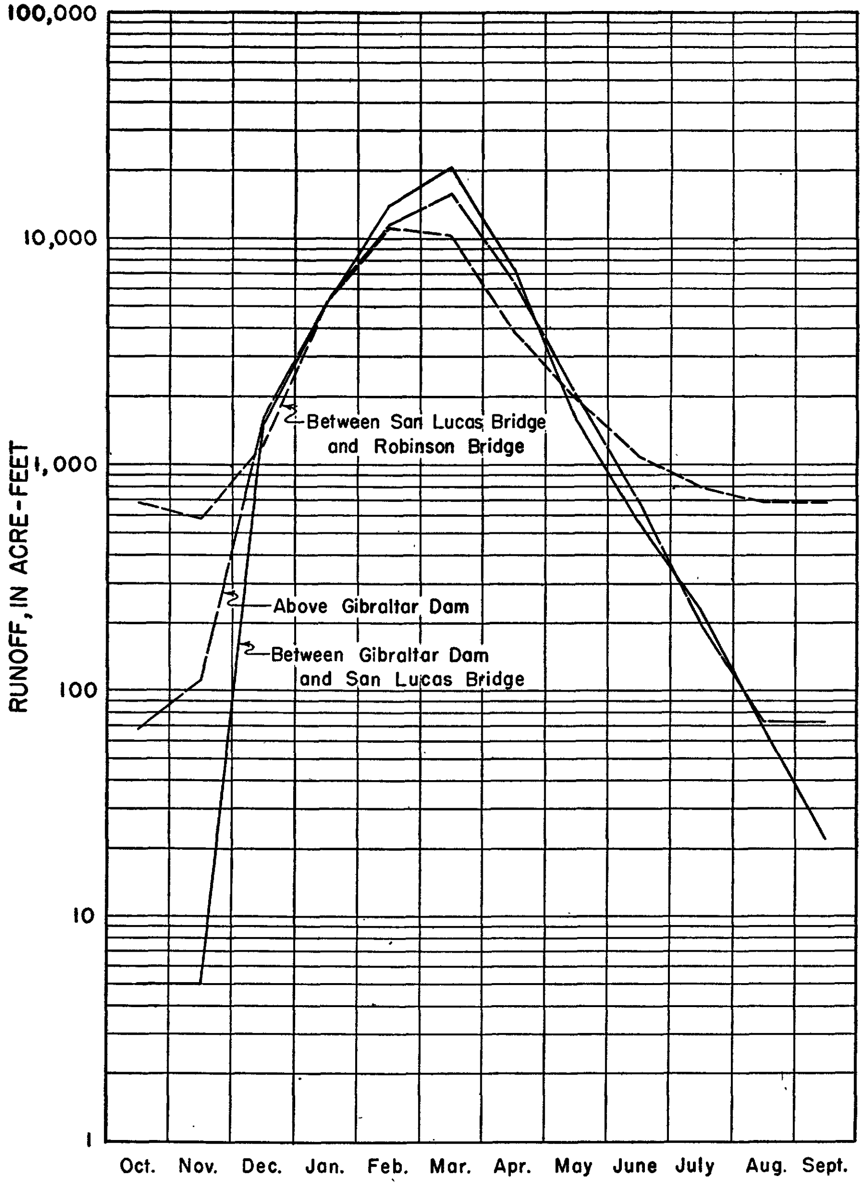

FIGURE 4.—Average monthly natural runoff, in acre-feet, from the basin of the Santa Ynez River in the 16 years ending September 30, 1929–44.

time lag necessary for flood peaks to travel between the two bridges to cause this phenomenon. Storm runoff from the 355 square miles of drainage area between the two bridges therefore serves only to broaden the base of the flood hydrograph at the lower bridge.

Table 19 shows the yearly natural runoff, in inches of depth at four gaging stations on the river, also from the intervening areas for all complete water years of record.

Both Juncal Dam and Gibraltar Dam are built on bedrock foundations and intercept all flow at those places. Downstream, however, the river flows on a filled channel for most of its length, so that gaging-station records at and below San Lucas Bridge do not include the underflow through the channel deposits and adjacent alluvium (pp. 71 to 81). This underflow is quite small and is disregarded in reducing measured yearly flows to natural yearly flows at the several stations. However, it is necessary to keep the underflow in mind with relation to the low-water gains and losses in the several reaches of the river.

TABLE 19.—*Yearly natural runoff, in inches, of the Santa Ynez River at four gaging stations, also from the intervening areas, 1905–44*

Water-year	Gaging station, and drainage area in square miles					
	Jameson Lake	Gibraltar Dam	Intervening area	San Lucas Bridge	Intervening area	Robinson Bridge
	18	219	216	435	355	790
1904–5		10.10				
1905–6		7.10				
1907–8						5.67
1910–11						12.6
1911–12		1.45				1.20
1912–13		1.46				1.12
1913–14		11.7				13.0
1914–15						9.37
1915–16						6.12
1916–17		3.81				3.25
1917–18						7.59
1920–21		.56				
1921–22		5.86				
1922–23		.74				
1923–24		.21				
1924–25		.27				
1925–26		4.09				2.40
1926–27		4.48				3.33
1927–28		.73				.88
1928–29		.32	0.27	0.30	0.43	.36
1929–30		.26	.23	.25	.26	.25
1930–31	0.28	.11	0	.04	.25	.14
1931–32	5.78	4.25	4.78	4.51	3.06	3.86
1932–33	1.82	.85	.64	.75	.47	.62
1933–34	2.55	1.35	.65	1.00	.53	.79
1934–35	2.74	2.17	2.03	2.10	.97	1.59
1935–36	2.00	1.45	1.65	1.55	.79	1.21
1936–37	10.3	6.96	7.04	7.04	3.02	5.23
1937–38	17.0	10.7	13.3	12.0	4.42	8.58
1938–39	1.82	1.24	.73	.98	1.03	1.00
1939–40	1.01	.78	.54	.66	.87	.76
1940–41	23.5	16.3	25.3	20.8	9.60	15.8
1941–42	2.59	1.84	1.16	1.51	2.15	1.79
1942–43	11.8	7.81	8.45	8.13	2.85	5.76
1943–44	5.45	4.48	3.78	4.13	1.99	3.17
Over-all median	2.66	1.58				2.78
Over-all average	6.33	3.78				4.19
16-year median [1]		1.64	1.41	1.53	1.00	1.40
16-year average [1]		3.80	4.41	4.11	2.04	3.18

[1] For the period 1928–29 through 1943–44.

Miscellaneous measurements of flow along the main stem of the river between San Lucas Bridge and the ocean and also on the tributaries (pl. 1) have afforded critical data with respect to the surface-water resources of the basin. Thus, the variation in simultaneous low-water flows localizes the low-water discharge from the several

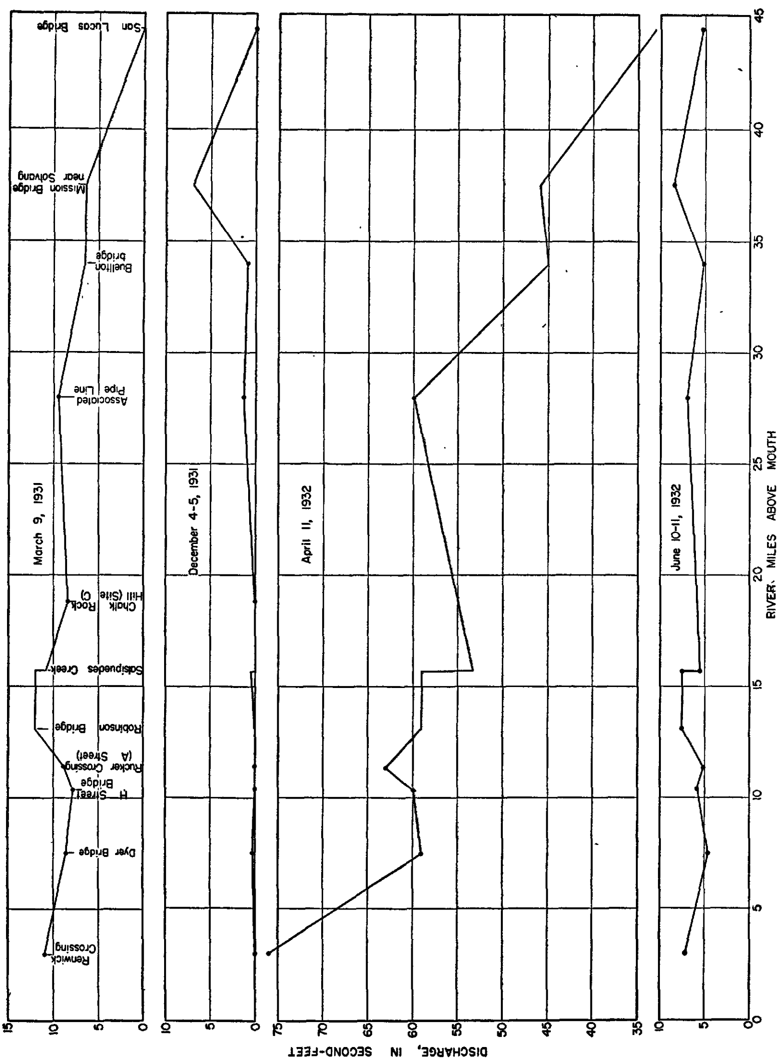

FIGURE 5.—Losses and gains along the Santa Ynez River below San Lucas Bridge, as defined by representative gagings made about simultaneously, 1931-44.

parts of the basin below San Lucas Bridge and evaluates the effects of withdrawals from the several reaches of river. In conjunction with records from the continuous gaging station at Robinson Bridge, also with estimates of underflow in the river-channel deposits, the miscellaneous measurements have made it possible to demonstrate the extent to which the Lompoc subarea is dependent on the river for replenishment of its ground-water body. Figures 5, 6, 7, and 8 show

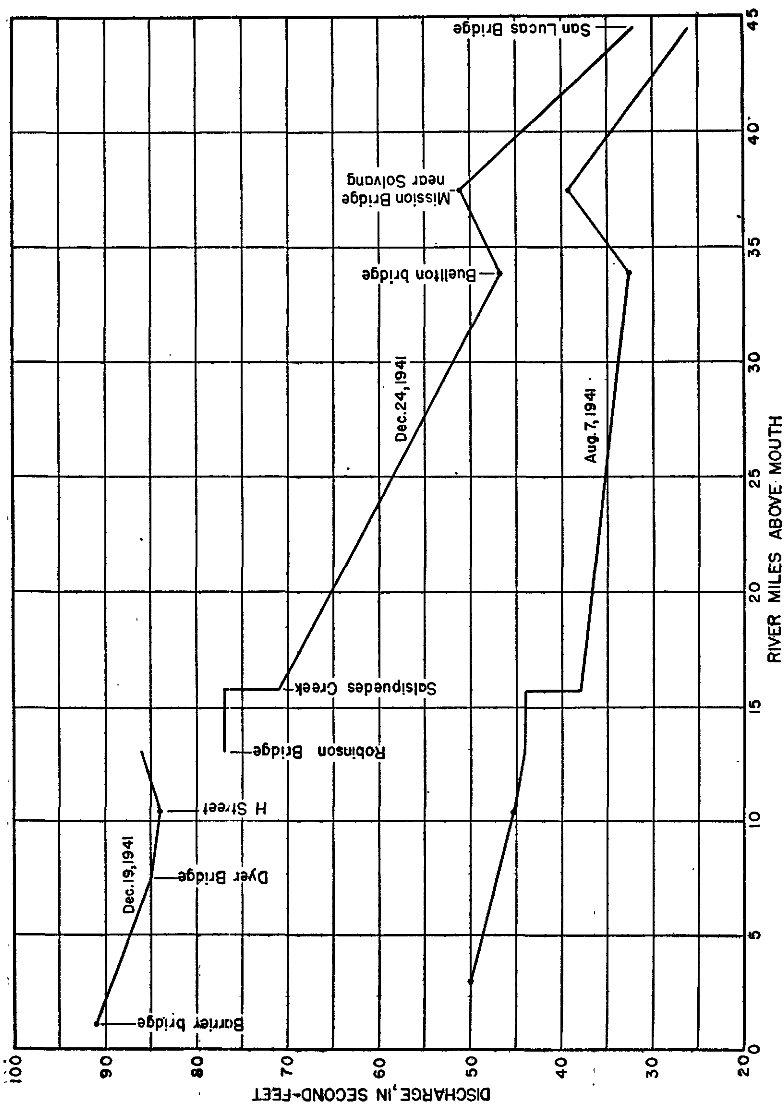

FIGURE 6.—Losses and gains along the Santa Ynez River below San Lucas Bridge, as defined by representative gagings made about simultaneously, 1931–44.

graphs of 13 representative series of these simultaneous discharge measurements made in different seasons of both wet and dry years. Gains and losses within the several reaches of the river are readily apparent from the graphs.

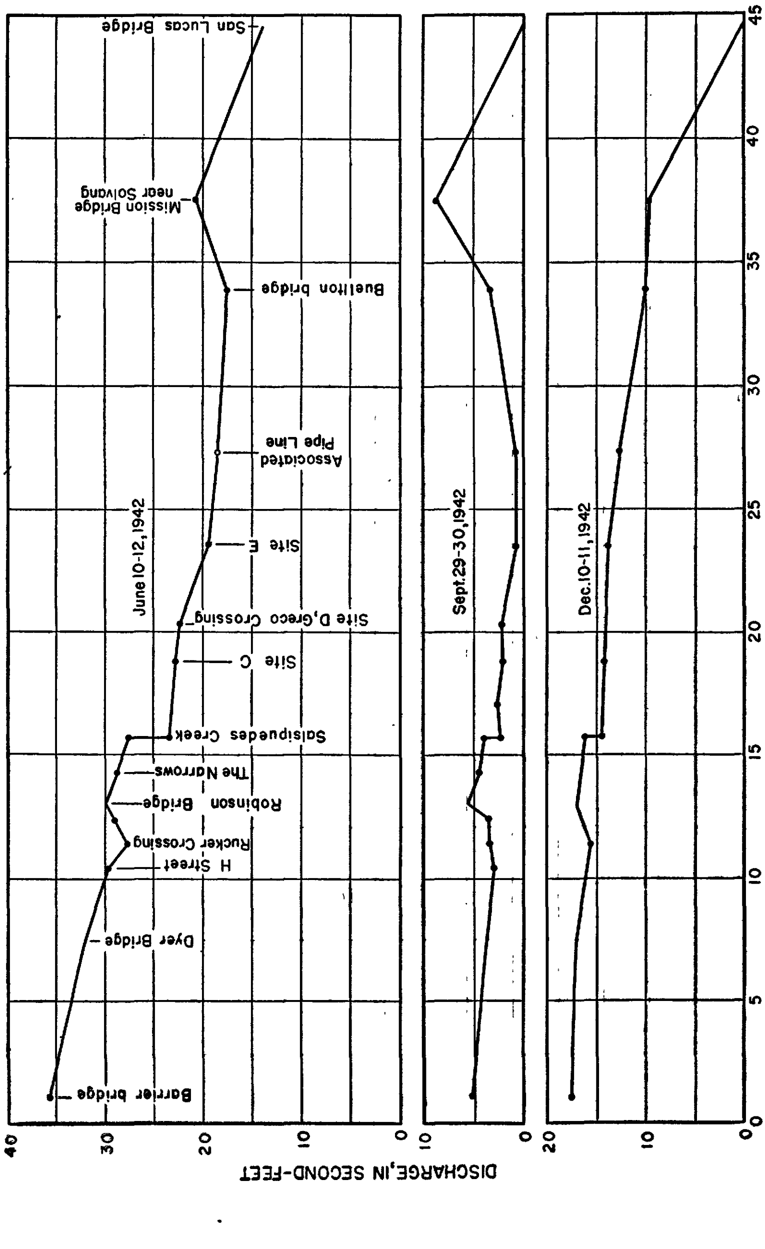

FIGURE 7.—Losses and gains along the Santa Ynez River below San Lucas Bridge, as defined by representative gagings made about simultaneously, 1931–44.

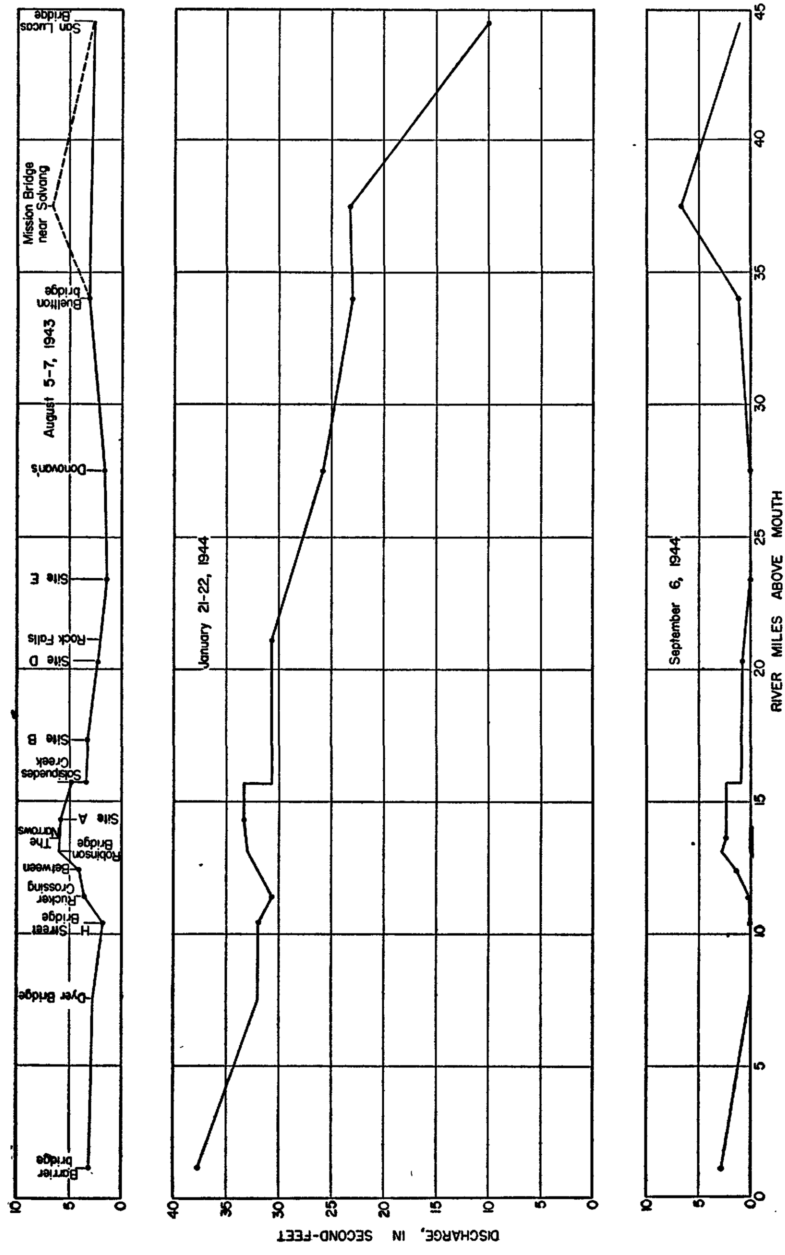

FIGURE 8.—Losses and gains along the Santa Ynez River below San Lucas Bridge, as defined by representative gagings made about simultaneously, 1931–44.

HEADWATER SUBAREA

Based on 14 years of record at Jameson Lake (Juncal Dam), the water yield of the 18 square miles above the dam is greater than that of any other part of the basin. The average yearly runoff of 6,080 acre-feet represents 338 acre-feet per square mile of drainage area, or 6.33 inches depth on that area. The median yearly runoff from the area—2,560 acre-feet—represents 142 acre-feet per square mile, or 2.66 inches depth, which also is greater than that from any other part of the basin. This is due in part to heavier rainfall than that received by almost any other part of the basin. The 14-year average depletion that is due to operation of the reservoir has been 1,740 acre-feet per year. As here used, depletion differs from diversion in that it also includes net loss from the reservoirs in the form of excess evaporation over rainfall.

Total drainage area above Gibraltar Dam is 219 square miles, so that the drainage area intervening below Juncal Dam is 201 square miles. The 16-year average undepleted runoff from this intervening area is 38,000 acre-feet a year, 189 acre-feet per square mile, or 3.54 inches depth. It is indicated that the intervening runoff is less than that from areas next upstream and next downstream, possibly owing in part to less precipitation at lower altitudes north of the river. On that score, however, the available information as to rainfall distribution is insufficient to be conclusive.

The 16-year average depletion that is due to the operation of Gibraltar Reservoir has been about 4,000 acre-feet a year, and the depletion that is due to the operation of Gibraltar and Jameson Reservoirs together has been about 5,500 acre-feet a year.

Between Gibraltar Dam and San Lucas Bridge the intervening drainage area is 216 square miles, or only 3 square miles less than the area above the dam. For this intervening area the 16-year average runoff is 50,820 acre-feet a year, 236 acre-feet per square mile, or 4.41 inches depth. Thus, it is 25 percent greater than for the roughly equal area above Gibraltar Dam. However, in years of average or less-than-average runoff the yield from the downstream area commonly is the less, whereas for wet years it has been as much as 155 percent of that from the upstream area.

A short and fragmentary record for Santa Cruz Creek indicates that unit runoff from that relatively extensive area is about equal to that from the entire area above San Lucas Bridge. The large body of unconsolidated material within its basin (p. 24) may account for the large runoff in 1942 following the excessive rainfall of 1941, this material having acted as a sponge to detain a part of the rainfall from 1941 into 1942.

Low-water runoff above San Lucas Bridge normally is quite small, and surface flow at the bridge drops to zero in the autumn of dry years. There is, however, a small underflow through the river-channel deposits, which is estimated as probably not more than 0.9 second-foot, or 640 acre-feet, per year (table 18). Thus, in years of average runoff this underflow is of little consequence, but in extremely dry years it may exceed the surface flow. For example, in 1930–31 only 1 acre-foot of surface flow was recorded all year.

SANTA YNEZ SUBAREA

The Santa Ynez subarea comprises the drainage area tributary to the 7-mile reach of the river from the San Lucas Bridge downstream to the Mission Bridge near Solvang. Throughout this reach the river flows in a narrow canyon cut in the consolidated rock and floored by a tongue of alluvial material. The surface drainage area contributing to the reach is 150 square miles of which about 30 square miles lies south of the river and is drained largely by San Lucas, Quiota, and Alisal Creeks. These short tributaries drain areas underlain by consolidated rocks; consequently their surface flow occurs very largely in the rainy season. Tributaries from the north include Santa Agueda, Zanja Cota, and Alamo Pintado Creeks. These streams drain the large body of unconsolidated deposits which underlies the Santa Ynez upland and the bordering foothills, immediately north of the consolidated-rock barrier along the river (pp. 100 to 102); each is perennial at that rock barrier.

Of the two terminal gaging stations on this reach of the river, that at the Mission Bridge near Solvang has the shorter record—continuously from January 1929 to September 1936 and thereafter during the irrigation seasons only (June through November) until September 1941. (See table 8.) For the eight full years of common record, the runoff per square mile of the Santa Ynez subarea was only about 80 percent of that from the next upstream, that is, from the area between San Lucas Bridge and Gibraltar Dam. However, in those particular 8 years the runoff from the upstream area was only 29 percent of the 16-year average and in only 1 year of the eight was the runoff greater than that average. Because the rainfall for any given period of time is characteristically heavier on the upper area and because runoff increases much more rapidly than a straight-line rainfall-runoff relation would imply, it seems probable that during the wetter years the unit runoff from the Santa Ynez subarea would be even less than the 80-percent ratio just derived for the 8 years of common record during a protracted dry period.

With respect to the low-water season, the yield of the Santa Ynez subarea probably is shown best by the 12-year record of November runoff, because in that month diversions probably are at a minimum and any early rains have not replenished the local deficiency in shallow ground-water storage. For the 12-year period the average increase in river flow between San Lucas Bridge and Solvang during November is 333 acre-feet, which is equivalent to a mean daily increase of 5.6 second-feet; the median is 334 acre-feet, or sensibly the same as the average. Miscellaneous measurements made on tributaries since 1928 indicate that more than 95 percent of the low-water inflow to the river is from the north, of which three-fourths is from Zanja Cota Creek and the remaining one-fourth is derived about equally from Santa Agueda Creek and from Alamo Pintado Creek.

Because the Santa Agueda Creek drainage area, 56.4 square miles, comprises almost half the area north of the river and includes the southwestern flank of the San Rafael Mountains, it might be expected to contribute more than this percentage would imply. However, continuous gaging station records since January 12, 1941, at the rock barrier about one-half mile above the mouth, show that low-water surface flow at that site ranges about from 50 to 75 acre-feet per month and that it was as little as 6.5 acre-feet in August 1942. Water-level contours (pl. 6) indicate that the stream bed is above the water table throughout much of its length and that some ground water probably moves from this area west to the Santa Ynez upland.

The increase in low-water flow of the river within the Santa Ynez subarea is due primarily to inflow from the tributaries and not to effluent ground-water seepage into the channel or to decreased underflow. In fact, underflow at the Mission Bridge near Solvang is estimated as probably not more than 1.2 second-feet, or about 880 acre-feet a year (table 18); that is, underflow may increase about 250 acre-feet a year within the subarea.

Miscellaneous measurements on tributaries and on the river at Solvang since 1941 show that the low-water runoff characteristics of the Santa Ynez subarea during that period have been the same as during the preceeding 12 years of gaging-station records. Thus, evidently the withdrawal of water from irrigation wells on the Santa Ynez upland and elsewhere in the subarea as yet has not appreciably altered the natural low-water regimen of the streams, a regimen in which the gain in main-stem river flow is derived almost wholly by ground-water discharge into the tributary streams that flow perennially from that upland. Under continuing withdrawals, some ultimate diminution may occur in the low-water gain of the river within the subarea.

BUELLTON SUBAREA

For the purposes of this treatment of water-supply characteristics, the next reach of river is taken from the Mission Bridge near Solvang downstream about 10 river miles to the Associated Pipe Line crossing; that is, it spans and extends downstream about 2 miles beyond the Buellton subarea as defined on page 25 and as shown on plate 1. The lower end of the Buellton subarea is fixed geologically at the point where the river channel leaves the unconsolidated deposits of the Santa Rita syncline and reenters the consolidated rock. The 2-mile overreach is convenient because a great many miscellaneous discharge measurements have been made at or near the pipe-line crossing beginning in 1929. For the present purpose the overreach is of no consequence because it involves virtually no change in surface flow. The only tributary streams of appreciable size within the subarea are Nojoqui Creek, which enters the river from the south at the Buellton bridge, and La Zaca Creek, which enters from the north about half a mile below this bridge.

In addition to the stream-flow data at either end of the main-stem reach, a considerable number of miscellaneous measurements have been made on the river at the Buellton bridge and on Nojoqui Creek. Also, since January 1941 a gaging station has been operated on La Zaca Creek where it is crossed by State Highway No. 150 in the town of Buellton.

Between Solvang and Buellton the characteristics of the river basin are quite different from those of the reach immediately upstream. Thus, although the south-bank drainage area with the one tributary, Nojoqui Creek, is similar in characteristics to the south-bank drainage area upstream, ground-water overflow from the north is blocked off between Solvang and Buellton.

The basin characteristics of this reach may be generalized from the discharge records at Solvang and the miscellaneous measurements at Buellton and on Nojoqui Creek. During the low-water pumping season each year the river flow has diminished from Solvang to Buellton, and the amount of this diminution has increased progressively as the season advances. (See fig. 5.) With cessation of pumping each autumn this drop in flow becomes less, and during years of average wetness a slight gain in flow begins prior to the winter rains. This characteristic indicates that there is some ground-water discharge from the alluvial deposits constituting the valley fill, but at a rate smaller than the peak demand for irrigation and native vegetation. Because in years of ordinary wetness the surface flow begins to increase within the reach prior to the winter rains, it follows that in those years the withdrawals have not drawn ground-water storage in the valley fill much below the level of the river. During one or two of the dry years, however, there was no increase in river flow prior to the winter rains, and in those dry years the ground-water storage was materially reduced.

Miscellaneous measurements on the river at Buellton and at the pipe-line crossing, made from 1929 to 1933 and since 1942, disclose water-supply characteristics somwehat like those of the reach from Solvang to Buellton, previously described. Specifically, within the reach below Buellton the river loses during the late part of the pumping season, beginning ordinarily in July or August, whereas in the reach just upstream the river begins to lose almost immediately after pumping starts in April. Even at the height of the pumping season the loss in the downstream reach seldom has exceeded 1 second-foot, whereas in the reach upstream the corresponding loss has been commonly from 3 to 8 second-feet. Measurements below Buellton during the late autumn, after pumping is largely completed, show that the river then gains from 3 to 5 second-feet; also, that in the 4 dry years ending with 1931, this gain was fairly constant at about 4 second-feet. Therefore, for late autumn months a value of 4 second-feet as the average inflow by effluent seepage into this reach of river is considered conservative. Of course, effluent seepage and other inflow to the river intermittently are much greater than this amount during the rainy season.

For the Buellton subarea as a whole, therefore, the average discharge of ground water to the river during late autumn months has been approximately 5 second-feet, or 300 acre-feet per month. Although continuous records of flow in the river are not available from which to compute the yearly quantities of ground-water escape and surface runoff within this subarea, nevertheless, the river gain during the late autumn months can be utilized to suggest certain minimum quantities. Thus, because throughout about half of the year, ground-water levels generally have been as high as or higher than those of late autumn (see fig. 11), and because irrigation draft and consumptive use by native vegetation during the winter and early spring are relatively low, it appears reasonable to say that the average discharge of ground water by effluent seepage into the river has been at least 2,000 acre-feet per year. Increased rates of escape during winter and spring months of highest water levels might increase this figure substantially. The autumn rate of escape to the river, as one element of the total discharge from the ground-water body in the valley fill, is utilized on pages 113–114 in estimating the minimum rate of replenishment to that ground-water body.

Also, for the Buellton subarea as a whole, during the height of the pumping season the draft by pumping and consumption by native vegetation has caused the river to lose as much as 8 second-feet.

Assuming an average rate of loss from the river of 2 to 3 second-feet for 6 months, it appears that during the period of analysis the ground-water body of the subarea has received about 700 to 1,000 acre-feet per year which originates upstream and is conveyed to the subarea by the river.

SANTA RITA SUBAREA

In the Santa Rita subarea ,which is here treated as extending from the Associated Pipe Line crossing downstream to Robinson Bridge, the river flows on its channel deposits within a narrow canyon cut in consolidated rock. Santa Rosa and Santa Rita Creeks enter the reach from the north and Salsipuedes Creek enters from the south.

The creeks from the north drain an area which is underlain largely by unconsolidated deposits (pls. 2 and 3) and on which the rainfall is relatively light. Santa Rosa Creek discharges a little surface runoff to the river but chiefly as storm runoff immediately after heavy rainfall. Underground drainage from this creek basin can reach the Santa Ynez River only through a small tongue of alluvial deposits, which crosses an intervening mass of consolidated rocks and the underflow capacity of which is estimated to be not more than about 0.05 second-foot. Also, the creek flows perennially about 0.25 second-foot as it leaves the consolidated rock; it is believed that 0.3 second-foot, or 220 acre-feet a year, represents the average base ground-water flow from the Santa Rosa basin to the river.

Santa Rita Creek has very little surface runoff, as is shown by the extremely small channel it has eroded near its mouth. This creek also passes through a narrow notch in the consolidated rock mass north of the river; there it definitely does not flow perennially and probably has negligible underflow. Ground-water drainage from the main part of the Santa Rita Creek basin moves toward the west (see pl. 7) and does not reach the Santa Ynez River within the subarea. Thus, the Santa Rita drainage basin doubtless contributes very little water to the river within the reach here treated.

On the other hand, Salsipuedes Creek drains an area of 46.6 square miles which lies south of the river and on which the precipitation is relatively heavy. (The average yearly rainfall measured at Rancho San Julian within the creek basin is about 24 inches, or about 50 percent greater than that at Lompoc.) A gaging station has been operated on this creek at the Jalama Road bridge, 3½ miles above the mouth. It was installed in January 1941, near the beginning of the extremely wet period of that year; through September 1941 a runoff of 50,100 acre-feet was recorded. For the following 3 water-years ending September 30 the runoff was 10,650 acre-feet in 1941–42, 10,710 acre-feet in 1942–43, and 8,870 acre-feet in 1943–44; also in those 3 years the low-water flow averaged about 1.5 second-feet, or

100 acre-feet a month. Miscellaneous measurements at the mouth of the creek indicate a consistent loss of 0.5 to 0.75 second-foot below the gage during the low-water season, owing largely to percolation into the alluvial deposits of the Santa Ynez River valley. Accordingly, to obtain the true yield of water from the Salsipuedes drainage area, about 0.5 second-feet should be added to any discharge measured near the mouth of the creek.

In addition to observed inflow from the three tributaries just discussed, the river usually gains slightly in surface flow within the subarea. Seemingly this gain is not due primarily to a variation in underflow capacity of the alluvial deposits; rather a considerable number of miscellaneous discharge measurements show that the gain begins about at the Santa Rosa dam site and increases steadily downstream regardless of any changes in estimated cross-sectional area of the alluvial deposits. Thus, because underflow at any point within the reach probably does not exceed about 1.5 second-feet (see table 18), it is concluded that the increase in channel flow is due largely to seepage through the valley fill from drainage areas which are immediately adjacent to the river but which are not within the principal three tributary areas previously described.

So far as is indicated by the miscellaneous discharge measurements alone, the water supply available along this particular reach of the Santa Ynez River in years of average wetness seems to be greater than the current requirement. Pumpage from wells near the upper end of the reach undoubtedly is supplied in part from the river and in that sense is sustained in part by water that originates upstream beyond the subarea; however, this pumpage is more than balanced by low-water inflow below the Santa Rosa dam site. During dry years the river does not flow continuously through the subarea; under those conditions the draft from wells doubtless is taken in part from local ground-water storage. Nevertheless, the irrigation development along the river within the Santa Rita subarea has not yet exceeded the average yearly supply available locally, beyond the amount consumed by native vegetation.

LOMPOC SUBAREA

The Lompoc subarea begins at The Narrows, about one-half mile above Robinson Bridge, extends to the Pacific Ocean, and has by far the largest demand for agricultural water among the several subareas of the Santa Ynez basin. As will be developed in some detail, the river enters the area from The Narrows, loses some water to the valley in the vicinity of Robinson Bridge, holds steady flow or gains slightly in the reach about between the H Street Bridge and Dyer Bridge, intermittently loses some water between 1 mile and 3 miles below

Dyer Bridge, and normally gains in flow near the lower end of the valley before spilling into the ocean.

From the 790 square miles of drainage area above the gaging station at Robinson Bridge and for the 16-year period ending September 30, 1944, the average measured runoff into the Lompoc subarea has been 124,100 acre-feet, or 157 acre-feet per square mile; the median yearly measured runoff has been 48,820 acre-feet, or 62 acre-feet per square mile. The natural or undepleted inflow has averaged 134,000 acre-feet a year, or 170 acre-feet per square mile; the corresponding median has been only 58,940 acre-feet a year, or 75 acre-feet per square mile. Within this period the measured yearly flow has varied between 2,390 acre-feet in 1930–31 and 652,300 acre-feet in 1940–41.

Because the agriculture of the Lompoc subarea depends almost entirely on irrigation, the relation of the Santa Ynez River to the valley water supply is critical. There is very little direct diversion from the river channel within the subarea, so that probably 98 percent of the irrigation water is pumped from wells. Of the recharge to the ground-water bodies tapped by these wells, a part is derived from the river; the amount so derived can be estimated from numerous miscellaneous discharge measurements made nearly simultaneously at six river stations (see fig. 5) and from the continuous records of discharge at the two gaging stations within the subarea. The estimate is developed in following paragraphs.

The principal river reach that loses water to the zone of saturation in the Lompoc Valley begins at The Narrows and extends downstream about 2.2 miles to Rucker crossing (pl. 3). At least intermittently the river has lost water as far downstream as H Street, a mile beyond Rucker crossing. However, the amount of loss in that downstream reach is relatively insignificant. Between The Narrows and Rucker crossing the loss from the river channel in recent years has averaged about 2 to 4 second-feet—a year-round average loss of 3 second-feet (2,170 acre-feet a year) appears reasonable because when the river flow at Robinson Bridge has been less than this amount the entire flow ordinarily has been absorbed above Rucker crossing; also because during the spring and early summer, when the river has flowed more than 3 second-feet at Robinson Bridge, its discharge ordinarily has diminished from 2 to 4 second-feet within the reach to Rucker crossing or to H Street.

Losses considerably greater than 3 second-feet have occurred during the early part of the runoff season, following periods when the river channel has been dry for some time and the adjacent alluvial deposits have been unwatered somewhat extensively by ground-water drainage down the valley. Then as soon as surface flow in the river resumes, the rather highly permeable river-bed materials (see table 16) absorb water rapidly so that the zone directly beneath is resaturated very quickly. Thereafter, as resaturation extends beyond the channel, the loss from the river diminishes progressively until the normal rate of about 3 second-feet is reached again. The duration of such cycles of excessive loss seems to have been primarily a function of the length of the antecedent period during which the river channel had been dry between The Narrows and Rucker crossing. Had the river not been dry, there would have been no unwatering by ground-water drainage and no resaturation.

During floods the loss from the river is greater, but, because the river stage rises only a few feet and because the floods are of short duration, the amount of additional loss seems to have been relatively small. Inherent inaccuracies due to poor measuring conditions preclude an evaluation of the flood loss solely from the stream-flow data. However, in another section of this report (pp. 127–129) evidence as to flood-flow contributions to the ground-water bodies of the Lompoc Valley is derived from data on water wells.

In addition to this contribution by seepage loss from the river in the reach from The Narrows to Rucker crossing (or H St.), the ground-water bodies of the Lompoc subarea also are sustained by the underflow through The Narrows. This underflow has been estimated in table 19 as probably not more than about 0.8 second-foot, or 600 acre-feet a year. Thus, it is believed that the water which originates in the Santa Ynez River above The Narrows and which is transmitted to the ground-water bodies of the Lompoc Valley above H Street in recent years has included only the seepage loss from the river channel in an amount of about 2,200 acre-feet a year and the underflow through The Narrows in an amount probably not much more than 600 acre-feet a year, the total not greatly exceeding 2,800 acre-feet a year.

From H Street downstream to Pine Canyon (Dyer Bridge) the river in recent years has gained in surface flow almost perennially. Ordinarily the gain in this reach has not exceeded 1 second-foot. It may be due in part to local ground-water inflow, to decrease in cross-sectional area of the river-channel deposits and so in underflow capacity (at Dyer Bridge the tongue of these deposits is only about 500 feet wide), or to the small quantity of sewage effluent from the city of Lompoc which is discharged to this reach of the river. The amount of gain is less critical than the fact that the gain has been substantially perennial; in other words, the critical fact is that in the upper part of the Lompoc Valley the downstream reach of seepage loss recharge from the river to the ground-water bodies has not been beyond H Street.

Unpublished notes and maps by the city of Santa Barbara show intermittent loss from the river in the reach about from 1 mile to

3 miles downstream from the Dyer Bridge. Discharge measurements to prove the magnitude of such loss are not available, but from the notes it appears to be only a fraction of a second-foot and to occur largely when nearby irrigation wells are pumped. Correlations of water levels in wells 7/35–23E2 and 7/35–24K1 with riverbed elevations (from a contour map by the city in 1931), and with discharge measurements at Dyer Bridge and at Renwick crossing, show that during the winter and spring the water levels in the wells are higher and that the river then cannot lose water to the deposits tapped by the wells. During the irrigation season the pumping levels in the wells have been several feet below the river, but with cessation of draft the ground-water level has recovered about to river level. Under these conditions a relatively small amount of water probably has been drawn intermittently into the ground-water body from the adjacent reach of the river. However, to withdraw any substantial amount of water from the river here it would be necessary permanently to lower the ground-water level in the vicinity. To date the river probably has been in approximate over-all balance in this reach, in that during the winter it has gained about as much water as it has lost during the summer.

Measurements during the 16-year period beginning in 1928 show that the river has gained almost perennially across the western or lower part of the Lompoc Valley. This gain may have been derived in part by shallow ground-water drainage from the adjacent hilly and terraced terrain, in part from excessive irrigation on the valley plain, and, since late 1942, in part from the effluent of the Camp Cooke sewage-disposal plant. This effluent has been released in a slough on the north side of the valley and is reported to have sunk before reaching the river. However, before Camp Cooke was established runoff characteristics of the lower half of the valley were about the same as they have been subsequently.

On figure 9 the net increase or decrease in river flow across the western part of the Lompoc Valley is plotted against flow in the channel at Robinson Bridge during the 15 years ending with 1944. The increase here plotted is the difference between the measured flow at the Barrier bridge or elsewhere near Surf and the least flow measured simultaneously in all the reach from the terminal station near Surf to the gaging station at Robinson Bridge, wherever that minimum flow was determined. Very commonly this point of minimum flow was at Rucker crossing or at H Street. (See figs. 5, 6.) This gain in the western part of the valley represents excess water that originated in the Lompoc area below Robinson Bridge and that has overflowed into the ocean.

On figure 9 the plotted points scatter somewhat, but they demonstrate that the increase in river flow within the western part of the Lompoc subarea has been rudely proportional to the flow at Robinson Bridge—that is, the greater the flow at Robinson Bridge, the greater the increase downstream. This relation implies that the gain has been due largely to natural ground-water drainage rather than to excessive irrigation. During periods of high sustained flow at Robinson Bridge the wet conditions causing such flow usually have been

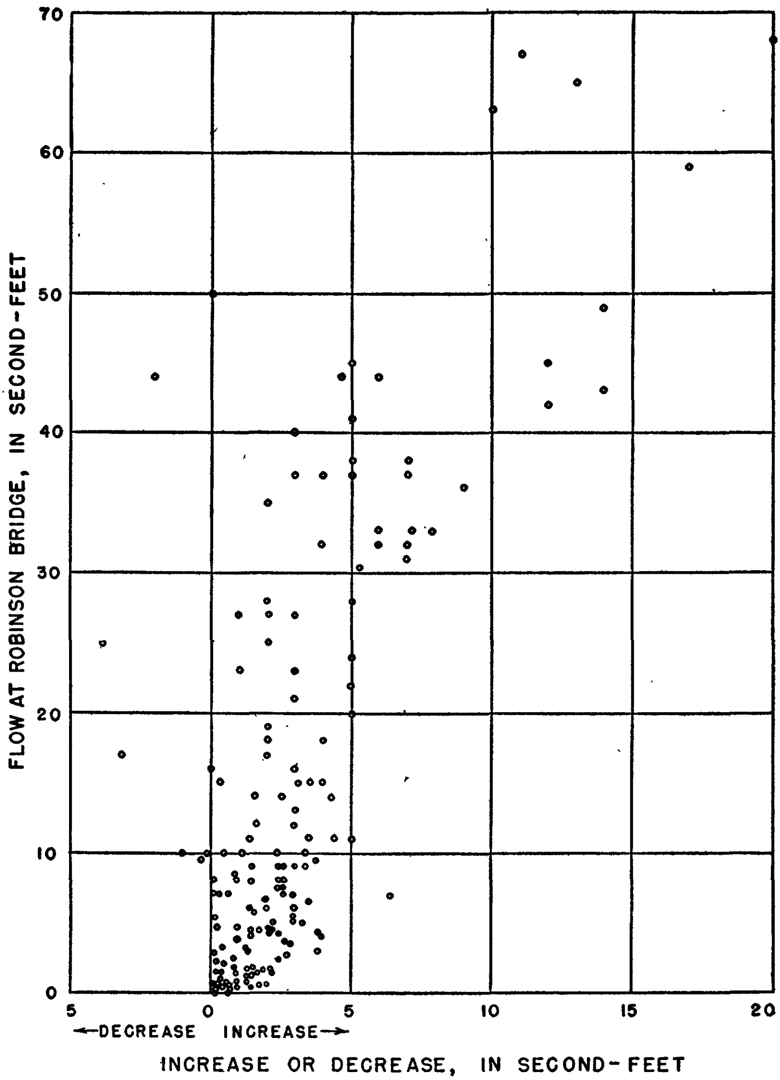

FIGURE 9.—Measured increase or decrease of flow in the Santa Ynez River across the western part of the Lompoc plain, 1930–44.

basin-wide; such conditions would have produced relatively high run-off and ground-water drainage downstream from Robinson Bridge. Conversely, for periods of low flow at Robinson Bridge, all the basin has been dry and the smaller gain in river flow would have followed naturally.

By way of summary, under the present state of agricultural development the Santa Ynez River probably supplies about 2,800 to 3,300 acre-feet of water a year to the Lompoc Valley as follows: seepage loss from the river channel from near The Narrows to H Street, 2,200 acre-feet; underflow through The Narrows, probably not more than 600 acre-feet; pumpage directly from the river, estimated not to exceed 200 acre-feet; additional seepage loss from the river during floods and net loss in the reach from 1 to 3 miles below Dyer Bridge, probably not more than 300 acre-feet. Each of these items necessarily is only an approximation, but it is believed that they represent average yearly values rather closely. With more intensive agricultural development the supply might be increased by additional diversion directly from the river channel or by drawing down the water table, especially in the eastern part of the valley, sufficiently that the hydraulic gradient from the river to the adjacent ground-water bodies is steepened at least during and immediately after the irrigation season. Additional diversions directly from the river of course could be made readily, but the hydraulic gradient could be steepened materially only by drawing the water table down a few tens of feet. The increase practically attainable by drawing down the water table probably would not exceed 2,000 or 3,000 acre-feet a year at most, and that increase could not be realized through a succession of dry years unless a flow were maintained in the river to or beyond H Street. It is concluded that only a relatively small part of the water supply of the Lompoc Valley is derived currently from the Santa Ynez River basin above The Narrows and that the greater part originates within its own area.

GROUND-WATER CONDITIONS AND RESOURCES

By J. E. Upson

In the Santa Ynez River basin, as in most areas, ground water occurs in three ways, all related to surface drainage to a greater or lesser degree. Some water, at least during the rainy season and for varying lengths of time thereafter, is retained in the mantle of soil and plant debris. A large part of this water is absorbed by plants, but much of it drains to streams and is an integral part of surface runoff. Some water is present in fractures and joints in consolidated rocks near the land surface. This water also is an integral part of the surface runoff. The total quantity of ground water occurring in each of these ways is relatively small. Relatively large bodies contained in the deep and extensive masses of unconsolidated deposits supply the bulk of the water pumped from wells. In some areas, depending on local geologic and hydrologic conditions, they discharge to the surface streams; in others they receive infiltrate from the streams. These large bodies are replenished in large part by infiltration of rain or by percolation from other bodies and to that extent are independent of at least the major stream courses.

The ensuing discussion of ground water deals primarily with these large bodies. Both the relation of the main bodies to the Santa Ynez River and the perennial yield of those bodies differ according to the subareas previously defined. Therefore, the ensuing discussion is by those subareas.

GROUND WATER IN THE HEADWATER SUBAREA

The Headwater subarea, or upper Santa Ynez River basin above San Lucas Bridge, is underlain mainly by consolidated and essentially non-water-bearing rocks. However, a tongue of unconsolidated deposits composed of the Careaga sand and the Paso Robles formation extends eastward into the area north of the river; and thin elongate bodies of alluvium and of channel deposits lie along the Santa Ynez River and tributaries. There are few wells in the area, and of these only one or two draw appreciable quantities of water. Little data are at hand regarding the occurrence and movement of ground water. The tongue of the Careaga sand and Paso Robles formation contains considerable water under some artesian pressure but is essentially not tapped by wells. One well drilled on the Murphy ranch about 1 mile north of the river and 3 miles east of Santa Cruz Creek, in Horse Canyon, penetrated at least 400 feet of these deposits and flowed slightly in November 1941. The threads of alluvium in the stream beds doubtless contain unconfined water. In practically all the area the ground water probably discharges into the Santa Ynez River through the channels and alluvial fill of the tributary streams that enter the river on the north. However, some ground water east of Happy Canyon percolates toward Santa Agueda Creek. (See pl. 6.) Because little water is pumped from wells in this area, most of the ground water discharged is accounted for either as surface flow or as underflow of the Santa Ynez River at San Lucas bridge.

GROUND WATER IN THE SANTA YNEZ SUBAREA

In the Santa Ynez subarea the water-bearing formations underlie two main areas, which are separated from each other by a nearly continuous barrier of impermeable consolidated rocks. (See pl. 2.) The larger body of water-bearing deposits is north of the Santa Ynez River and underlies the Santa Ynez upland and adjoining foothill areas. It comprises the deformed Careaga sand and Paso Robles formation, a large body of terrace deposits beneath the Santa Ynez upland, and the threads of younger alluvium such as those along Alamo Pintado and Santa Agueda Creeks and their tributaries. The consolidated rock barrier that borders these deposits on the south is crossed only by Alamo Pintado, Zanja Cota, and Santa Agueda Creeks. In these stream courses tongues of younger alluvium cross the bedrock barrier. The smaller body of water-bearing deposits comprises the river-channel deposits and younger alluvium which lie along the Santa Ynez River and which are almost completely enclosed by the consolidated rocks.

WATER IN DEPOSITS BENEATH THE SANTA YNEZ UPLAND AND ADJOINING STREAM VALLEYS

GENERAL FEATURES OF OCCURRENCE

In the area north of the Santa Ynez River most wells derive water chiefly from the Paso Robles formation. The wells in the upland area derive some water from the overlying terrace deposits but enter the Paso Robles formation at depths ranging from 50 to 150 feet and take water mostly from gravel strata in that formation. (See table 26, well 7/30–32H1 and others.) A few wells in this area, as 6/31–1B2 6/31–13L1, and 6/31–13L2, enter beds of sand that are thought to belong to the Careaga sand. Wells in the valleys of Santa Agueda Creek and Alamo Pintado Creek pass through the younger alluvium and derive water largely from the Paso Robles formation, but a few wells, such as 6/31–11E1, 6/31–11E2, and 6/31–14C1, penetrate beds belonging to the Careaga sand. Thus, the water drawn upon occurs principally in the Paso Robles formation.

Information now at hand does not suffice to segregate distinct water bodies in this area, but there is some evidence that three different bodies not fully confluent with each other exist. First, several shallow wells on the high part of the terrace about 1 mile east of Ballard have somewhat higher water levels than deep wells in the same area. For example, as of April 9–10, 1945, the water level in well 7/31–36H2, which is 230 feet deep, stood at 647 feet above sea level, whereas the level in well 7/31–36H1, which is 46 feet deep, stood at 681 feet on the same date. In the 180-foot well 6/31–1B1 and 402-foot well 6/31–1B2 water levels were inaccessible to measurement in 1945 but on February 2, 1942, were approximately 689 and 648 feet above sea level, respectively. The deeper well of the two enters deposits assigned to the Careaga sand. A quarter of a mile to the north water flows from the casing of well 7/31-36Q2 at an altitude of at least 692 feet. Its static level, probably represented by the level in nearby well 7/31-36Q1, is about 703 feet above mean sea level. Each of these two wells is about 175 feet deep.

Thus, in this area head of water appears to decrease with depth. Whether changes in head correspond to formational boundaries is not known, but water in the Careaga sand may have a low head. Also, the highest head seems to be associated with the beds less than 200 feet below land surface. Thus, the shallow water is semiperched. Also, it is confined under positive head, as is indicated by the flow from well 7/31-36Q2. Other flowing wells include 7/31-26C1 and 7/31-26C2 near Los Olivos, 6/31-15A1 to 6/31-15A4 near the mouth of Alamo Pintado Creek at Solvang, and several others along that creek such as 7/31-35B1 and 7/31-35B2. At all these wells the flow is small, and the static level is probably only a few feet above the land surface.

It is believed that near wells 6/31-15A1 to 6/31-15A4 the artesian head results because ground water is trapped by the barrier of consolidated rocks across the mouth of the creek and by confining beds within the alluvium. Elsewhere, however, the flowing wells are believed to be caused by the easterly and northeasterly dip of the alternating permeable and impermeable beds in the lower part of the Paso Robles formation. (See pl. 2, cross section *B–B′*.) These beds slope from outcrop and catchment areas high on the Purisima Hills. Thus, water moving down the dip in strata of sand and gravel is confined by the impermeable beds of clay. When tapped, it rises in the well and, if the land surface is low enough, flows from the well casing. Similarly, the valley of Alamo Pintado Creek cuts the strata of the Paso Robles formation and may permit this confined water to escape into the alluvial fill. This condition may account in part for the seemingly perennial flow in the creek at and near Los Olivos and for the springs along the creek between Los Olivos and Ballard.

SOURCE AND MOVEMENT

Although confined in part, the ground water of the Santa Ynez subarea is here considered as a single water body. Plate 6 shows contours connecting points of equal altitude on the pressure surface of that body, based on depth-to-water measurements made April 9–10, 1945. In the area east of Ballard the static levels in wells that tap the deep water of low head are not considered in drawing the contours.

The water level is about 800 feet above sea level near Los Olivos and around the north edge of the Santa Ynez upland and thence slopes to an altitude of about 450 feet at the lower reaches of Zanja Cota Creek and Alamo Pintado Creek. Thus, because water moves, or potentially can move if there are no impermeable restraining beds, in directions at right angles to the contours, plate 6 shows that the water tends to move generally toward the south and southwest. The main source of water is the hilly area north and northeast of the upland, where the deformed strata of the Paso Robles formation crop out and form an extensive catchment area. In that area water probably is derived in part by direct infiltration of rain, and in part by seepage from the streams. In summer Santa Agueda Creek and Happy Canyon are dry along most of their courses, at least as far downstream as their junction, and Alamo Pintado Creek generally goes dry in the reach north of Los Olivos. Information is not now at hand concerning the altitude of the water surface west of Alamo Pintado Creek, but that area probably is a source of ground water also.

Although the ground water moves to the south and southwest toward the Santa Ynez River, its passage is obstructed by the impermeable rocks that rise to the land surface along the north side of the river course, and it converges toward the gaps trenched across this barrier by Santa Agueda Creek, Zanja Cota Creek, and Alamo Pintado Creek. These trenches extend below the water table and are filled with alluvium through which a small part of the water moves as underflow. However, their underflow capacity is small, so that nearly all the water is forced upward in springs along the lower reaches of the creeks. Other small unnamed creeks do not extend northward across the consolidated rocks and so do not tap the ground-water body. Hence, they do not flow except during and immediately after rains.

In addition to this discharge over the consolidated rock barrier into the Santa Ynez River, considerable water evidently seeps into the bed of Alamo Pintado Creek below Los Olivos. Several springs occur near Los Olivos, and the contours on plate 6 indicate potential movement of water toward the creek from the east in the reach between Los Olivos and Ballard.

NATURAL DISCHARGE

Natural discharge of ground water from the deposits north of the Santa Ynez River is chiefly by overflow through the three stream outlets just described. The contours of plate 6 show a preponderance of ground-water movement toward Zanja Cota Creek. As is discussed on p. 90, this discharge supplies more than 95 percent of the low-water inflow to the river in this reach. This inflow is at a rate of 5.6 second-feet, which amounts to about 4,000 acre-feet a year. Thus, the natural yearly discharge from the ground-water bodies of the Santa Ynez upland is about 4,000 acre-feet.

PUMPAGE

In addition to this natural discharge some water is pumped from wells, of which most are on the Santa Ynez upland, but some are in the valleys of the bordering creeks. This pumpage has been estimated on the basis of the electric energy expended on irrigation pumps, for which a summation of the yearly amounts has been supplied by the San Joaquin Power Division of the Pacific Gas & Electric Co., and the results of efficiency tests on pumps, also by that company, which indicate a mean energy input of about 450 kilowatt-hours to deliver 1 acre-foot of water to the land. Table 20 lists the estimates of yearly pumpage so derived for the 10 years ending with 1944.

TABLE 20.—*Water pumped from wells on and near the Santa Ynez upland*

Year	Acre-feet	Year	Acre-feet
1935	590	1940	420
1936	580	1941	430
1937	400	1942	690
1938	420	1943	830
1939	400	1944	1,380
		10-year average	614

Although the values for pumpage shown in the preceding table are only approximate, the trend in power consumption probably is a very good index of the relative amount of water pumped each year, and of the acreage irrigated. Thus, the pumpage seemingly decreased from 1936 to 1937, was nearly constant from 1937 through 1941, and then increased threefold by 1944.

EFFECT OF PUMPAGE ON WATER LEVELS

Water levels were measured periodically in several key wells on the Santa Ynez upland from the autumn of 1942 to the spring of 1945. Hydrographs of these wells and the charts from a continuous water-stage recorder on well 7/31–36L2 situated 1 mile northeast of Ballard show similar and comparable water-level fluctuations, which probably are fairly typical for the whole upland area. Figure 10 gives graphs of the fluctuations in the recorder well and shows that the water level usually is lowest during November, at the end of the irrigation season, and then rises to a maximum altitude in March or April. From December 1942 to April 1943 the rise was about 2 feet, and from December 1943 to March 1944 it was about 1.5 feet. During the autumn of 1942 the water level was about 1 foot lower than during the autumn of 1943 and of 1944. From late autumn in 1944 into April 1945 the water level rose only about 0.2 foot.

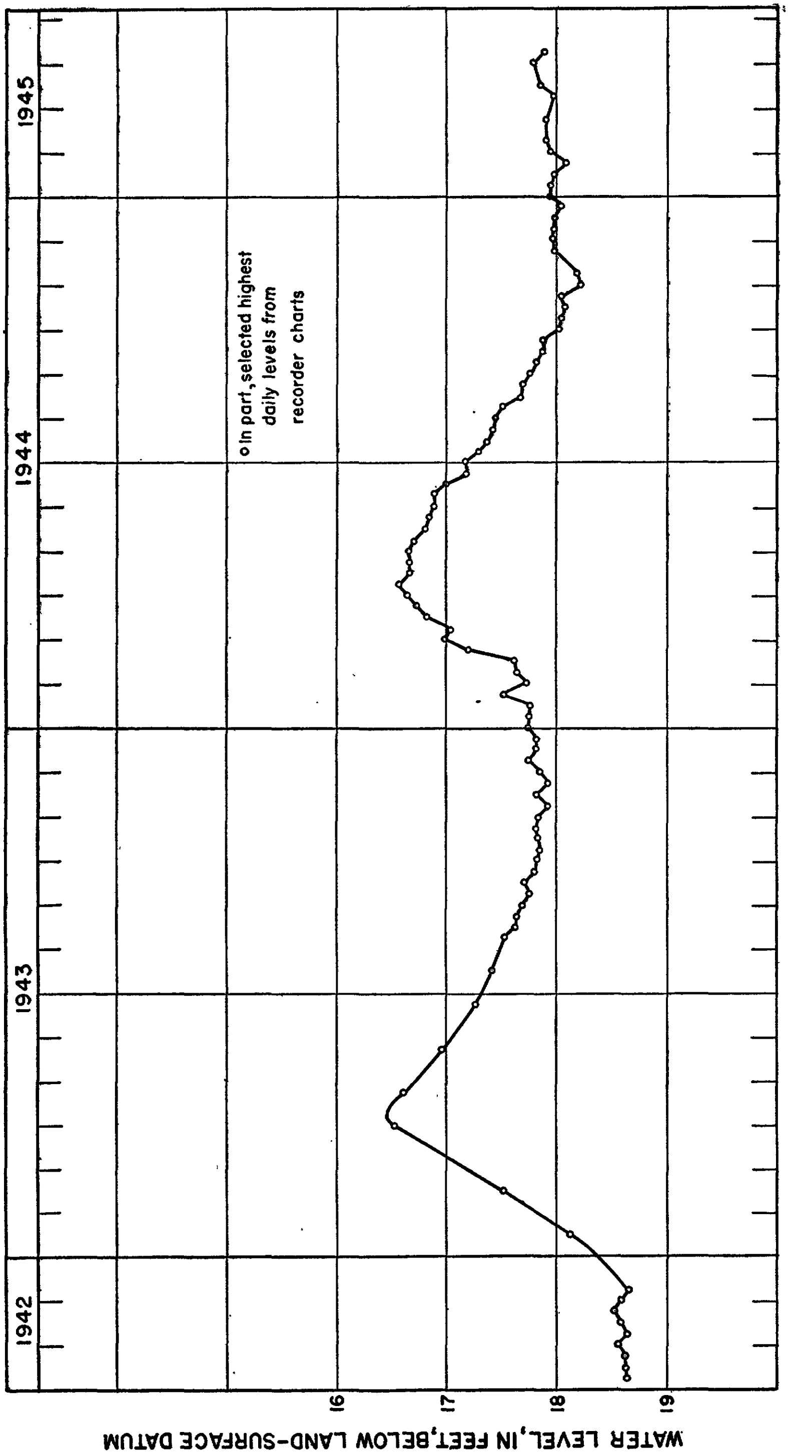

FIGURE 10.—Fluctuations of water level in well 7/31-36L2 on the Santa Ynez upland.

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The record of water levels in this area is not long enough to indicate the general long-time effect of pumpage on ground-water level. However, the pumpage during 1943 was a little more than in 1942, yet the water level was about 1 foot higher in December 1943 than in December 1942. Pumpage increased from about 800 acre-feet in 1943 to about 1,400 acre-feet in 1944, but the water level was about the same in December 1944 as it was in December 1943. The failure of the water level to rise during the spring of 1945 may be due to low recharge from rainfall on the area, to heavier pumpage for irrigation during these months, or both. In general, however, the pumpage seems not to have caused the water level to decline progressively.

Furthermore, pumpage seems not to have affected the flow of Alamo Pintado Creek. From Los Olivos southward nearly to State Highway No. 150 that creek flows for the most part at the level of, and probably controls the height of, the water table. Therefore, original water levels could not have been very much higher than the bed of the creek. As the water still drains into the creek, the pumpage from wells evidently has not lowered the water table very much below its original level. Accordingly, the pumpage probably is within the safe yield of the water-bearing deposits.

EFFECT OF PUMPAGE ON NATURAL DRAINAGE

Pumpage from wells on the Santa Ynez upland evidently has not lowered the ground-water level appreciably along the Santa Agueda, Zanja Cota, and Alamo Pintado Creeks. Accordingly, the low-water runoff of recent years, which represents ground-water drainage from the area, probably is about the same as for many previous years. Some of the water pumped in this area probably has been taken from storage by a small lowering of the water table over a large area remote from the creeks, as is suggested by the flattening of the water-level surface beneath the central part of the upland (pl. 6). This suggested small lowering of the water table several miles from Alamo Pintado Creek and Zanja Cota Creek would have diminished the ground-water drainage into those creeks only very slightly and very gradually, if at all. It is believed therefore, that the aggregate low-water flow of the three creeks, about 4,000 acre-feet a year, represents closely the sustained average recharge to the water-bearing beds in the area and hence also the probable perennial yield.

As has been shown by table 20, the pumpage from 1935 through 1944 has averaged only about 15 percent of this probable yield, but in 1944 it was nearly 35 percent.

Thus, withdrawals at the rate of 1,380 acre-feet a year, as in 1944, are substantially less than the perennial yield and can probably be sustained indefinitely. Larger withdrawals eventually would cause some decline of the water levels as more water was taken from storage. With respect to the yield within the upland area itself, more recharge would take place if the water levels were drawn down permanently below the bed of Alamo Pintado Creek so that the natural drainage into the creek would cease, and so that water would seep from the creek to the water-table during the rainy seasons. However, if 4,000 acre-feet of water should be withdrawn and consumed annually by irrigated crops within the area, after a number of years the ground-water level would be lowered considerably; also, the yield of the springs on the lower reaches of Santa Agueda, Zanja Cota, and Alamo Pintado Creeks would diminish and eventually might cease. Thus, a large increase in the withdrawal from wells on the Santa Ynez upland without any importation of additional water eventually would cause a corresponding decrease in the natural discharge to the Santa Ynez River by the three spring-fed creeks. As discussed on page 90, this natural discharge is the principal source of inflow to the Santa Ynez River within the Santa Ynez subarea and largely sustains the low-water flow of the river below San Lucas Bridge.

WATER IN DEPOSITS ALONG THE SANTA YNEZ RIVER

Along the Santa Ynez River within the subarea here treated, water occurs in the river-channel deposits and in contiguous thin bodies of younger alluvium. Probably most of this water is in the channel deposits, where it is unconfined and confluent with water in the river. In the few wells that tap the deposits the water level fluctuates with the stage of the river and has no relation to the water levels of the Santa Ynez upland.

The beds are replenished by seepage from the river and in part by seepage of water from the creeks that drain the Santa Ynez upland. Comparatively few wells tap them, but from those wells rather large quantities of water are withdrawn for irrigation.

With respect to pumpage from wells along the river, data were supplied by the Pacific Gas & Electric Co. on the efficiencies of certain pumps and on the aggregate expenditure of electric energy on electrically driven pumps in all the reach from San Lucas Bridge to Robinson Bridge. Thus, to derive values for pumpage in the Santa Ynez subarea alone, it was necessary to estimate pumpage by electrically driven plants in all the reach, for which a mean energy coefficient of 135 kilowatt hours to the acre-foot of water was derived, and to prorate that over-all estimate among the several subareas in proportion to the respective numbers of pumps driven by electric motors and to the numbers of additional pumps driven by gasoline or Diesel engines. The factual basis for the proration is given in the next paragraph.

The relative quantity of water pumped in the three subareas involved was roughly proportional to the number of currently active irrigation wells in each. The agricultural development of the valley reached its peak in the 1920's, and the total number of active wells in each subarea probably has been about the same for each year of the period covered by power records, from 1935 through 1944. No attempt was made to evaluate changes in pump efficiency. Among 61 wells recently active, 7 are in the Santa Ynez subarea, 34 are in the Buellton subarea, and 20 are in the Santa Rita subarea. Of these, none in the Santa Ynez subarea are driven by gasoline or Diesel engines. However, the Buellton subarea contains five pumps and the Santa Rita subarea contains three pumps so driven.

Table 21 gives the yearly pumpage so computed for the Santa Ynez subarea, for the 10 years ending with 1944.

TABLE 21.—*Water pumped along the river in the Santa Ynez subarea, largely from wells in the alluvial deposits*

Year	Acre-feet	Year	Acre-feet
1935	420	1941	520
1936	540	1942	670
1937	530	1943	660
1938	500	1944	1,000
1939	600		
1940	730	10-year average	620

Seemingly the pumpage has averaged about 620 acre-feet a year, but in 1944 it was considerably more than in any previous year of record. The yearly pumpage has been almost as great as from the Santa Ynez upland to the north (table 20) and has ranged about from 10 to 25 percent of the 4,000-acre-foot yearly inflow to this reach of the river from that upland. Even if this inflow ultimately should cease, owing to greater withdrawals on the Santa Ynez upland, the current pumpage along the river could be taken from storage in ordinary years and under the present stage of river development that storage would probably be replenished by seepage from the river during the ensuing winter except in very dry years. Should the river flow become regulated completely above San Lucas Bridge through the operation of additional reservoirs, adequate releases of water of course would be required to sustain the existing developments here considered.

GROUND WATER IN THE BUELLTON SUBAREA

In the Buellton subarea of the Santa Ynez River basin (pl. 1 and p. 25) the chief water-bearing formations are the river-channel deposits and the younger alluvium. The Paso Robles formation and

Careaga sand underlie the area north of the river but are largely untapped by wells. They contribute some water, however, to the younger deposits. The subsurface characteristics of these deposits are shown by logs of representative wells given in table 27.

The river-channel deposits lie along the river course and are nearly everywhere flanked by bodies of the younger alluvium. They overlie the Paso Robles formation at certain places, but on the southwest and south they rest on the consolidated rocks. They supply water to a number of wells drilled in and along the river channel.

The younger alluvium underlies irregularly shaped areas on each side of the river-channel deposits, where it forms alluvial terraces 10 to 20 feet above river level. It supplies water to most of the wells in the area. The Paso Robles formation is penetrated by some of the wells drilled on the alluvial plain, but the Careaga sand is known to be tapped by only one well. Thus, little is known as to the capacity of these older formations to yield and transmit water. As indicated on page 36, however, the Paso Robles formation in this area is predominantly clayey and probably yields and transmits water very slowly.

The river-channel deposits and younger alluvium support the bulk of the pumpage from wells and contain the main water body of the area. That body occurs not only in the channel deposits along the river, in the bodies of alluvium that form the bordering plains, but also in the alluvium of the adjoining tributary valleys, especially that of La Zaca Creek. It is doubtless confluent, or in hydraulic continuity, locally with water in the older formations and is confluent with water in the river. There are no known barriers to the movement of water throughout the body, which is therefore considered to be unconfined.

SOURCE AND MOVEMENT

Plate 6 shows contours on the water table in the Buellton subarea based on depth-to-water measurements made April 9–10, 1945. Altitudes of measuring points were determined by barometer traverses. Near the river the water table slopes downstream, but to the north it seemingly slopes southward and southwestward toward the river and from the Purisima Hills. At the west edge of the subarea the water table slopes southeastward from the divide between the Santa Ynez River and Santa Rosa Creek drainages. Thus, the map shows that water moves generally southward from a source area in and near the Purisima Hills. Presumably that water is derived largely from infiltration of rain on the outcrop of the Paso Robles formation and Careaga sand and on the alluvium itself, and from seepage from small creeks that cross the outcrop of those formations and debouch onto the alluvial plain. As the Paso Robles formation is relatively impermeable near the alluvial plain the quantity of water transmitted probably is small. However, in winter considerable water probably seeps into the alluvium from La Zaca Creek, as that creek seldom flows at the gage immediately east of Buellton even though it usually has some flow off the consolidated rocks to the north. On the south, some water doubtless reaches the alluvium by seepage from Nojoqui Creek which enters the Santa Ynez River opposite Buellton; and also by percolation from fractures and from the soil mantle of the consolidated rocks composing the adjacent foothills.

In addition to these sources, the Santa Ynez River also supplies some water. During the irrigation seasons when the ground-water levels are depressed by pumping, hydraulic gradients are locally established from the river to the alluvial deposits along and near it; and water seeps from the river into those deposits. (See p. 92.) After pumping ceases in autumn, seepage from the river continues until the ground-water levels have been restored. Thereupon the normal gradients toward the river are reestablished, and in most years ground water seeps into the river throughout the winter or until the next pumping season begins.

FLUCTUATIONS OF WATER LEVELS

Measurements of water level have been made periodically in a number of wells in the Buellton subarea, mainly at monthly intervals. However, in well 6/32–12J2 at Buellton, an automatic water-level recorder was operated from September 25, 1942, to April 21, 1943, and measurements were made weekly thereafter until November 25, 1943. Figure 11 shows fluctuations of water level in four wells along the river, from 1931 through 1944. Its graphs show the usual decline of water level in summer, owing largely to withdrawals for irrigation, but concurrent with and to some extent probably caused by low flow in the river. Two of the wells graphed, 6/31–17F1 and 6/32–9A1, are near the river. In them the yearly fluctuations of water level have been only a few feet; also the low levels of the successive years were constant through 1936, rose somewhat in 1937, remained relatively steady through 1940, and then rose somewhat further in 1941 owing to the excessive rainfall of that year. All these features suggest that the river stage effectively controls the ground-water level.

The remaining two wells of figure 11, 6/32–12J7 and 6/32–12J2, are situated in Buellton somewhat less than half a mile from the river, on the fan of La Zaca Creek. In these wells the water levels have fluctuated more widely, especially in the years of much rainfall, in 1938 and 1941. Together, the graphs for these two wells show that the autumn water level was relatively steady in the middle thirties, rose about 4 feet in 1937, and then rose about 6 feet more from 1941 through 1944. Conversely, the high levels of spring or early summer

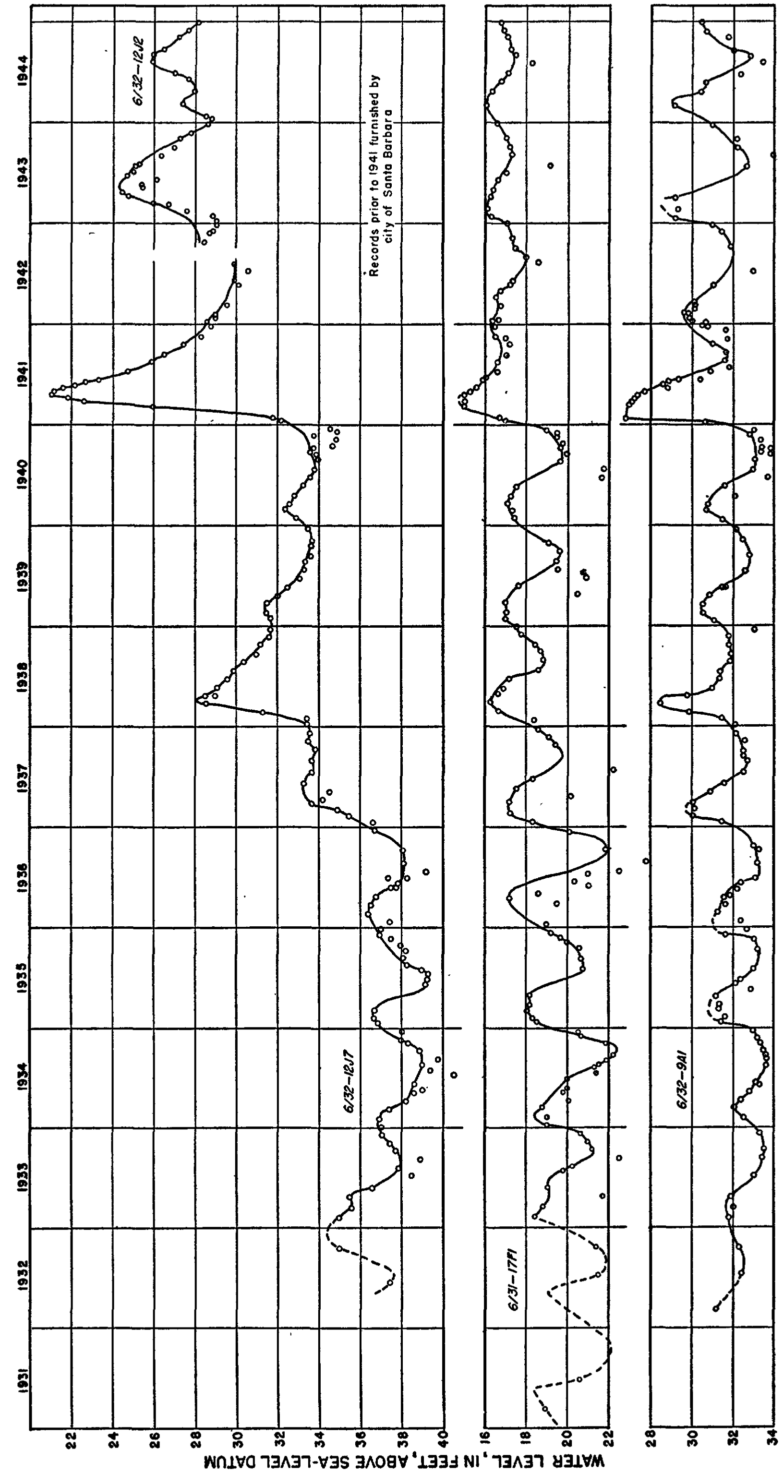

FIGURE 11.—Fluctuations of water level in four wells in the Buellton subarea, 1931–44.

declined about 5 feet from 1941 to 1944, owing to dissipation of the uncommonly large increase in ground-water storage in 1941 induced by the excessive rainfall of that year, to deficient rainfall in 1942, and possibly to slight relative overdraft. Therefore, the water levels in these wells probably are affected more strongly by local recharge than by seepage from the river.

The year-end levels of 1944 were as high as, or slightly higher than, those of 1932 in these wells on the terrace near Buellton. Accordingly, for the vicinity of those wells, withdrawals at the current rate probably are not excessive over the long term.

PUMPAGE

Table 22 gives the amount of water pumped along the river in the Buellton subarea, computed as described on pages 104 and 108. Essentially all this water is pumped from wells, and largely from wells so close to the river that the draft causes a simultaneous decline in river flow. However, a small quantity may be taken from pumps set to draw directly from the river.

TABLE 22.—*Water pumped along the river in the Buellton subarea, largely from wells in the alluvial deposits*

Year	Quantity (acre-feet)	Corresponding rate of flow for 6 months (second-feet)	Year	Quantity (acre-feet)	Corresponding rate of flow for 6 months (second-feet)
1935	2, 100	5. 8	1941	2, 600	7. 2
1936	2, 700	7. 5	1942	3, 300	9. 1
1937	2, 600	7. 2	1943	3, 200	8. 8
1938	2, 500	6. 9	1944	5, 100	14. 1
1939	3, 000	8. 3			
1940	3, 600	9. 9	10-year average	3, 000	8. 3

Table 22 shows that the pumpage increased almost steadily from 1935 to 1940, then fell off somewhat through 1943, but increased to a maximum in 1944. Figures for 1945 are not available, but the pumpage of that year probably was even greater than in 1944. The general increase may result in part from an increase of irrigated acreage, although most such lands had been developed before 1935. Generally, however, the pumpage seems to fluctuate inversely as the yearly rainfall. The correspondence is not perfect, but years of low pumpage, such as 1938 and 1941, were years of relatively high rainfall, and, conversely, years of high pumpage, such as 1940, were years of small rainfall.

From 1942 through 1944, for which miscellaneous stream-flow measurements (p. 56) can be compared with pumpage, that pumpage has ranged from about 3,200 to 5,000 acre-feet a year. The irrigated area has been about 2,500 acres; hence, roughly from 1.3 to 2 acre-feet has been applied to each irrigated acre. Doubtless, most of the water has been consumed by the crops, but as much as 20 percent (p. 125) may percolate back to the ground-water body, so that the net withdrawal probably has been roughly between 2,500 and 4,000 acre-feet a year. As stated on page 92 and shown on figures 5, 6, 7 and 8 across the Buellton subarea the river has lost as much as 8 second-feet at the height of the irrigation season and probably has averaged from 2 to 3 second-feet throughout the season, that is, from 700 to 1,000 acre-feet in 6 months. Thus, it would appear that about 25 percent of the pumpage has been supplied by the river immediately. The remainder has been taken temporarily from ground-water storage but during the ensuing winter has been replenished by infiltration of rainfall and by seepage from La Zaca Creek and other small creeks and perhaps in small part by seepage from the river.

YIELD

To estimate the yield of the alluvium and river-channel deposits, which contain the main ground-water body of the Buellton subarea (p. 108), use is made of two principles: that for any ground-water reservoir total discharge plus the amount of storage increase or minus the amount of storage decrease equals total recharge; and the perennial yield of a ground-water reservoir equals the average recharge, or inflow, provided all the discharge can be salvaged.

The average annual discharge for this ground-water reservoir comprises: effluent seepage to the river, net pumpage, and evaporation and transpiration by native vegetation. Effluent seepage to the river is estimated to be at least 2,000 acre-feet per year (p. 92). The gross pumpage from 1935–44 has averaged 3,000 acre-feet per year; if 20 percent returns to the ground-water body the net pumpage has been about 2,400 acre-feet per year on the average. The evaporation from the river surface and from bare ground plus the transpiration by native vegetation on the river-channel deposits, based on unit loss of 2.5 acre-feet per acre (p. 134), is estimated roughly to be about 3,200 acre-feet per year. Thus, the total estimated discharge has been at least 7,600 acre-feet per year for this period.

If there were no change in storage within the deposits, this average discharge would equal the average recharge. However, the graphs of figure 11 show that from the peak of water-level recovery in 1935 to the peak of 1944, there was a noticeable net rise of water level, thus demonstrating an increase in storage. On the basis of reasonable assumptions, it appears that the increase in storage would amount to only a few hundred acre-feet each year on the average. Nevertheless, the probable inflow, or recharge, is greater than the discharge by that amount. Furthermore, as brought out on page 113, the estimated discharge of 2,000 acre-feet per year by effluent seepage to the river is considered a minimum. Accordingly, an estimated average total recharge of 7,600 acre-feet per year for the period 1935–44 is considered conservative.

If the perennial average recharge is 7,600 acre-feet per year, theoetically that amount could be pumped for use and that amount would constitute the perennial yield. About 2,400 acre-feet net are being pumped currently, and the remaining 5,200 would have to be salvaged from natural ground-water discharge into the river and from evapotranspiration losses. Actually, it probably would not be practicable to salvage all these losses. Hence under current conditions the perennial yield would be between 2,400 acre-feet per year (the current yearly average net pumpage) and 7,600 acre-feet per year (the estimated total recharge).

Of the total recharge to ground water under current conditions it has been estimated that the river supplies from 700 to 1,000 acre-feet per year. (See p. 93.) Thus, the recharge from local sources independent of the river has been about 6,600 to 6,900 acre-feet per year. This recharge probably cannot be greatly increased. However, the contribution from the river could doubtless be increased substantially by increasing net withdrawals so as to deplete ground-water storage in the deposits near the river more than has been done currently, and by regulating river flow so as to obtain the optimum over-all rate of infiltration to the alluvium. The amount by which the river contribution could be increased in this way is not subject to accurate estimate with the data at hand.

GROUND WATER IN THE SANTA RITA SUBAREA

The Santa Rita subarea, like the Santa Ynez subarea, has two parts with respect to the occurrence of ground water. North of the Santa Rita Hills, ground water occurs in the deformed Careaga sand, Paso Robles formation, Orcutt sand, and to some extent in the tongues of younger alluvium that lie in the valleys. The water here is essentially separated from water in the river by the impermeable consolidated rocks that form the core of the Santa Rita Hills (see pls. 2 and 3), but it has a small discharge into the river through the main gap in the hills occupied by Santa Rosa Creek. South of the Santa Rita Hills, ground water occurs in the river-channel deposits and flanking bodies of younger alluvium along and adjacent to the Santa Ynez River. The subsurface characteristics of the deposits are shown by the logs of typical wells given in table 28.

OCCURRENCE, SOURCE, AND MOVEMENT OF WATER IN THE AREA NORTH OF THE SANTA RITA HILLS

In the area north of the Santa Rita Hills are two separate water bodies whose extent is not fully known, a shallow perched body and a deep body. In and near the Santa Rita Valley (pl. 3) water in shallow wells, such as 7/33-26E1, 7/33-26J1, 7/33-36L1, 7/33-27J1, stands 15 to 60 feet below the land surface, or about 100 feet higher than water in wells 200 to 250 feet deep, such as 7/33-25E1 and others farther west. The difference in altitudes indicates that this shallow water is perched. It appears to be contained in the Orcutt sand and to be prevented from seeping downward by clayey beds in the lower part of that formation or in the upper part of the underlying Paso Robles formation. It is unconfined and is evidently derived entirely from infiltration of rain. Its movement is not defined, but water probably moves generally southward toward the gaps cut in the consolidated rocks of the Santa Rita Hills by Santa Rita and Santa Rosa Creeks. Probably it seeps downward to the deep water body at places where the Orcutt sand is missing. In the Santa Rita Valley, perhaps the entire discharge of the shallow body is into the deep body.

Along Santa Rosa Creek, below an altitude of about 600 feet, unconfined water stands near creek level, which apparently controls the height of the water table. Near the lower end of Santa Rosa Creek, where the stream approaches the consolidated rock barrier along the river, the water table is higher than the creek on both sides, resulting in springs along the creek. The total flow of these springs is estimated to be 100 gallons a minute, which seems to be unusually low for an area as large as the drainage area of Santa Rosa Creek. Because the water table is very near the surface the flow of the springs probably represents drainage from a perched or semiperched water body.

Most wells in the Santa Rita Valley tap a deep water body. For example, wells 7/33-21H1 (table 28), 7/33-28D1, and 7/33-28E1 pass through the alluvial fill and derive water in the Paso Robles formation. Static levels are 200 to 400 feet below the land surface and are thought to represent a deep water body contained in the Paso Robles and Careaga formations. The water does not rise when encountered in drilling and hence is considered to be unconfined. Replenishment of this water body is partly by seepage downward from the perched body where restraining beds are missing, but mainly by seepage of rain through the Paso Robles formation and Careaga sand from outcrop areas of those formations. (See pl. 3.)

Data on the movement of water in this body are scanty and not very reliable. Few wells tap the body, and most are equipped with windmills, which ordinarily pump constantly though intermittently. Accordingly, measurements may not have shown true static levels of the water. Nevertheless, plate 7 gives contours showing the altitude of the deep water surface based on measurements made in the spring and summer of 1945. They are believed to be accurate in general; and show that the water surface slopes westward throughout most of the area. The divide between ground water moving northwestward and ground water moving southward toward the river is not defined but is probably close to the consolidated rock. Hence essentially none of the ground-water body in the Santa Rita Valley discharges southward to the Santa Ynez River. At the same time, the southward slope of the water table in the alluvial tongue at wells 6/33–5C1 and 6/33–5E1 near the river indicates that river water cannot and does not discharge northward to the Santa Rita Valley.

In the area north of State Highway No. 150, and also about well 7/33–28D1, the water table slopes and water tends to move westward and northwestward more or less along the axis of the structural trough toward the Lompoc Valley. However, the westerly component of the gradient is very gentle and cannot induce very rapid movement.

The quantity of water pumped in this area has not been estimated but is doubtless very small as there are only a few wells; and they are equipped chiefly with windmills and are operated almost exclusively for domestic and stock use.

OCCURRENCE, SOURCE, AND MOVEMENT OF WATER IN THE AREA ALONG THE SANTA YNEZ RIVER

Along the Santa Ynez River ground water occurs in the younger alluvium and river-channel deposits which lie along the river and which are completely enclosed laterally by the impermeable consolidated rocks. (See pl. 3.) Occupying mostly the lower member of coarse gravel of the younger alluvium, it is confluent, or in hydraulic continuity, through the channel deposits, with the Santa Ynez River, and its static level is in large part determined by river level. At most places it is unconfined, although where the static level lies above the base of the comparatively fine grained upper member of the younger alluvium it is doubtless confined locally.

In the large embayment at the Rennie ranch along the south side of the river in secs. 14 and 15, T. 6 N., R. 33 W., the lower member of the younger alluvium is missing or very thin, and the water evidently occurs mainly in the upper member. Static water levels apparently do not fluctuate readily in response to fluctuations of river level, and water is reported to stand above the surface of the alluvial deposits in parts of the embayment after rains. Accordingly, it is inferred that the water-bearing materials here are too fine grained throughout to receive infiltrate rapidly from the river and that they derive the water they contain chiefly by slow infiltration of rain and seepage from small drains in the hills to the south.

The ground water in the alluvial deposits south of the Santa Rita Hills is confluent with the water of the Santa Ynez River and in a sense is river underflow. However, although the river is a constantly available source of supply, the chief source of water under current conditions seems to be miscellaneous inflow from the sides (p. 94), which is not measured. The inflow from Santa Rita Creek is negligible, but the inflow from Santa Rosa Creek is an appreciable amount. Surface flow of this creek during the summer is about 0.25 second-foot (p. 93). Underflow in the alluvial tongue that crosses the consolidated rocks is estimated to be at most 0.05 second-foot, making a total of about 0.3 second-foot. Thus, this low-water inflow, exclusive of runoff during and immediately after rains, is about 220 acre-feet a year, or 110 acre-feet in 6 months.

PUMPAGE OF GROUND WATER

Table 23 gives the quantity of water in acre-feet pumped along the river course in the Santa Rita subarea in the years 1935–44, computed as described in previous paragraphs (pp. 104 and 108), and the corresponding rate of flow for 6 months in second-feet.

TABLE 23.—*Water pumped along the river in the Santa Rita subarea, largely from wells in the alluvial deposits*

Year	Quantity (acre-feet)	Corresponding rate of flow for 6 months (second-feet)	Year	Quantity (acre-feet)	Corresponding rate of flow for 6 months (second-feet)
1935	1, 200	3. 3	1941	1, 500	4. 1
1936	1, 600	4. 4	1942	1, 900	5. 2
1937	1, 600	4. 4	1943	1, 900	5. 2
1938	1, 400	3. 9	1944	3, 000	8. 3
1939	1, 700	4. 7			
1940	2, 100	5. 8	10-year average	1, 800	4. 9

Like the pumpage in other parts of the Santa Ynez River basin, the pumpage in the Santa Rita subarea increased from 1935 to 1940, declined appreciably during the rainy year 1941, and rose to a maximum in 1944. The maximum amount was about 3,000 acre-feet or the equivalent of approximately 8.3 second-feet flowing for 6 months. The average was 1,800 acre-feet, or 4.9 second-feet for 6 months. This water is withdrawn from the lower member of gravel in the younger alluvium. The proportion that returns to the ground-water body is not known but may be about 20 percent. If so, the net pumpage has averaged about 1,400 acre-feet per irrigation season. Transpiration by water-loving plants and evaporation in the 2,200 acres of river-bottom land cause an additional draft, computed by using a factor for consumptive use of 2.5 acre-feet per acre, of about 5,500 acre-feet.

The total draft is taken immediately in large part from storage and in small part from the river itself during the summer. Pumpage from wells near the river locally unwaters deposits to the extent that at times of very low flow the river temporarily disappears. During dry years with heavy pumping, an appreciable volume of the water-bearing deposits may be locally unwatered during the pumping season. With cessation of pumping such unwatered areas near the river are promptly refilled by seepage from the river as long as the river flows. Away from the river the depleted storage may be replenished by seepage from the bordering soil-mantled hillsides and small creeks, and by infiltration of rain.

YIELD

As in the Buellton subarea, the yield of the ground-water body in the Santa Rita subarea may be approximated from the estimated discharge. The discharge comprises effluent seepage to the river, net pumpage, and evaporation and transpiration by native vegetation.

The average yearly net pumpage for the period 1935–44 is estimated as about 1,400 acre-feet; and the average yearly discharge by evaporation and transpiration is estimated to be about 5,500 acre-feet. (See page 117) Discharge measurements have not been sufficiently numerous to use as a basis for estimating perennial ground-water discharge to the river. However, figures 5, 6, 7 and 8 show that in summer during the years 1941 to 1944 the river has gained in the reach between Donovan's and a point immediately upstream from Salsipuedes Creek at a rate of from 1 to 3.5 second-feet. The largest gain was during the summer of 1941 after the excessively wet winter of that year. If the average rate is about 2 second-feet, the total for 6 months, about the length of the summer season, would be about 725 acre-feet. This gain in flow was exclusive of Salsipuedes Creek whose low-water contribution has been approximately 2 to 3 second-feet more. Also, this gain was much greater than the estimated contribution from Santa Rosa Creek, about 110 acre-feet per summer season, and cannot thus be accounted for. Unfortunately, this gain was observed during the years immediately following the excessively wet winter of 1941; and may be due in appreciable part to depletion of excessive ground-water storage built up during that year.

Figures 5, 6, 7, and 8, and other miscellaneous discharge measurements not illustrated also show that in the same reach during the summers of 1929 to 1932, following the years 1927–31 of deficient rainfall, the river lost at rates of from less than 1 to as much as 2 second-feet. Accordingly, the over-all average low-water discharge to the river might be on the order of 0.5 to 1 second-foot. This rate of discharge would be increased somewhat in most winters owing to somewhat higher water levels, and hence a rate of 1 second-foot can probably be taken conservatively as a minimum value for perennial ground-water discharge to the river. This amounts to only about 725 acre-feet a year. Thus, the estimated total average annual discharge for the period 1935–44 has been: estimated net pumpage of 1,400 acre-feet, estimated evapotranspiration loss of 5,500 acre-feet, and estimated seepage to the river of at least 725 acre-feet, making a conservatively rounded total of about 7,500 acre-feet.

Records of water-level fluctuations within the Santa Rita subarea show that there was essentially no change in storage from the peak level of 1935 to the peak level of 1944. Hence for that period the average total discharge from the ground-water body about equalled the estimated average total recharge, or about 7,500 acre-feet a year.

If all the discharge could be salvaged, the recharge would be the average perennial yield. However, it would probably not be practicable to salvage all the natural discharge. Therefore the average practicable yield for the period 1935–44 was somewhat more than the net pumpage of 1,400 acre-feet a year, but less than the total discharge of 7,500 acre-feet a year. Furthermore, the long-term rainfall and hence runoff would be appreciably less than those during the period 1935–44 which included 2 years of excessive rainfall; one of them the wettest of record. Accordingly, the long-term perennial yield should be decreased proportionately.

These considerations are based on current conditions of unregulated river flow and pumpage that has not unwatered appreciable volumes of the water-bearing deposits. The perennial yield might be increased appreciably, especially under regulated river flow, by increasing pumpage so that large volumes of the water-bearing material were unwatered in summer and during dry years, and allowed to fill up by seepage from the river in winter during years of ordinary or excessive wetness. The extent to which the alluvium along the river could thus be utilized as a storage reservoir depends upon several factors, including the storage capacity of the deposits, the possible rate of seepage loss from the river, and the amount and duration of river flow entering the reach at the end of each period of pumping draft. Ordinarily, winter flow is many times greater than the quantities of water currently pumped (table 8), but data on this and the other factors involved are not now adequate to yield a satisfactory quantitative solution to this problem.

GROUND WATER IN THE LOMPOC SUBAREA

SUMMARY OF PERTINENT GEOLOGIC FEATURES

The Lompoc subarea, westermost reach of the Santa Ynez River basin, comprises the river reach between The Narrows near Robinson Bridge and the ocean, and the tributary valleys—Cebada Canyon and Purisima Canyon on the north and of San Miguelito, San Pascual, Rodeo, and Lompoc Canyons on the south. As shown on the geologic map (pl. 3), the Lompoc plain, the adjacent terraced and hilly upland to the north, and the trough between the Purisima Hills and the Santa Rita Hills are underlain by unconsolidated deposits that contain and transmit ground water with varying facility. The Santa Rita Hills, the foothills of the Santa Ynez Mountains, the highest parts of the Purisima Hills, the Burton Mesa and the Lompoc Terrace are underlain by and largely composed of the consolidated, non-water-bearing rocks.

The water-bearing formations are the river-channel deposits, younger alluvium, Orcutt sand, Paso Robles formation, and the Careaga sand. Terrace deposits are locally quite permeable but are mainly above the zone of ground-water saturation. Only a few are sufficiently extensive to yield appreciable supplies of water, and only the terrace deposits beneath the Lompoc plain (pl. 5) are tapped by known used wells. However, they transmit water locally to underlying formations and, where they rest on impermeable materials, constitute reservoirs for wet-weather springs at their bases. The river-channel deposits and the younger alluvium underlie the Lompoc plain and its extension eastward along the Santa Ynez River course. The younger alluvium also extends as tongues up the canyons of smaller tributary streams, where it includes minor channel deposits not included in the river-channel deposits. The Orcutt sand, Paso Robles formation, and Careaga sand underlie the terraced and hilly upland north of the Lompoc plain and also underlie the younger alluvium beneath the Lompoc plain. Thus, beneath the Lompoc plain ground-water in the older deposits is locally continuous with ground water in the younger alluvium.

SHALLOW WATER BODY

Ground water in the Lompoc subarea is divided into two main bodies—a shallow body and a deep body. The shallow body comprises the water contained in permeable beds in the upper member of the younger alluvium and the river-channel deposits. It is essentially limited to the area of the Lompoc plain, although tongues extend up the tributary canyons. It is confluent through the river-channel deposits with the river. It is also confluent with the water of the side streams that enter the valley on the south.

The shallow water body is continuous with the deep water body in the vicinity of Robinson Bridge, off the mouths of the side canyons along the southern part of the Lompoc plain from Lompoc Canyon eastward, and in the small area along the river in secs. 23 and 24, T. 7 N., R. 35 W. (See pl. 3.) Elsewhere it may be continuous locally, but by such devious routes around and between overlapping lenses of relatively impermeable material that actual interchange of water is greatly retarded. The shallow body is considered a separate body because it is generally unconfined, because it fluctuates to a lesser degree than the deep water, and because, where comparison can be made between adjacent shallow and deep wells, its static level is from 1 foot to 10 feet higher than the head of the deep water. Thus, it is semiperched above the deep water. The several permeable deposits in which the shallow body occurs are collectively termed the "shallow water-bearing zone."

At most places the shallow body is unconfined although locally it is confined under slight pressure by lenses of impermeable material. The water levels in wells that tap the body therefore represent the water table. In most of the Lompoc plain this water table is from 10 to 40 feet below the land surface. In the river-channel deposits the water table is adjusted to river stage and ordinarily ranges from the land surface to about 5 feet below the land surface. When the river is in flood, however, water of course stands several feet or even tens of feet above the land surface.

MOVEMENT AND SOURCE OF THE SHALLOW WATER

Comparatively few wells tap the shallow water body alone, so data on the shape of the water table are lacking within most of the plain. However, its shape is rather accurately determined in the eastern part of the plain, as is also its relation to the river, by measurements in bored observation wells and at posts set along the river. In 1943 the Geological Survey bored a number of shallow observation wells in the Lompoc plain and in the channel deposits on each side of the river in a reach extending from about half a mile above Robinson Bridge to about half a mile below Rucker crossing. In addition to actual wells, which were bored by hand auger and cased with 2-inch iron pipe or 6-inch concrete title, a few short lengths of pipe were set as posts at the river edge for measurement of river stage. Altitudes of measuring points at the wells and river posts were determined with respect to sea-level datum of 1929 by spirit level. Water levels in most of the wells and at the river posts were measured weekly from October 1943 to November 1944 and monthly thereafter. Measurements were more frequent in some of the wells during a short period in February 1944.

Figures 12 and 13 show by contours the configuration of the water table in this area as of May 3, 1944, near the spring high level, and September 27, 1944, late in the ensuing irrigation season, respectively. At the river posts the contours represent the river surface. Levels

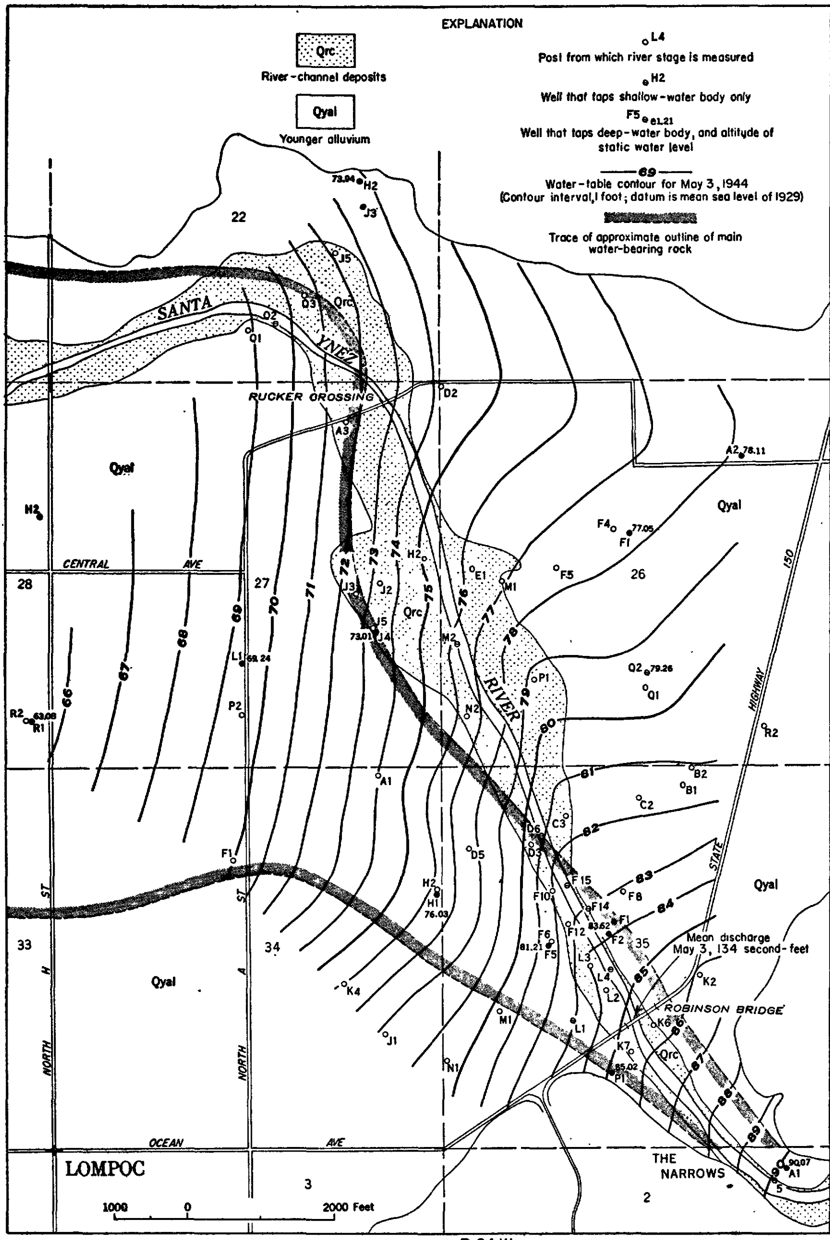

FIGURE 12.—Map of the eastern part of the Lompoc plain showing water-table contours for May 3, 1944.

in the deep wells, such as 7/34–34H2, 7/34–35F5, and 7/34–35L1, in which the water level was generally about 1 foot lower than in adjacent shallow wells, are indicated but were not taken into account

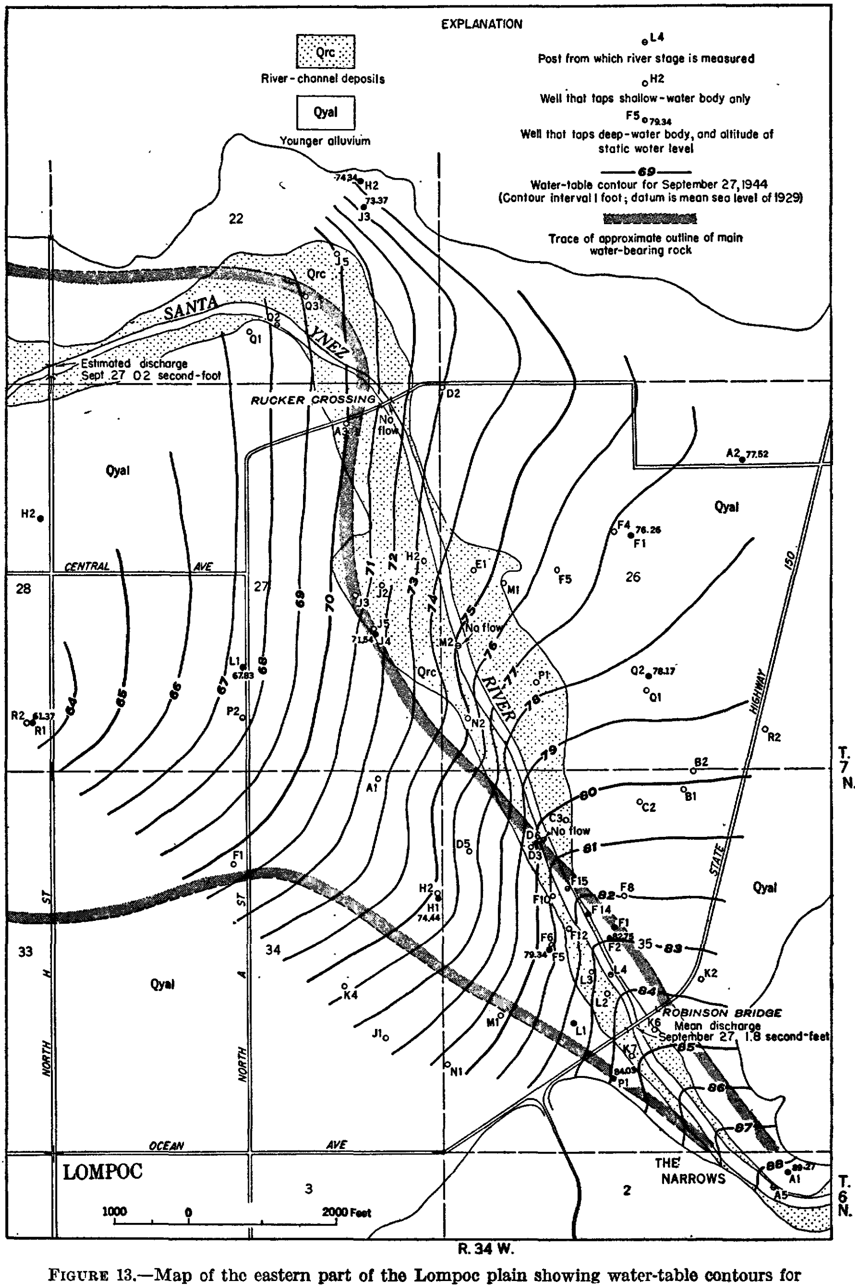

FIGURE 13.—Map of the eastern part of the Lompoc plain showing water-table contours for September 27, 1944.

in drawing the contours. Most of the observation wells that are shown and that tap the shallow water were bored by the Geological Survey, but a few are used domestic or stock wells.

Both maps show the same general features: east of the river, a gentle, uniform slope of the water table generally parallel to the river for a short distance below Robinson Bridge, but farther downstream somewhat toward the river, and west of the river, a slope that is everywhere away from the river and relatively steep in the first 3,000 feet below Robinson Bridge, This gradient is progressively less steep at greater distances from the river.

On the east side of the river the map for May 3, 1944 (fig. 12), which is typical of conditions in the spring, shows no movement of water away from the river, thus indicating that spring recharge to this part of the shallow water body is from hills bordering the plain on the east and is evidently largely infiltrate of rain. The map for September 27, 1944 (fig. 13), typical of low-water river conditions and near the close of the irrigation season, shows that for about 1 mile below The Narrows the river contributes water to the shallow water body on the east but that farther downstream the recharge is from the east even in autumn.

On the west side, both maps show that the river loses water along the entire reach from The Narrows to about 2,000 feet below Rucker crossing at all times of the year. The water-table gradient away from the river is steepest in autumn but even in spring is fairly steep. On the map for May 3, 1944 (fig. 12), the gradient is 20 to 24 feet per mile in the first 3,000 feet below Robinson Bridge, and thence it is progressively gentler both downstream along the river and westward away from the river. For example, between A Street and H Street the gradient is about 7.5 feet per mile.

Thus, the water-table contours show that the Santa Ynez River contributes water to the shallow water body chiefly west of the river. Although the total seepage loss from the river enters the shallow water-bearing zone at first, as described in subsequent paragraphs, only a small part of the loss remains in and becomes a somewhat permanent part of the shallow water body. Most of the seepage loss passes quickly downward to the main water-bearing zone.

Figures 12 and 13 show a movement of water westward from the east margin of the plain; and outside the area shown on these plates the water level in a few scattered shallow wells is relatively high near the north and south margins of the plain. Thus, the water table everywhere slopes toward the plain from both north and south and shows that most of the source of the shallow water body is from infiltration of rain and of water seeping from tributary streams.

RECHARGE TO THE SHALLOW WATER BODY

Because the water table is not far below the land surface and loose, unconsolidated materials intervene between the land surface and the water table, the shallow water body theoretically is enabled to derive water by infiltration of rain and of irrigation water and by seepage from streams and from water stored in adjacent hills. In years of average rainfall the shallow water-bearing zone probably receives replenishment mainly by seepage from the streams on the south and by seepage through the deposits that compose the hills and terraces bordering the north and east sides of the Lompoc plain.

It is generally considered that irrigation is rarely more than 80 percent effective; in other words, at least 20 percent of the total water pumped is evaporated, runs off, or percolates below the plant roots to an underlying water body which, in the Lompoc area, would be the shallow water body. The amount thus lost varies widely with different types of crops, soil, irrigation practice, and climatic conditions. Pillsbury and others (1946, pp. 7, 10) state that on lemons and oranges, efficiencies of 70 percent are common and 80 percent are rare. Data supplied by Harold Conkling [6] indicate that in a part of the Salinas Valley the "irrigation efficiency" has been about 66 percent for all crops except lettuce and celery. Celery and lettuce are grown in the Lompoc area and there the average efficiency may be taken as about 60 percent. There seem to be little data available on the percentage of deep infiltration. Little irrigation water runs off from the Lompoc plain, so the loss of efficiency probably is due mainly to evaporation and only partly to deep percolation. Accordingly, the quantity that penetrates below the plant roots is here taken as not more than about 40 percent of the loss, or about 15 percent of the average pumpage. In areas of sandy soil, such as the Buellton and Santa Rita subarea, it may be as much as 20 percent. The water involved probably does not reach the water table in most of the plain within the irrigation season during which it was pumped. Rather, it probably reaches the water table in or after the following winter, when it is added to downward moving infiltrate of rain.

In regard to recharge from rainfall, only a part of the rain that falls penetrates to a water table; most of it is evaporated from the soil or transpired by plants. Some work (Blaney, 1933b) has been done on the proportion of any one season's rain that penetrates below plant roots. Computed values for this "deep" penetration are given in Table B of the California State Division of Water Resources report on Ventura County. The values are tabulated according to different classes of land cover, including irrigated beans, miscellaneous garden

[6] Conkling, Harold, personal communication, November 1945.

truck crops and alfalfa, grass and weeds, and bare land. Land cover on the Lompoc plain is almost entirely in these classes, with most of the land in miscellaneous garden truck crops and alfalfa. For each class the values for penetration of rainfall as computed by Blaney for the numerous localities have been plotted against seasonal rainfall, and smooth curves have been drawn. From these curves values of penetration corresponding to the seasonal rainfall on the Lompoc plain during the years 1935–44 have been picked off. Rainfall on the Lompoc plain is determined by combining rainfall at Lompoc and at Surf in the ratio of 2 to 1. The penetration for areas planted to miscellaneous garden truck crops and alfalfa is considered characteristic for the whole plain as areas of bare land with a high penetration probably compensate for areas of grass and similar plants having a low penetration.

Table 24 gives the rainfall on the Lompoc plain for seasons ending September 30, and corresponding estimated values, in inches and in acre-feet, for deep penetration below the plant roots. This penetration represents recharge to the shallow ground water.

TABLE 24.—*Infiltration of rain to the shallow water table beneath the Lompoc plain*

Year	Computed rainfall (inches)	Penetration for garden truck crops and alfalfa (inches)	Recharge to shallow water body (acre-feet)
1935	16.63	3.3	4,500
1936	10.86	0	0
1937	17.97	4.4	6,000
1938	22.25	7.8	10,600
1939	13.17	.2	300
1940	12.91	0	0
1941	38.29	±13.4	18,200
1942	[1] 17.05	3.6	4,900
1943	[1] 14.10	1.1	1,500
1944	[1] 14.97	1.8	2,400
Average	17.82	3.6	4,800
Long-term average	14.62	1.5	2,000

[1] Includes estimated values for rainfall at Surf.

Thus, the recharge by rain to the shallow water is zero in years of little rainfall and very great in years of much rainfall. The long-term average is about 2,000 acre-feet, or about 10 percent of the average rainfall, but the period 1935–44 was relatively wet and included the largest seasonal rainfall of record in 1941. The average for this period is 4,800 acre-feet.

Probably a large proportion of the recharge to the shallow water-bearing zone is by seepage from the streams that enter the valley and from the surrounding elevated tracts. Unlike those from the north, the tributary streams from the south, chiefly San Miguelito Creek, those in San Pascual, Rodeo, and Lompoc Canyons, drain moderately extensive areas of foothill and mountainous terrain, which receive comparatively heavy rainfall. Except for the stream in Lompoc Canyon they flow perennially almost to the canyon mouths and there lose most of their flow by percolation into the marginal parts of the upper member of the younger alluvium—and hence to the shallow water body.

Runoff conditions from the drainage areas of these canyons are thought to be nearly comparable to those in the drainage basin of Salsipuedes Creek. Unfortunately, data are available only for years since 1941. However, in the years 1942, 1943, and 1944 runoff at the Salsipuedes Creek gage (p. 93) averaged about 10,000 acre-feet from the drainage area of 46.6 square miles, or about 210 acre-feet per square mile. Because these years followed the wet winter of 1941, and because the drainage area of Salsipuedes Creek probably has somewhat more rainfall than areas farther west, it is thought that a runoff of 150 acre-feet per square mile is reasonable for the drainage areas of San Miguelito Creek, San Pascual, Rodeo, and Lompoc Canyons. Their total area is about 36 square miles; hence the runoff reaching the Lompoc plain is approximately 5,400 acre-feet. As the streams rarely if ever flow to the river, essentially all the water percolates to the shallow water-bearing zone.

In regard to recharge from the Santa Ynez River itself, river water directly and promptly replaces water that is discharged from the river-channel deposits. During low-water stages the shallow water table in the river-channel deposits is about at river level; and the water table in the younger alluvium is generally conformable with that in the channel deposits. Study of shallow water levels indicates that in most of the plain there is no appreciable hydraulic gradient away from the river in accord with which water may seep from the river. However, in the reach within about 1½ miles below Robinson Bridge there is at all times some gradient away from the river channel and hence seepage from the river in that reach. As shown on figures 12 and 13, the distance within which water is moving from the river channel westward about between The Narrows and 2,000 feet below Rucker crossing is about 13,000 feet. The effective distance, adjusted for the angle between the contours and the river channel, is about 9,000 feet. The maps also show that the section through which the water from the river moves is progressively narrower westward. For example, near A Street and parallel with the 69-foot contour on figure 12 the section transmitting water from the river is not more than about 7,000 feet wide. The quantity of water moving from the river remains constant, and the permeability of the deposits is probably about the same, whereas the hydraulic gradient decreases westward. Therefore, the effective cross-sectional area actually must increase westward; and because the width of the section decreases, it must increase in depth. Accordingly, the contour map (fig. 12), shows that a large part of the water leaving the river between The Narrows and the point 2,000 feet below Rucker crossing passes downward as well as westward (thus traversing in effect a larger cross-sectional area) and doubtless enters the deeper-lying main water-bearing zone. Only a small part of the total water transmitted remains in the shallow water-bearing zone. This amount is computed approximately as follows.

Assume first that the edge of the predominately impermeable deposits in the upper member of the younger alluvium is about at H Street, and second that the hydraulic gradient between A Street and H Street, 7.5 feet per mile, is about the same as that effective at the edge of the predominately impermeable deposits. By approximation from sections *E–F–E′* and *G–G′* of plate 5 the top of the main water-bearing zone is near sea level along H Street and between the southwest corner section 27 and the river, a distance of about 5,400 feet (fig. 12). This plate shows the altitude of the shallow water table to be about 66 feet, making a saturated thickness of about the same amount above the main water-bearing zone. Logs of wells near this section show about 50 percent sand and gravel and 50 percent clay and silt above the main zone. The sand and gravel are assumed to have about the same permeability as the modern river-channel deposits, or about 1,000 gallons per day per square foot (p. —), and the clay beds are considered to have zero permeability, making an over-all average of about 500 gallons per day per square foot.

With a cross-sectional area of 5,400 times 66, or 356,400 square feet, an average permeability of 500 gallons per day per square foot, and a hydraulic gradient of 7.5 feet per mile, the amount of water transmitted west of H Street to the shallow water-bearing zone from the river, as derived from the equation

$$Q=PIA$$

is about 253,000 gallons per day, or about 280 acre-feet a year.

This figure is derived from conditions prevailing in May 1944 near the height of the recharge season and hence is a maximum figure. During the pumping season (see fig. 13) the shallow-water gradient is lower, and the effective cross-sectional area is somewhat smaller. Accordingly, a rounded-off figure of 250 acre-feet probably more closely approximates the true yearly average replenishment from the river to the shallow water-bearing zone.

During flood stages, water immediately fills all open spaces below river level in the river-channel deposits, and a fairly steep gradient is established at the contact between the channel deposits and the younger alluvium. The gradient is much steeper than at low water, but the condition is short lived and the gradient returns to or nearly to low-water slope as soon as the flood subsides. Even during a flood it is inferred that, because of the low permeability of the younger alluvium, little water enters the shallow zone. In the flood of February 22, 1944, river stage reached a peak of 13.06 feet at 6 p. m. February 22 at Robinson Bridge. This was about 7.5 feet above the stage that preceded the storm. Water-level measurements were made in a number of the shallow observation wells both in the flood channel and in the nearby part of the Lompoc plain on February 22 before the peak, in the morning and afternoon of February 23, in the morning and afternoon of February 24, and on February 25, 26, and 28. These measurements showed an abrupt and large rise of water levels in wells situated in the river-channel deposits within 1,500 to 2,000 feet below Robinson Bridge. Farther downstream, however, and especially in wells that penetrate the younger alluvium, the response was everywhere less than 2 feet, and only a fraction of a foot at a distance of 1,500 feet from the river. Thus, ground-water waves representing increase of storage traveling away from the river during floods are of small amplitude and travel only a short distance across the width of the plain.

Accordingly, it is believed that only a small proportion of the water in the shallow water-bearing zone is derived from the Santa Ynez River. The computed amount, 250 acre-feet a year, is considerably less than the average measured loss from the river during low water (p. 95), or 2,200 acre-feet a year; the remainder, or 1950, acre-feet, apparently passes directly to the main water-bearing zone of the deep water body. Furthermore, it would be impossible to increase appreciably the replenishment from the river unless pumpage should be so increased and so maintained that the head of the deep water body should everywhere be lowered by amounts at least in the order of 20 to 30 feet.

DISCHARGE FROM THE SHALLOW WATER BODY

Ground water is discharged from the shallow water body in part by seepage to the river, in part by evaporation and transpiration largely along the river channel, and in part by downward percolation to the deep water body. In an attempt to evaluate the percolation to the deep water body, values for the remaining two means of discharge are approximated roughly from the long-term hydrographs of shallow wells and from other data.

The decline of shallow water level during the summer is a measure of the total discharge during that period. Figure 14 shows the seasonal declines of water level in five shallow wells. The fluctuations are similar to those of the deep wells (figs. 22 and 23) in that they exhibit the same summer decline, followed by a rise in winter. The seasonal changes, however, are from about 2 to 8 feet and generally are less abrupt as they represent changes in storage and not pressure changes. The fluctuations of water level in well 6/34–4M1 are relatively wide because that well is close to the mouth of San Miguelito Canyon, the source of recharge. The fluctuations in well 7/34–28F1 are somewhat less, as the well is situated in the middle of the plain and is remote from recharge. Its record is probably the most typical of those shown.

The curves show an over-all decline from 1930 to 1936 and a large net rise to 1941. They show abrupt and large rises in 1938 and in 1941, years of excessive rainfall. These rises, especially that in 1941, are followed by generally higher water levels indicating that the rainfall of those years resulted in considerably increased shallow groundwater storage. As indicated by the record of well 7/34–34A1 (see fig. 14), water levels at the end of 1944 were apparently as high as, or a few feet higher than, in 1930. The same record shows a net rise from 1935 to 1945 of about 3 feet. Unfortunately, data in most wells are lacking between 1941 and 1945. However, figures 15 and 16 show a decline of about 1½ feet from 1944 to 1945. Applying this change to the record of well 7/34–34A1 gives a net rise from 1935 to 1944 of about 4½ feet. If this amount is representative for the whole plain the net change of shallow-water storage from 1935 to 1944, using a specific yield of 14 percent (p. 133), was about 10,000 acre-feet, or an average of about 1,000 acre-feet a year.

The seasonal decline varies from year to year, apparently mainly in response to rainfall. The largest declines occurred after the 1938 and 1941 winters of excessive rain when pumpage was small, and probably are accounted for by relatively large seepage to the river in the ensuing summer seasons. The variations in seasonal decline seem to have little relation to differences in seasonal pumpage from the deep water, but the records are too short and too scarce to constitute an adequate basis for comparison. The median yearly decline in seven wells, including 7/34–30R1 (fig. 17), for which records are available, is between 3.5 and 4.5 feet for the period 1930 to 1941. Partial records in these and other wells in the period 1935 to 1944 give a median value of 3.5 feet. The records are few, and few data are available on shallow wells in the northeastern part of the plain and in the western part of the plain. It is thought that the decline would be less in

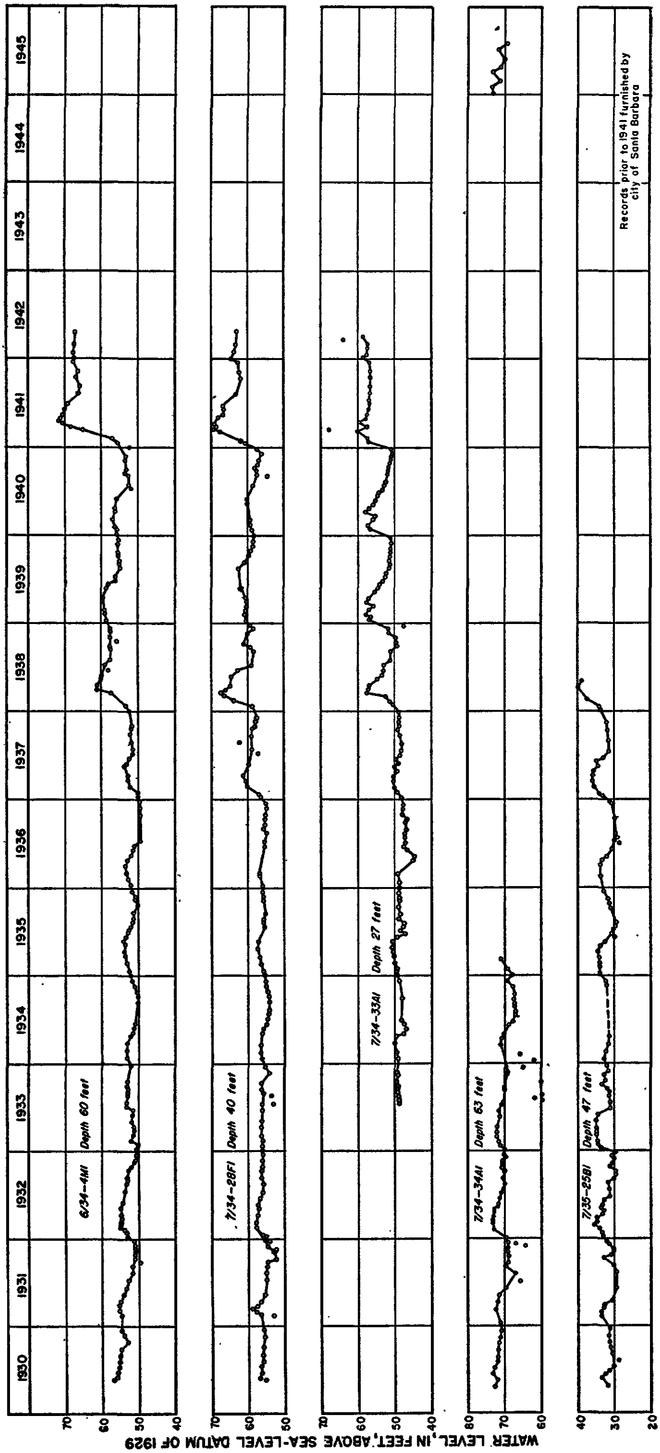

FIGURE 14.—Fluctuations of water levels in five wells that tap the shallow water body beneath the Lompoc plain, 1930 to 1945.

those areas. However, the average for the entire plain in the period 1935–44 is taken as 3.5 feet.

To determine the quantity of water represented by this decline of water level it is necessary to determine a value for the specific yield of the materials within the zone of water-level fluctuation. Specific yield is estimated approximately from the physical composition of the deposits by using a method similar to that employed by Piper (Piper, Gale, Thomas, and Robinson, 1939, pp. 120–121) in the Mokelumne area. This method utilizes independently determined values for the specific yield of different grade sizes of material, together with the proportionate volumes of different sizes as revealed by well logs. Inasmuch as specific yield is desired for material within the zone of water-table fluctuation in the Lompoc plain, water-level records were examined for the period 1930 to 1941 to ascertain the range. This period includes the lowest and highest water levels of recent years. Although the lowest levels occurred in 1931, the range is considered to give sufficient span beyond the range in the period 1935–44, for which pumping records are available, to allow adequately for lateral as well as vertical change in composition of the material. The ranges measured at the wells were plotted on a map and were used as a basis for interpolating the approximate range at other wells for which water-level records were not kept.

The total footage of each of several types of material within the determined range of water-level fluctuations was obtained from well logs. The types are designated according to the drillers series, and are grouped into four main classes as follows: Gravel and coarse sand; sand; silt, including fine sand, sandy clay, and soft clay; and clay. A number of logs show "soil," which is probably the same as material for which descriptive terms are given in other wells and which was excluded from the computations. These footages were totaled by eight areas and the percentage of each class of material computed for each area. These percentages were compared with percentages similarly obtained from records of wells bored by the Geological Survey. The materials penetrated by these wells were classified by inspection. The percentages agreed fairly well in general except in the area along the river near Robinson Bridge, where a considerably higher proportion of gravel is recorded in Survey logs than in other drillers' logs. However, most of the drillers' logs were for wells farther from the river than the Survey wells and were expected to show less gravel. Next, the total footage of the different classes of material as recorded in drillers' logs and Survey logs were added by areas, making allowance for a preponderance of wells bored in the coarse channel deposits; and new percentages were obtained. The percentages were weighted according to the acreage of the several areas and the following percentages by volume of the four classes of materials within the range of water-table fluctuations over the entire Lompoc plain obtained: Gravel and coarse sand, 7 percent; sand, 23 percent; silt, 32 percent; and clay, 38 percent.

The terms applied by drillers apparently correspond in general to standard terminology for grain sizes. By refering to the report on the Mokelumne area (Piper, Gale, Thomas and Robinson, 1939, p. 117, fig. 8), the following values of specific yield for the grade sizes distinguished were taken: Gravel and coarse sand, 35 percent; sand, 30 percent; silt, 12 percent; and clay, 2 percent. Applying these values in proportion to the percentage volumes of the different classes of material, the average specific yield of the deposits within the zone of water-table fluctuation in the Lompoc plain is computed to be 14 percent.

Taking the total area as 16,300 acres, the average specific yield as 14 percent, and the average yearly decline as 3.5 feet, the amount of water represented by the decline is about 8,000 acre-feet a year. This represents the total amount discharged during the season of no replenishment, or about half the year. Some discharge also occurs in winter, but its effect is masked by recharge. Of this total discharge, some seeps to the river in the west end of the Lompoc plain, a large part is evaporated and transpired by native vegetation, and the remainder passes downward to replace water drawn from the deep water body.

In regard to discharge of shallow ground water to the river, figures 5, 6, 7, and 8 show small gains in flow of the river across the western part of the Lompoc plain in summer of the years 1941–44. These gains probably closely represent the base discharge from shallow ground water. Except in 1941, which followed an exceptionally wet winter, the gain amounted to about 2 second-feet. This rate is taken as average for the period 1935 to 1944 and amounts to about 1,500 acre-feet a year.

Discharge by evaporation and transpiration is the greatest part of the total discharge and takes place mainly bordering the river channel, where there is considerable native vegetation and where the water table is generally less than about 10 feet deep. Outside the channel there is little native vegetation except at the west end of the plain, and at most places the water table is greater than 10 feet deep. Data are not available as to the consumptive use of water by native vegetation along the Santa Ynez River bottom lands, but considerable data have been compiled by the Division of Irrigation of the United States Department of Agriculture, in part in cooperation with the Geological Survey, for the bottom lands of the Santa Ana River in Riverside and Orange Counties.

Troxell (1933, pp. 147–172) reported on water losses, including both transpiration by native vegetation and evaporation from water surface and bare soil, in the river bottom land between the Riverside Narrows and the Prado Dam. Troxell's table 1 (1933, p. 148) gives the classification of bottom land, and the total acreage as 4,040 acres. Troxell's table 5 (1933, p. 171) gives the total natural losses from October 1930 to September 1931 as 17,500 acre-feet, and from October 1931 to September 1932 as 16,300 acre-feet. The total losses then are a little over 4 acre-feet per acre. More recent work in the valley below the Prado Dam[7] has given data on the consumptive use of water by dense, medium, and sparse native vegetation and on the evaporation of water from the stream surface and from bare areas in the channel. By summarizing these data and prorating the loss of water according to the relative acreage of river surface, bare land, and plant growth of different densities, an average natural loss of 2.5 acre-feet of water per acre from April 1, 1943, to March 31, 1944, is obtained. Conditions in the lower Santa Ana Canyon are roughly comparable to those in the Lompoc plain in the years 1935–44. Accordingly, the figure of 2.5 acre-feet per acre is taken as the approximate loss of water along the Santa Ynez River channel owing to evaporation and transpiration. The river channel is about 0.15 mile in average width by about 12.5 miles long, or about 1,200 acres. At 2.5 acre-feet per acre per year, the average annual evapotranspiration is about 3,000 acre-feet.

In the area outside the river channel, only the western 1.5 miles of the plain have any appreciable vegetation other than crops. This area averages between half and three-quarters of a mile wide and is nearly 1 square mile, or about 600 acres. Vegetation in this area is chiefly varieties of salt grass, wire rush, and tules. Experiments on plants (Blaney, 1933a, pp. 66–67) of this type indicate a consumptive use between about 2 and 7 acre-feet per acre per year. Because of the proximity to the coast with frequent morning fogs and low temperatures, an average value of 3.5 acre-feet per acre is used, which makes the total evapotranspiration loss from the 600 acres 2,100 acre-feet per year.

The total evapotranspiration losses from the shallow ground-water body plus discharge to the river equals about 6,600 acre-feet a year. Subtracting this amount from the 8,000 acre-feet represented by seasonal lowering of water levels leaves 1,400 acre-feet a year, which passes downward to the deep water body. However, the total discharge, 8,000 acre-feet, is measured in the summer half of the year (p. 130), whereas the seepage to the river and evapotranspiration are computed for the whole year. Probably an additional quantity of

[7] Muckel, D. C., Consumptive use of water in the lower Santa Ana Canyon: unpublished manuscript in the files of the Soil Conservation Service, U. S. Dept. Agr., 1944.

water passes downward from the shallow to the deep water body in winter—its loss being masked by the normal winter rise of water levels. The amount thus seeping downward in the winter half of the year is estimated as about 800 acre-feet on the average. (See p. 155.)

RELATION BETWEEN SHALLOW AND DEEP WATER BODIES

The foregoing rough computations indicate that a comparatively small part of the natural discharge from the shallow ground water passes to and constitutes replenishment of the deep water. This conclusion is supported by additional evidence presented in the following paragraphs, on the freedom of hydrologic interchange between the shallow and deep ground-water bodies.

Evidence from geology.—As has been discussed (p. 47), fine-grained deposits in the upper member of the younger alluvium form a nearly continuous body beneath about half the total extent of the Lompoc plain. This body contains considerable clay and silt, predominately impermeable deposits,with small amounts of sand and a little gravel. The clay and silt beds are locally relatively thick and probably closely overlap. Accordingly, this body is considered locally to prevent entirely and generally to retard greatly the vertical movement of water from the land surface downward, or vice versa. Thus, it divides the area of the plain into two parts: a central part within which downward movement of water is prevented or greatly retarded; and an outlying part in which the downward movement of water is comparatively free. The central part is coextensive with the body of fine-grained deposits. It extends eastward from the sea about to H Street, at Lompoc, and from the north margin of the plain southward across the entire width of the plain west of Lompoc Canyon and about two-thirds to three-quarters of the width east of Lompoc Canyon. (See pl. 3.) In this discussion the area is termed the area of no interchange between shallow and deep water. Within its limits, however, is a small area along the river in secs. 23 and 24, T. 7 N., R. 35 W., where deposits are mostly sand and where water is enabled to move downward relatively freely at such times as the hydraulic gradient is favorable.

The outlying part of the plain includes the south-marginal portion east of Lompoc Canyon and the east end of the plain east of H Street. This area is termed the area of interchange between shallow and deep water. It includes the river channel near Robinson Bridge in which the bulk of low-water river seepage loss takes place.

Evidence from water-table contours.—The general evidence for downward movement of water from the shallow- to the deep-water bodies in the vicinity of Robinson Bridge based on water-table contours (see fig. 12 and 13) has been discussed in foregoing paragraphs (pp. 122 and 127). The basining of water-table contours over the buried tongue of the main water-bearing zone, and the westward decrease of water-table slope both indicate loss of water downward to the main zone in the part of the Lompoc plain east of H Street. Figures 12 and 13 also show no such evidence of downward movement of shallow water east of the river or east of the tongue of the main water-bearing zone.

In detail, also, figure 13 shows a small but marked basining of water-table contours in the vicinity of wells 7/34–35F5 and 7/34–35F6, directly over the main water-bearing zone. Furthermore, local owners report that when wells 7/34–35F5 and 7/34–35L1 are heavily pumped during a period of low river flow, "the river is dried up." Numerous contour maps, of which figure 13 is an example, show that when several of the deep wells are pumped simultaneously a localized depression of the water table amounting to 2 to 3 feet is developed in the same area. Thus, the depression of the water table is doubtless induced by pumping from the deep water. When the river is only a few inches to 1 foot deep, pumpage is sufficient to lower the water table below the river bottom, thus causing a cessation of surface flow. Similarly in secs. 23 and 24, T. 7 N., R. 35 W., and at times extending into sec. 22, the river has gone dry in summer, whereas there has always been some water upstream in the vicinity of Dyer Bridge.

Evidence from seasonal fluctuations of shallow water level.—The hydrographs in figures 15 and 16 show the comparative fluctuations of water level over two irrigation seasons in four pairs of companion shallow and deep wells.

Figure 15 shows fluctuations of water levels in wells 7/34–26F1, deep, and 7/34–26F4, shallow. Well 7/34–26F1, 149 feet deep, passes through the younger alluvium and penetrates and derives water entirely from the Paso Robles formation. The casing is said to be perforated between depths of 130 and 143 feet. Well 7/34–26F4, down the hydraulic gradient about 220 feet to the northwest, was bored by the Geological Survey to a depth of 19½ feet in the younger alluvium. The well was cased with 6-inch concrete tile. The well was equipped for a time with an automatic water-stage recorder whose record showed that the shallow water level essentially did not fluctuate when the neaby well was pumped. These wells are situated in the so-called area of interchange, but they are outside the extent of the main water-bearing zone. Their records show that interchange between shallow and deep water at this place is not free.

Figure 15 shows fluctuations of water levels in wells 7/34–28R1, deep, and 7/34–28R2, shallow. Well 7/34–28R1 is 146 feet deep and derives water from the main water-bearing zone of the deep water body. The casing is said to be perforated between depths of 106 and 146 feet. Well 7/34–28R2 was bored by the Geological Survey

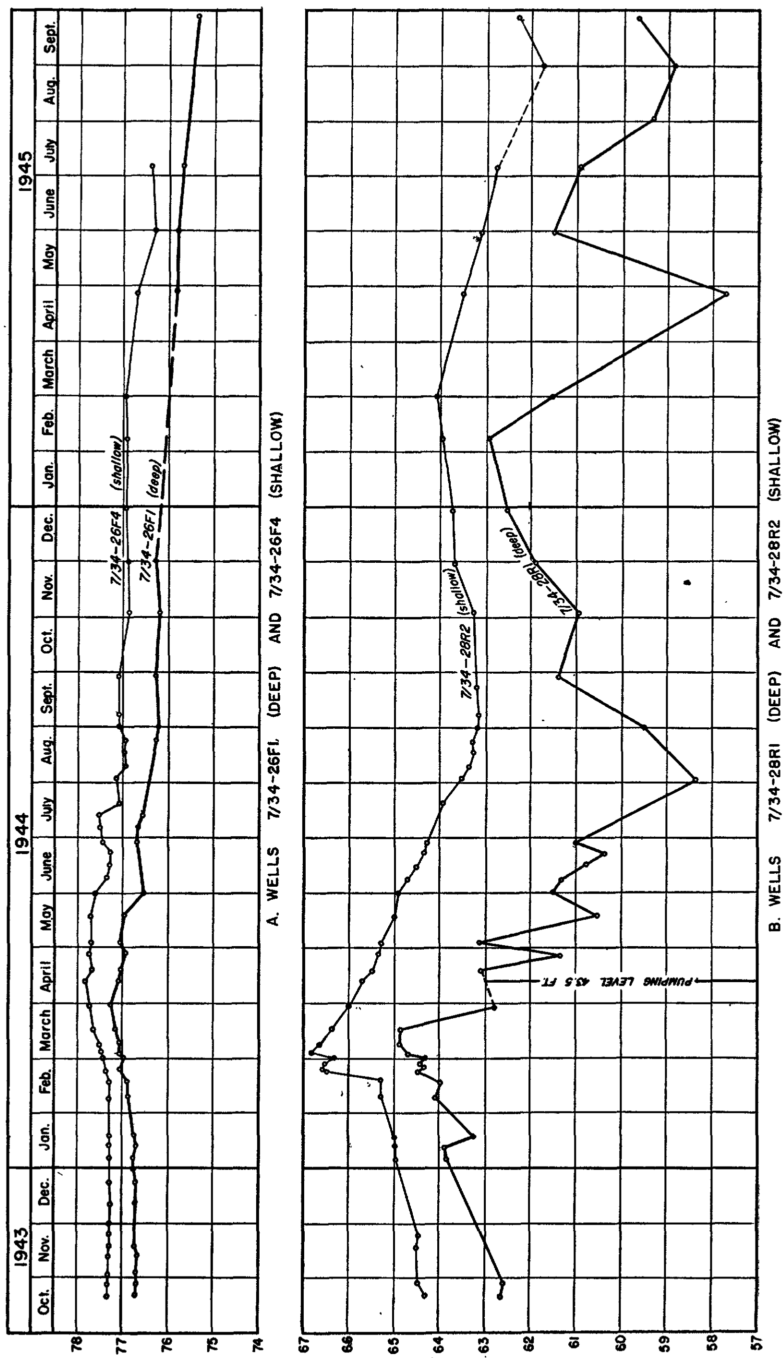

FIGURE 15.—Hydrographs showing fluctuations of water levels in paired shallow and deep wells.

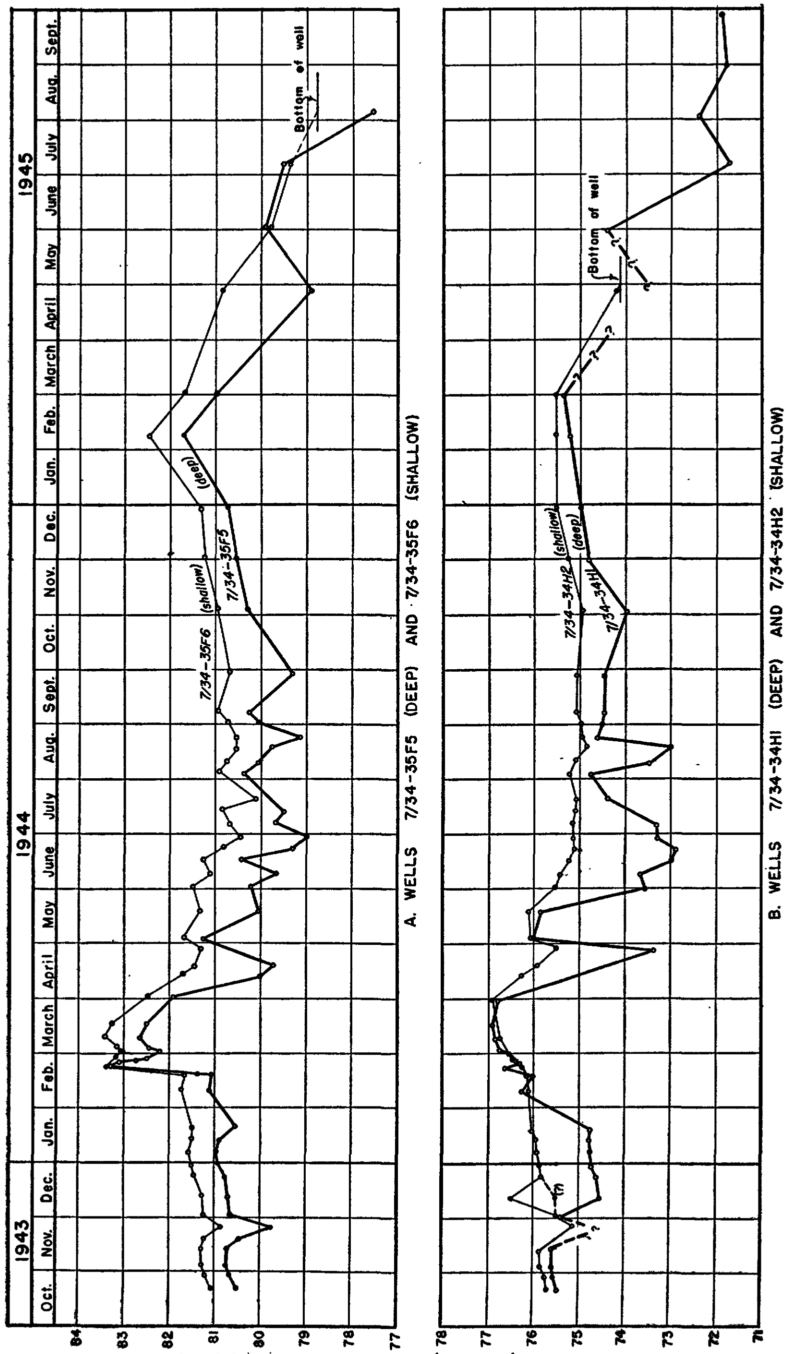

FIGURE 16.—Hydrographs showing fluctuations of water levels in paired shallow and deep wells.

at a point about 12 feet west of the deep well and to a depth of a little more than 16 feet. Water under artesian head was encountered at 10½ feet and rose to about 8 feet. The well is cased with 2-inch iron pipe perforated in the lower 3 feet. These wells are situated a short distance within the area of no interchange. The graphs show some correspondence in general but little correspondence in detail. For example, in March 1944 and 1945, and in September and October 1944, the shallow water apparently fluctuated independently of the deep water.

Figure 16 shows fluctuations of water levels in wells 7/34–35F5, deep, and 7/34–35F6, shallow. Well 7/34–35F5 is 164 feet deep and the casing is said to be perforated between depths of 110 and 164 feet. It derives water directly from the main water-bearing zone of the deep water body. Well 7/34–35F6 was bored by the Geological Survey to a depth of 40½ feet at a place about 10 feet northeast of the adjacent deep irrigation well. It is cased with 2-inch iron pipe perforated in the lower 3 to 4 feet. These wells are situated within the area of interchange of shallow and deep water. The graphs show a correspondence both in general and in detail between the fluctuations of shallow and deep water; and interchange of shallow and deep water at this place is considered free.

Figure 16 shows fluctuations of water levels in wells 7/34–34H1, deep, and 7/34–34H2, shallow. Well 7/34–34H1 is 160 feet deep. The casing is reported to be perforated between 116 and 154 feet, in which interval the well taps the deep water body from which it derives water. Well 7/34–34H2 is 37½ feet deep and was bored by the Geological Survey about 10 feet north of the deep well. It is cased with 2-inch iron pipe perforated in the lower 3 to 4 feet. These wells are situated within the area of interchange of shallow and deep water. The fluctuations of shallow water coincide fairly well with fluctuations of the deep water but seem to have some lag in response. At times, as in February and March 1944, the shallow water seems to have fluctuated somewhat independently of the deep water. Thus, even here the interchange is not free.

In each of these pairs of shallow and deep wells the shallow water level followed the general curve of fluctuation of the deep water level. It declined in the spring and summer as the deep water level declined and recovered in the fall and winter as the deep water level recovered. The recovery of the shallow water coincided with recovery of the deep water except in well 7/34–28R2 (fig. 15), in which it lagged about a month in 1944. In the shallow wells, 7/34–28R2 (fig. 15) and 7/34–35F6 (fig. 16), the water levels began to rise before the rain in 1944. Thus, the rise appears to have depended on restoration of head of deep water. In well 7/34–26F4 (fig. 15) and 7/34–34H2 (fig. 16) the shallow water began to rise after the early part of November probably largely as a result of rain. In summation, it is concluded that outside the area of predominately impermeable deposits in the upper member of the younger alluvium there is local free interchange between shallow and deep water, but also locally relatively limited interchange.

Within the area of no interchange and 2 to 3 miles west of the pairs of wells just discussed is another pair of shallow and deep wells, 7/34–30R1 and 7/34–31A1, whose water-level fluctuation are compared in figure 17. Well 7/34–30R1 is 30 feet deep, tapping only the shallow water body; and well 7/34–31A1 is reported to be 156 feet deep and probably taps only the deep water body, though the log is not reliable. These two wells are about 600 feet apart, and the deep well may be slightly upgradient from the shallow well. The records cover the period from April 1930 to April 1942; and the measurements were made by the city of Santa Barbara. The fluctuations of water level in well 7/34–31A1 are abrupt and of large amplitude, suggesting that the water is confined; whereas the fluctuations of the shallow water level are gentle and of small amplitude. They correspond to those of the deep well in general but not in detail, as in the summers of 1932 and 1933 and the winters of 1940 and 1941. In some winters the deep water level has stood 1 foot to 2 feet higher than the shallow water level. Thus, here the shallow and deep water seem to have little or no hydraulic continuity.

Finally, in secs. 25, 26, and 35, T. 7 N., R. 35 W., deep wells have a small flow. Accordingly, there can be no appreciable downward percolation of shallow water in that area.

Evidence from pumping tests.—In the fall of 1945 the Geological Survey bored six shallow wells to depths of a few feet below the water table each adjacent to a pumped irrigation well in the central part of the Lompoc plain. The casings of the deep wells are perforated only in the deep water body. Four of those pairs are situated within the area of no interchange and where well logs indicate that shallow and deep water bodies are separated by comparatively impermeable deposits. Two are in secs. 23 and 24, T. 7 N., R. 35 W., where such impermeable deposits are not present and interchange is free. Measurements of water level in the shallow wells were made during periods of pumping from the respective adjacent deep wells. The results of four tests are shown in figures 18 to 21.

Figure 18 shows the effect of a 9-hour pumping run in well 7/34–29E4 reported to be 186 feet deep. The pumping had no effect on the water level in well 7/34–29E5, which is 19.5 feet deep and is 63 feet from the pumped well. The result of this test, together with the fact that the shallow water level stands about 7 feet above the static head of the deep water, is taken to indicate essentially no hydraulic interconnec-

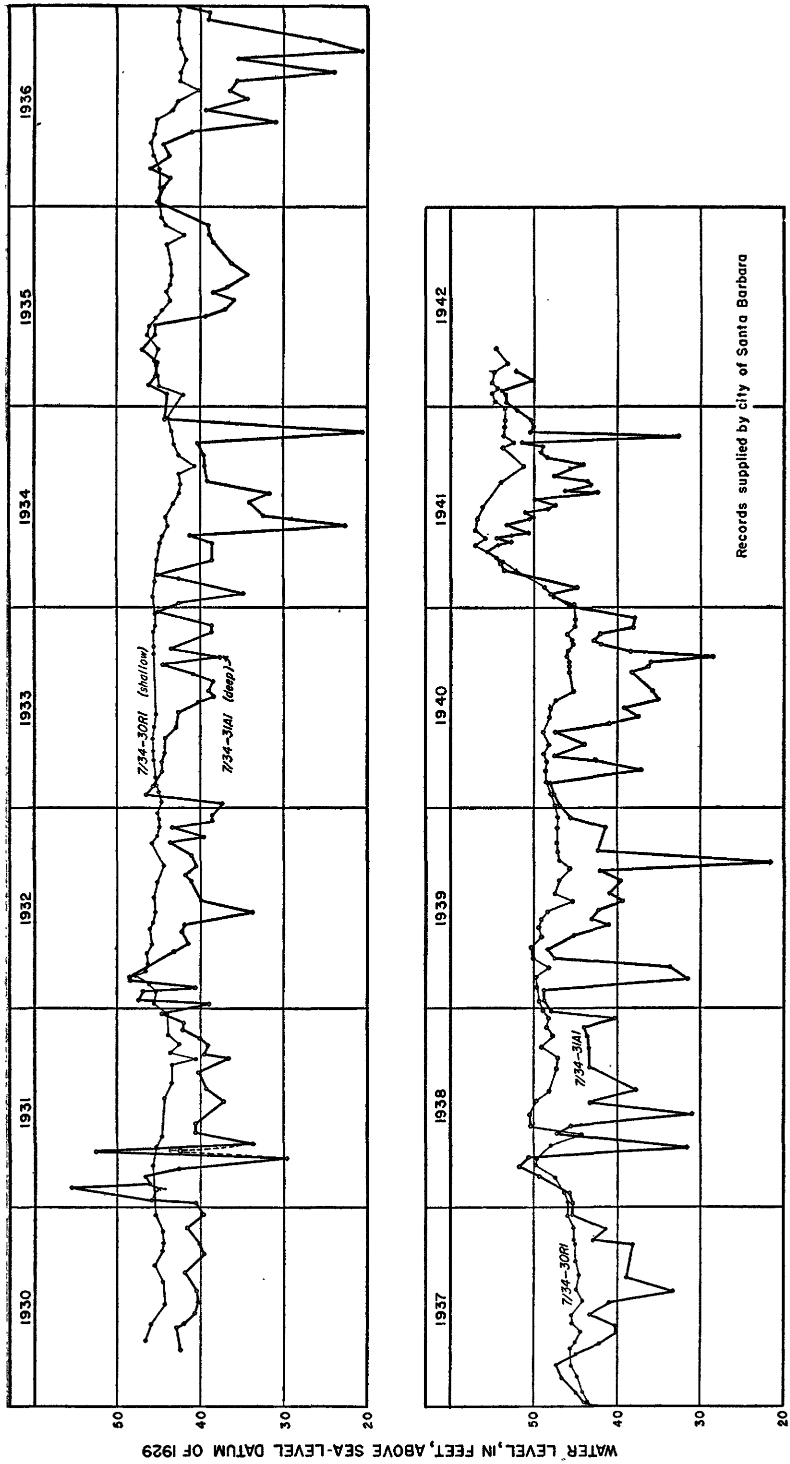

FIGURE 17.—Hydrographs for wells 7/34-30R1 (shallow) and 7/34-31A1 (deep) nearby, comparing fluctuations of water levels.

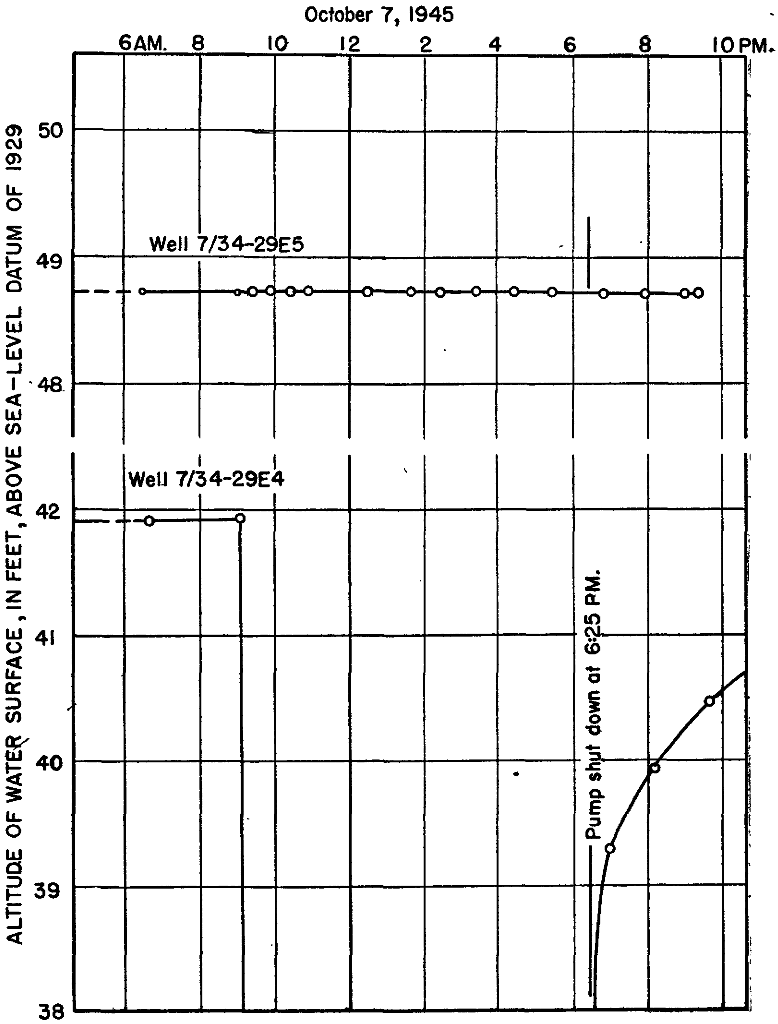

FIGURE 18.—Fluctuations of water level in wells 7/34-29E5 (shallow) and 7/34-29E4 (deep) showing the effect on the water table of pumping from the deep water body.

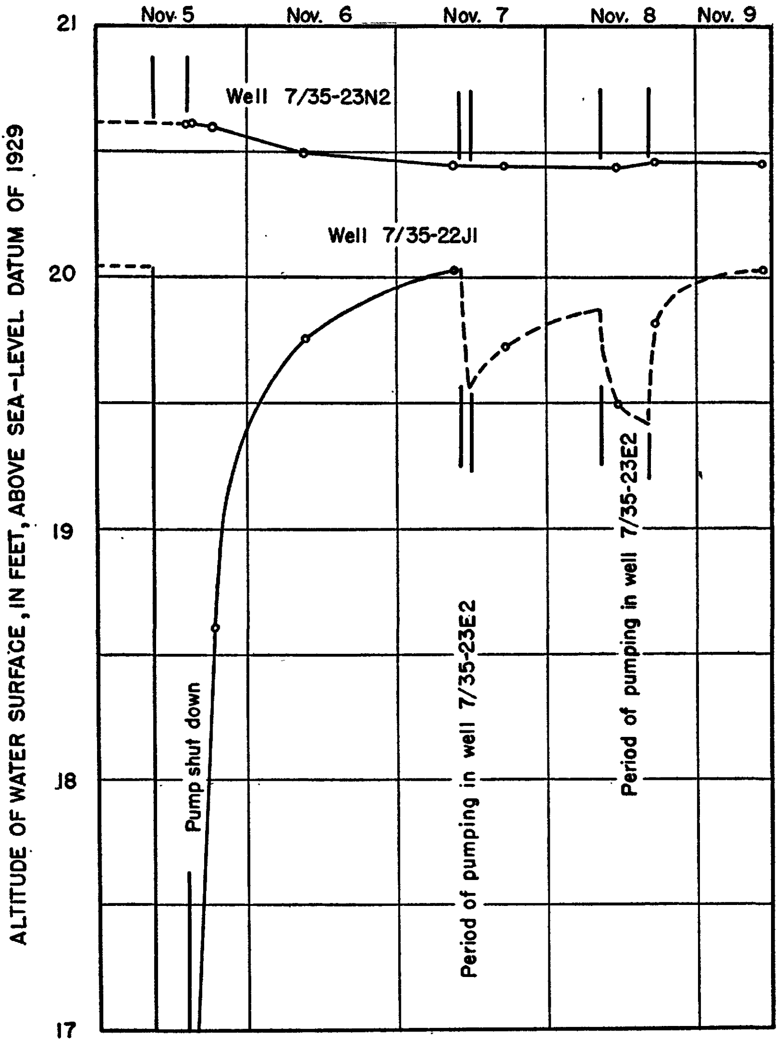

FIGURE 19.—Fluctuations of water level in wells 7/35-23N2 (shallow) and 7/34-22J1 (deep) showing the effect on the water table of pumping from the deep water body.

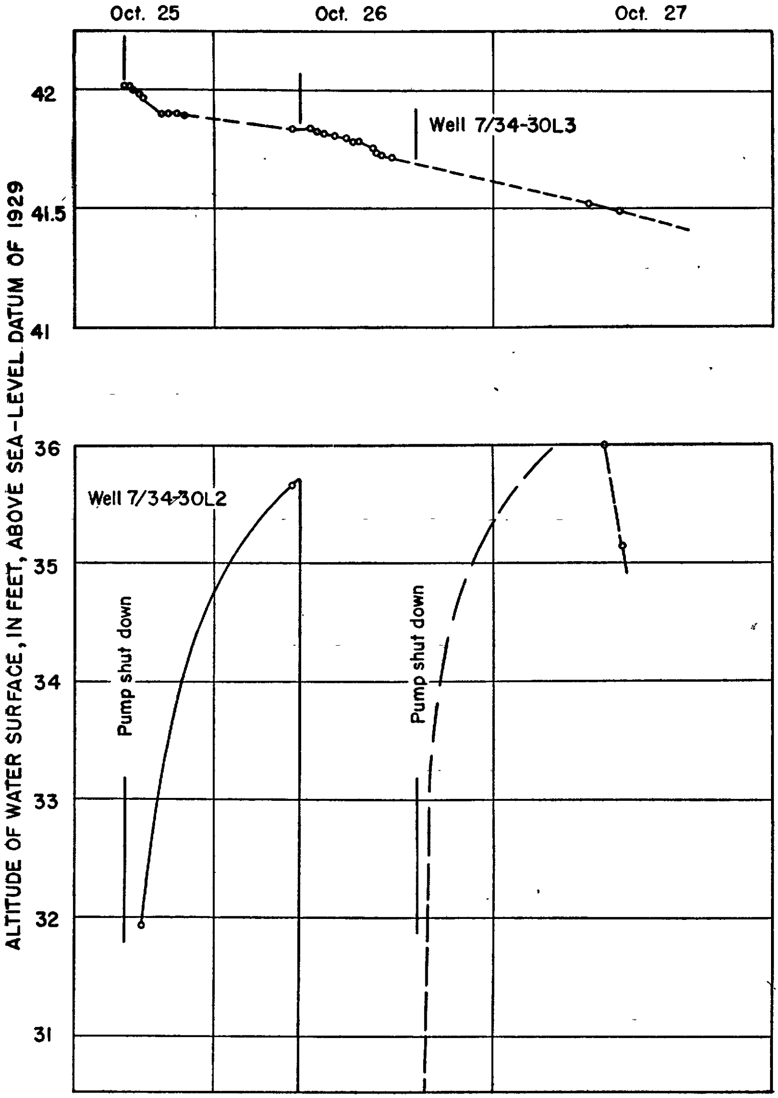

FIGURE 20.—Fluctuations of water level in wells 7/34–30L3 (shallow) and 7/34–30L2 (deep) showing the effect on the water table of pumping from the deep water body.

tion of shallow and deep water at this place, and hence no possible interchange.

Figure 19 shows the fluctuations of water level November 5 to 9, 1945, in shallow well 7/35–23N2, 17 feet deep and 60 feet from well 7/35–22J1, reported to be 185 feet deep. The adjacent deep well was pumped for 6 hours on November 5. Decline of the shallow water level did not begin until after the pump had been shut down. On subsequent days the shallow water level declined a total of about 0.15

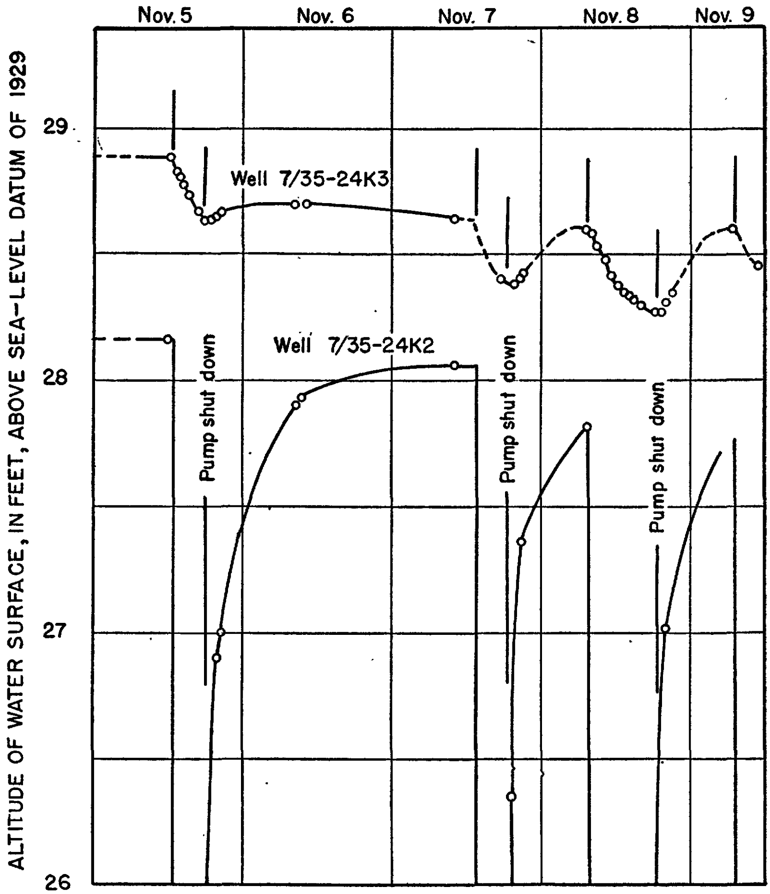

FIGURE 21.—Fluctuations of water level in wells 7/35-24K3 (shallow) and 7/35-24K2 (deep) showing the effect on the water table of pumping from the deep water body.

foot apparently in response to pumping November 7 and 8 in well 7/35–23E2, about half a mile to the northeast. These data are interpreted to indicate that there is essentially no interconnection between shallow and deep water bodies near well 7/35–22J1 but that there is interconnection in the area to the northeast near well 7/34–23E2.

Figure 20 shows the fluctuations of water level in the shallow well 7/34–30L3 in relation to pumping on October 25, 26, and 27 from the deep irrigation well 7/34–30L2, reported to be 194 feet deep. The shallow water level is 5 to 7 feet above the static head of the deep water; yet the shallow water seems to respond to pumping from the deep water in that declines of a few hundredths coincide in general with the pumping periods. These small declines are superimposed on a general downward trend and do not start until 4 to 5 hours after pumping begins. Interconnection between shallow and deep water is inferred to be either remote from this area or considerably retarded at this place. The general downward trend of shallow water level which continued for several days in association with daily pumping after the detailed test is probably brought about largely by depletion because of pumping in outlying areas.

Figure 21 shows the effect of pumping from the deep well 7/35–24K2 on the water level in the shallow well 7/35–24K3, 24 feet deep and 20 feet from the pumped well. The shallow water level declined promptly as soon as the pump in the deep well was turned on and in an appreciable amount during the pumping run, though probably not so much as the decline of deep water head at the site of the shallow well. Thus, interconnection between shallow and deep water bodies at this place is considered to be direct, though somewhat limited in freedom.

Summary of evidence.—Unfortunately, the hydrologic data bearing on the degree of interconnection of shallow and deep water in the areas of interchange and of no interchange are not comparable. The collection of more data is desirable, especially pumping tests on companion shallow and deep wells in the area of interchange, and continued observations of long-term water-level fluctuations in both areas. However, it is concluded tentatively that the existing data—the water-table contours near Robinson Bridge, the seasonal fluctuations of water level in paired shallow and deep wells, and the fluctuations of shallow-water level in response to pumping from deep wells—bear out the geologic inference that nearly all the interchange between shallow and deep water can take place in the southern and eastern parts of the Lompoc plain, and chiefly near the river. Some interchange also can take place in secs. 23 and 24, T. 7 N., R. 35 W. Conversely, very little interchange can take place in most of the plain within the area of predominately impermeable deposits in the upper member of the younger alluvium. Hydrologic data are not available for the area in the extreme western part of the plain, but well logs show predominately fine grained materials, and the shallow water is considered to be hydraulically discontinuous with the deep water.

Thus, pumping from the deep water body can and does cause a small part of the seasonal lowering of shallow water level, and hence decrease in shallow-water storage, within at least part of the Lompoc plain. The effect is probably felt mainly in the south and east marginal parts of the plain, and in the area in secs. 23 and 24, T. 7 N., R. 35 W., where interconnection is freest. Declines of water level in these areas probably cause a lesser decline in the remaining parts of the shallow water body by local spread of cones of depression, and by intercepting along the south margin of the plain part of the normal replenishment seeping from the tributary streams in that area. Accordingly, the seasonal decline of shallow water levels represents in part actual replenishment to the deep water body. The amount of replenishment has been estimated indirectly in previous paragraphs (p. 134).

DEEP WATER BODY

SEGREGATION OF WATER-BEARING ZONES

The deep water body is defined as the water in the lower member of the younger alluvium and underlying formations of unconsolidated material comprising the buried terrace deposits and the Orcutt, Paso Robles, and Careaga formations. The lower member of the younger alluvium is the most permeable of the water-bearing materials and supplies water to most of the irrigation wells in the area. It is therefore termed the main water-bearing zone. The terrace deposits beneath the southern one-third of the Lompoc plain also supply water to irrigation wells in that area and are termed the secondary water-bearing zone. The deep water in lenses of permeable material in the Orcutt and Paso Robles formations and in the Careaga sand is tapped by few wells and is less readily available as the enclosing deposits are less permeable. However, the water is probably all rather interconnected and is confluent with water in the main water-bearing zone, where the containing formations are in contact beneath the Lompoc plain with the lower member of the younger alluvium. Water in the Careaga sand is also confluent with water in the secondary zone. (See pl. 5.) Hence the waters in all these formations and zones are considered parts of the same water body, but they occur in distinct water-bearing zones. In the following pages the deep water body is discussed according to these several zones.

Main water-bearing zone.—The main water-bearing zone, or lower member of the younger alluvium, comprises three separate segments: a principal segment which extends beneath nearly the full length of the Lompoc plain (pl. 5), a secondary segment or tongue that extends southeastward through The Narrows, and subsidiary tongues or lobes not clearly delineated which probably extend toward San Miguelito Creek, San Pascual, Rodeo, and Lompoc canyons along the south margin of the plain. (See pl. 5.)

The most extensive segment of the zone is overlain by the predominantly impermeable deposits of the upper member of the younger alluvium (p. 47), which acts as a confining bed beneath which the water in the main zone is held under artesian pressure. Beneath the eastern part of the Lompoc plain the water in the main zone rises in wells to within 35 to 40 feet of the land surface, or about 80 feet above the bottom of the confining bed; and in the western part, as in well 7/35–18J1, to within 2 to 5 feet of the land surface, or about 110 feet above the bottom of the confining bed. (See pl. 5.) In this well the water at times stands in the casing as much as 1 foot above the land surface.

The secondary tongue or lobe that extends into The Narrows begins about 1 mile below Robinson Bridge. This tongue is largely outside the area of the fine-grained deposits in the overlying upper member; and hence, although the contained water appears to be confined to some degree where its level stands above the base of the upper member, it is in general considered more or less readily confluent with the shallow water body. Beginning about 3,000 feet below Robinson Bridge and extending upstream the water in this segment is confluent through the river-channel deposits with the river, and its head apparently adjusts itself to river stage. Hence interchange of water takes place, and in that sense this part of the deep water body is essentially unconfined. Similarly, the third segment is mainly outside the area of the predominately impermeable deposits, and its contained water is considered mainly unconfined, though it may be confined locally.

Secondary water-bearing zone.—The secondary water-bearing zone consists of the buried bodies of terrace deposits, together with local overlying lenses of gravel and sand in the marginal part of the younger alluvium beneath the southern one-third of the Lompoc plain east of Lompoc Canyon. These deposits are comparatively thin and discontinuous, yet they supply considerable water to irrigation wells drilled outside the southern limit of the main water-bearing zone.

The lenses of permeable material in which the water occurs are overlain by lenses of clay and of silt. Also, the water level in certain of the wells that penetrate the zone, such as well 7/34–32R2, exhibits a pressure effect from pumping in nearby wells. Accordingly, the water is confined at least locally. However, it is unconfined in the sense that water is enabled to percolate fairly readily to the zone by devious routes, especially through the lenses of gravel and sand that occur near the mouths of San Miguelito Canyon and other canyons.

The water is confluent with water in the underlying Careaga sand and with water in the main water-bearing zone directly through the already described third segment of that zone. Therefore, it is an integral part of the deep water body.

Water in the Orcutt sand.—Little information is at hand concerning water in the Orcutt sand. In its main area of outcrop north of the Lompoc plain (pl. 3) the formation is essentially not tapped by wells. A few old wells, such as 7/34–19H1 and 7/34–17M1, probably derived water from the Orcutt sand, but details as to the mode of occurrence and availability of the water are not known. However, several wells drilled in the central and southern parts of the Lompoc plain, such as 7/35–24B2, 7/35–25D1, 7/35–25P1, 7/35–35C2, and others (see pl. 5) penetrate and obtain water from deposits believed to be part of the

Orcutt sand. These wells do not reveal distinctive features of the occurrence of water that would differentiate it from water in the overlying main water-bearing zone. Accordingly, the parts of the Orcutt sand that lie beneath the Lompoc plain are considered part of the main water-bearing zone.

Outside the Lompoc plain where the Orcutt sand is not overlain by other deposits its contained water is possibly separated from the deep water body. On the north side water may be semiperched locally by impermeable beds of clay at the base of the formation, as it seems to be in the Santa Rita Valley, but at most places water in the Orcutt sand probably is enabled to seep downward into the underlying Paso Robles formation. On the south side of the Lompoc plain the beds of the Orcutt sand dip toward the plain, and there, as along the north margin, the water moves along the bedding into the main water-bearing zone.

Water in the Paso Robles formation.—The Paso Robles formation is tapped by several wells in the extreme eastern part of the Lompoc plain. Most wells in secs. 23, 24, 25, and 26, T. 7 N., R. 34 W., enter the Paso Robles after passing through the upper member of the younger alluvium. Outside the area of the plain a few wells, such as 7/33–17N1 and 7/33–30B1, enter the Paso Robles directly or after penetrating only a thin cover of soil or alluvium. The water occurs in lenses of sand and of gravel, or of sand and gravel, some of which are fairly thick and coarse-grained and transmit the water fairly readily. The water stands at depths ranging from a few feet to several hundred feet below the land surface, depending on the altitude, or topographic position, of the well. For example, on April 26, 1945, in wells 7/34–26A2 and 7/34–26F1, which have altitudes of 113 and 109 feet, respectively, the water level stood at 36.12 and 33.34 feet, respectively, below the land surface. On the other hand, the water level on the same day in well 7/33–30C1, which has an altitude of 233 feet, was 150.57 feet below land surface. Static water level in well 7/33–17N1 at an altitude of 344 feet is reported to have been 275 feet below the land surface when the well was drilled in 1925.

The records of the wells and the fluctuations of water levels indicate that the water is largely unconfined. In some wells the water is reported to have risen slightly when drilled, but the rise probably indicates local rather than general conditions. Water is probably enabled to percolate throughout the formation, though doubtless slowly and by devious routes.

Lenses of water-bearing gravel in the Paso Robles formation beneath the Lompoc plain are in contact with the main water-bearing zone (see pl. 5), and the water in the two zones is confluent and essentially the same water body. Water in the Paso Robles formation also underlies and may be confluent with the shallow water body in the upper member of the younger alluvium. However, the fluctuations of water levels in the paired shallow and deep wells (7/34–26F4 and 7/34–26F1, p. 136 and fig. 15) indicate that interchange between the shallow and deep water is not free.

Water in the Careaga sand.—The Careaga sand underlies the other water-bearing formations in the Lompoc subarea, and beneath the Lompoc plain it is encountered by many wells. It is saturated with water and probably supplies a large percentage of the water withdrawn from the main water-bearing zone. Most wells, however, are ordinarily plugged within the formation, and the casings are perforated opposite bodies of sand and of gravel in the overlying formations. They do not derive water directly from the Careaga. Therefore, little data are at hand concerning the occurrence of water in the Careaga sand alone.

Because it is in direct contact with a large part of the main water-bearing zone (pl. 5), the head of water in wells that tap that zone probably represents fairly closely the head of water in the Careaga sand. However, outside the zone the static head and direction of movement of the water in the Careaga sand are unknown. Well 7/35–25P1, which is 503 feet deep, penetrates 105 feet of deposits in the bottom that are assigned to the Careaga sand. The casing is perforated from 48 to 493 feet; hence, in both the Careaga and overlying formations. A few measurements suggest that the static water level in the well has been 1 foot to 2 feet higher than in nearby wells that tap only the main water-bearing zone. Thus, within the plain the natural head of water in the Careaga sand may be slightly higher than in the main water-bearing zone alone.

Water in the Careaga sand is in contact with the secondary water-bearing zone beneath the southern part of the Lompoc plain (pl. 5). As there are no continuous intervening strata of impermeable deposits, water is enabled to pass from one zone to the other depending on the local hydraulic gradient. Beneath the easternmost part of the Lompoc plain and outside the plain on the north, northeast, and east, the Careaga sand is overlain by the Paso Robles formation, but water may not pass readily from the Paso Robles formation because of the beds of impermeable clay at the base of that formation. Accordingly, the water in the Careaga sand may be replenished to a large extent by infiltration of rain on its outcrop areas (pl. 3) and to a lesser extent by passage through the Paso Robles formation.

MOVEMENT AND SOURCE OF THE DEEP WATER

Plate 7 shows contours representing the pressure surface of the deep water body in the spring of 1941. It is based on the highest observed water levels, which occurred chiefly in March or April. The map thus covers a time range of several weeks. Water-level measurements were mostly those made by the Geological Survey, though some measurements were obtained from city of Santa Barbara records. Except to the extent that water levels beneath the plain are affected by the head of water in the Careaga sand, the contours represent the head of water in the main water-bearing zone beneath most of the Lompoc plain, in the secondary zone beneath the southern one-third of the plain east of Lompoc Canyon, and in the Paso Robles formation in the area including and northeast of the extreme eastern part of the plain. At the south margin of the Lompoc plain and in the vicinity of Robinson Bridge the contours may nearly coincide at places with the level of water in the shallow water body. As discussed elsewhere, the shallow water body has stood from 0.5 foot to 10 feet higher than the static level of the deep body. Therefore the contours have not been adjusted to water levels in wells less than 50 feet deep. The contours are solid lines where control is good but are dashed where control is poor or interpretation is questionable.

The contours show a general movement of water more or less westward down the valley to an outlet at the ocean. Because, generally speaking, the upper member of the younger alluvium (see log of well 7/35–18J1) is poorly permeable, it is inferred that the outlet is a submarine one a short distance offshore and that the water does not leak upward to the shallow body to any appreciable extent. The contours also show that the piezometric surface slopes northwesterly from the south side of the valley, especially from near the mouth of San Miguelito Canyon. Thus, water in the secondary zone appears to be moving from sources along the south side of the valley, and discharging into the main water-bearing zone. Similarly water appears to be moving toward the main water-bearing zone from the older deposits beneath the terraces north of the Lompoc plain. In the area northeast of the plain data are scanty, and there may actually be a depression in the water surface there. In any event, the gradient is very low and would permit only slow movement. In general only west of Purisima Canyon is there appreciable movement of water from the north and northeast. At the east end of the Lompoc plain water evidently moves westward and northwestward from the Santa Rita Hills.

At and for a short distance downstream from Robinson Bridge the water-surface contours show a fairly steep gradient west and northwest of The Narrows. Contours along the river upstream from Robinson Bridge are based on poor data and are generalized. When the basic measurements were made the river was at a high stage and the relation of river level to water level differed widely from place to place.

Thus, within the deep body, water appears to move centripetally toward the main water-bearing zone from the north, the east, and the south. Because the levels were measured in the spring they represent the effect of water moving from source areas rather than the effect of withdrawals. The main and secondary water-bearing zones, which sustain nearly all the artificial draft, thus appear to act as huge gravel-enveloped wells through which water is withdrawn from underlying and more extensive finer-grained material. Ultimately, of course, the source of water is rain that falls on the outcrops of the water-bearing formations and is transmitted underground or that reaches the area as runoff in the Santa Ynez River and the tributary streams. However, on the basis of the water-level contour map and the known relation of the several water-bearing formations to each other beneath the Lompoc plain, three specific and more immediate sources may be distinguished. In order of relative volume of contribution these are: the Orcutt, Paso Robles, and Careaga formations by transmission underground from the margins of the plain, and from below; the shallow water-bearing zone, partly by continual transmission of water to the main and secondary zones from the streams and partly by seasonal unwatering as a result of pumping from the main and secondary zones; and the Santa Ynez River by seepage loss in the first 3,000 feet below Robinson Bridge and in small part in secs. 23 and 24, T. 7 N., R. 35 W., and by movement of underflow through the tongue of the main zone that extends upstream through The Narrows. The inflow of water to the main and secondary zones from each of these sources is discussed in ensuing paragraphs.

REPLENISHMENT OF THE MAIN AND SECONDARY WATER-BEARING ZONES

Replenishment from the Santa Ynez River.—As has been discussed, the Santa Ynez River supplies no water to the secondary water-bearing zone. It does, however, supply water to the main water-bearing zone partly by direct inflow of underflow through The Narrows and partly by rapid percolation through the shallow zone chiefly in the area near Robinson Bridge but in small part in the area below Dyer Bridge in secs. 23 and 24, T. 7 N., R. 35 W.

Miscellaneous stream-flow measurements (p. 95) show loss from the river between Robinson Bridge and Rucker crossing during low water at an average rate of about 3 second-feet, which amounts to 2,200 acre-feet in a year. Of this annual loss, about 250 acre-feet remains in the shallow zone (p. 128); the remainder, or 1,950 acre-feet, passes to the main zone. In addition, underflow transmitted through The Narrows has been computed to be about 600 acre-feet a year (p. 80).

Finally, seepage loss from the river below Dyer Bridge also represents some inflow to the main water-bearing zone. The loss has not been measured but apparently takes place only during the irrigation season and as a direct result of pumping from nearby irrigation and public supply wells. Assuming that these wells pump water in proportion to their numerical percentage of the total number of irrigation and public-supply wells in the valley, they pump about 9.3 percent of the average annual draft from the valley, or 930 acre-feet. Most of this draft probably is supplied from elsewhere in the main zone and from the underlying formations, and only a small part is derived indirectly from the river nearby. If as much as one-third is supplied indirectly by the river, its contribution would be about 300 acre-feet a year. If this figure is approximately correct, the total contribution from the Santa Ynez River to the main water-bearing zone is 1,950 acre-feet seepage loss below Robinson Bridge, 600 acre-feet underflow through The Narrows, and 300 acre-feet seepage loss below Dyer Bridge, or a total average of 2,850 acre-feet per year. This amount is less than 30 percent of the average yearly pumpage in recent years. Accordingly, the irrigation requirements of the Lompoc plain seem to be sustained to only a small extent by the Santa Ynez River.

Replenishment from underlying formations.—Although data are few, it is possible to arrive at a rough approximation of the quantity of water entering the main water-bearing zone from the Orcutt and Paso Robles formations and the Careaga sand. The quantity depends on the cross-sectional area of the deposits that transmit the water, the permeability of those deposits, and the hydraulic gradient in them—expressed by the equation, $Q=PIA$.

The cross-sectional area is determined from plate 4, which shows that the three formations named are so situated as to transmit water directly to the main water-bearing zone. The contour map, plate 7, shows that there is virtually no hydraulic gradient, however, toward the zone approximately east of Purisima Canyon. Accordingly, that area is excluded from consideration. The effective cross section, then, is west of Purisima Canyon, below the top of the water-saturated zone about as far as the bend in the line of section, and thence west below the projected top of the main water-bearing zone. The area is about 16,000,000 square feet in the plane of the section, but adjusted to the angle made with the contours is about 13,500,000 square feet.

The permeability can only be approximated because the deposits vary so widely in grain size and degree of sorting. The results of laboratory tests of the permeability of the Careaga sand, which constitutes about 78 percent of the effective cross section, are interpreted to indicate an average permeability for the saturated, unexposed material of 70 gallons per day per square foot. Material in the Paso Robles and Orcutt formations ranges widely in permeability, some lenses of gravel being relatively much more permeable, and lenses of clay being relatively less permeable. The formations as a whole may have about the same average permeability as the Careaga. Although it is considered conservative the average permeability of the entire section is taken as 70 gallons per day per square foot.

The hydraulic gradient is not accurately known, as there are few wells that tap the deposits north of the plain and none that are known to penetrate the Careaga sand near the line of section. The data at hand (pl. 7) give an approximate hydraulic gradient in the Paso Robles formation. Possibly the water in the Careaga has a higher head (p. 150), but it probably does not have a lower head. Accordingly, the gradient, too, is conservative. The effective gradient across the line of section is about 10 feet per mile. Applying these figures to the formula $Q=PIA$ where Q is the quantity desired in gallons a day, P is a permeability of 70 gallons per day per square foot, I is the hydraulic gradient of 10 feet per mile, and A is the effective adjusted area, or 13,500,000 square feet, then Q is about 1,800,000 gallons a day. Thus, the quantity of water that can, under these assumptions, enter the main water-bearing zone from the Careaga, Paso Robles, and Orcutt formations on the north is on the order of 2,000 acre-feet a year.

In addition, some water is contributed from the Orcutt and Careaga sands on the south side of the valley. The cross-sectional area beneath the younger alluvium along a line extending southeastward from the outcrop of Tertiary rocks (pl. 3) near the southwest corner sec. 22, T. 7 N., R. 35 W., about to the mouth of Rodeo Canyon, about 3 miles long, is about 3,168,000 square feet. The hydraulic gradient from the contour map (pl. 7) is about 10 feet per mile. Adjusted for the angle between the line of section and direction of the gradient, it is an effective gradient of about 6 feet per mile. Assume that the average permeability is 100 gallons per day per square foot because gravel beds of probably rather high permeability in the Orcutt sand may serve to raise the low average permeability of the Careaga sand somewhat. Under these figures, the quantity of water moving from the southwest to the Lompoc plain, substituted in the same equation, $Q=PIA$, is computed to be about 360,000 gallons a day, or 400 acre-feet a year.

From Rodeo Canyon east about to its limit of outcrop the Careaga sand alone also transmits a small additional quantity of water. The length of section is about 2.5 miles, and the average thickness of Careaga sand (sec. *B–B′*, pl. 4) is about 200 feet, making a cross-sectional area about 2,640,000 square feet. The hydraulic gradient (pl. 7) averages about 5 feet per mile at an angle of 25° to the line of section, or an effective gradient of about 2 feet per mile. The permeability of the Careaga sand is taken as 70 gallons per day per square foot. If these figures are inserted in the equation, $Q=PIA$, the quantity of water transmitted is 70,000 gallons a day, or about 80 acre-feet a year. The inflow from the older formations along the south side of the valley is then about 500 acre-feet a year, making a total contribution from the older formations of about 2,500 acre-feet a year.

Replenishment from the shallow water-bearing zone.—As discussed on pages 132–133, the total summer discharge from the shallow water-bearing zone has been about 8,000 acre-feet, of which about 6,600 is accounted for by drainage to the Santa Ynez River at the lower end of the Lompoc plain and by evapotranspiration losses. The remainder, 1,400 acre-feet, is thought to percolate to the main and secondary water-bearing zones. This percolation takes place in summer, but an additional quantity percolates to the main water-bearing zone in winter as long as there remains a difference in head between shallow and deep water. The ratio between the quantity percolating in winter and the quantity percolating in summer would be proportional to the difference in head between shallow and deep water in the two seasons. From the hydrographs in figures 15 and 16 the average estimated difference in head in the 6 winter months, October through March, is to the average estimated difference in the 6 summer months as 5.8 is to 10. Assuming that these hydrographs are representative, the proportionate downward percolation in winter, then, is about 800 acre-feet, making a total contribution from the shallow water-bearing zone of about 2,200 acre-feet a year.

PUMPAGE OF GROUND WATER

Most of the water discharged from the deep water-bearing zones of the Lompoc subarea is discharged artificially by withdrawals through wells. Only a few wells draw water from the shallow zone alone, and these are ordinarily equipped with windmills capable of pumping only small quantities of water. Also, only a few of the deeper irrigation wells have casings perforated in the shallow zone. Therefore, by far the greatest amount of water pumped is taken from deep wells that penetrate only the main or secondary water-bearing zones. A small amount of water is pumped each year directly from the river.

Practically all the irrigation wells are equipped with electrically driven pumps. It is therefore feasible and fairly accurate to estimate the amount of water pumped by computations from the amount of electric energy consumed. The annual consumption of electric energy in the vicinity of Lompoc for the years 1935 to 1944, inclusive, was compiled by the San Joaquin Power Division of the Pacific Gas &

Electric Co. That company also permitted access to results of efficiency tests on about 60 wells in the area. The results of 110 tests made during the period 1933–44 give an average of 135 kilowatt-hours as the power required during that period to deliver 1 acre-foot of water to the crops. The annual pumpage was determined by dividing the annual kilowatt-hour consumption by 135. Also, data were assembled regarding the total draft from wells by Camp Cooke since its establishment, and that part of the supply for the city of Lompoc which is pumped from wells. Table 25 gives the total pumpage from all these sources.

TABLE 25.—*Annual pumpage from the main and secondary water-bearing zones of the Lompoc plain*

[Compiled from data furnished by the Pacific Gas & Electric Co., Camp Cooke Military Reservation Reservation, and the city of Lompoc]

Year	Acre-feet	Year	Acre-feet
1935	8, 700	1941	6, 300
1936	12, 700	1942	8, 250
1937	10, 200	1943	10, 800
1938	8, 800	1944	12, 850
1939	10, 000		
1940	11, 000	10-year average	10, 000

Pumpage in the year 1944 was the greatest for the period but was only slightly higher than in 1936. It declined from 1936 to 1938, increased somewhat in 1939 and 1940, and then decreased greatly in 1941 following the excessive rainfall of that winter. Thereupon, it increased steadily to 1944. The increase from 1942 to 1944 is in part due to the additional draft for Camp Cooke.

According to information compiled by the Bureau of Reclamation, irrigation was begun in the lower Santa Ynez River basin by diverting a small amount of water from the river in 1899. Pumping from wells began a few years later, and in 1912 an area amounting to 1,590 acres was irrigated. The Bureau has also estimated that during 1943 and 1944 the average area irrigated amounted to 7,700 acres. Taking the average from the foregoing table as about 10,000 acre-feet, in recent years that amount has been used to irrigate about 7,700 acres, indicating a duty of water amounting to 1.3 acre-feet per acre. This may be a little high, because on some land more than one irrigated crop was grown; but on the other hand, some water was pumped from the river that would tend to compensate for part of the acreage on which two crops were irrigated.

RELATION OF PUMPAGE TO FLUCTUATIONS OF WATER LEVEL

Little information is available regarding the water levels when irrigation from wells was first begun on the Lompoc plain. Systematic

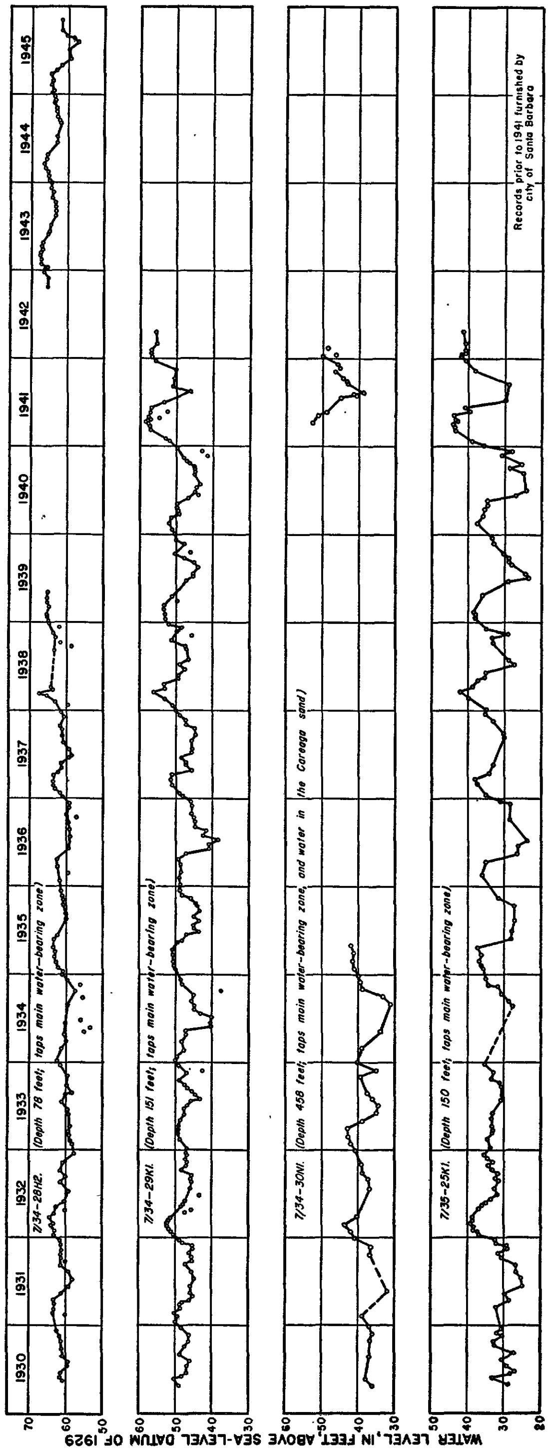

FIGURE 22.—Fluctuations of water levels in four wells on the Lompoc plain, 1930–45.

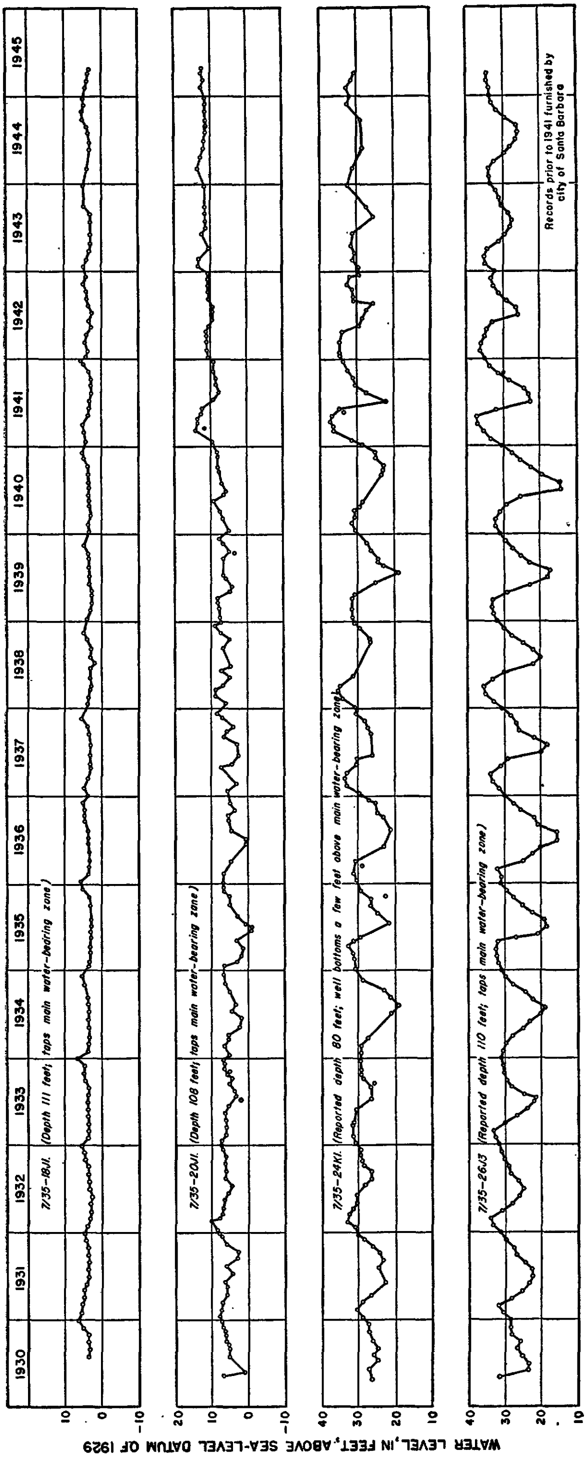

FIGURE 23.—Fluctuations of water levels in four wells on the Lompoc plain, 1930–45.

measurement of water levels in wells was begun by the city of Santa Barbara in 1930 and continued until the spring of 1942. Measurements of the water levels in some of the key wells measured by the city were begun by the United States Geological Survey in the spring of 1941. Thus, some of the wells were measured by both organizations for a period of about a year. The water-level records of four of these wells are shown graphically on figure 22 and four are shown on figure 23. These wells all tap the main water-bearing zone, which is the chief source of withdrawals. The graphs of the water levels in well 7/35–26J3 (fig. 23) and in well 7/34–28H2 (fig. 22) in the years 1942–45 are based on the graphs drawn by continuous water-stage recorders. The other graphs are based on periodic water-level measurements made with a steel tape mostly once a month or once a week, though in some summer months measurements were not made because the wells were being pumped at the time they were visited. Water levels declined 1 foot to 2 feet from 1930 to 1936 and then rose 3 to 4 feet from 1937 to 1944. Thus, the average water level in all the wells during the spring of 1944 was about 2 feet higher than during the spring of 1931. Therefore, figures 22 and 23 show that there has been no net decline of deep water levels in the Lompoc plain during the period of record from 1930 to 1944.

Although the total pumpage from wells on the Lompoc plain amounted to more than 12,000 acre-feet during the summer months of 1944, figures 22 and 23 show that the water levels were lowered only 2 to 8 feet during the pumping season and that they rose again nearly to the previous height after a few months of rest. The effect of pumpage during previous seasons has been comparable to that during 1944 and has caused no permanent lowering of the water levels during the period of record from 1930 to 1944. It is believed, therefore, that the inflow to the main and secondary water-bearing zones beneath the Lompoc plain has been about equal to the amount withdrawn since pumping from wells began.

YIELD OF GROUND-WATER BODIES IN THE LOMPOC SUBAREA

The perennial yield of ground-water bodies, or the amount of water that may be drawn from them without permanent depletion of supply, depends on the perennial inflow to the bodies. Though the main and secondary water-bearing zones of the deep water body supply nearly all of the pumpage from wells in the Lompoc subarea, these zones, in turn, are replenished in some degree by the shallow-water-bearing zone. Hence the three zones are here first considered together. The following table summarizes the inflow to and outflow from these three zones in the Lompoc plain considered as a unit:

Over-all hydrologic equation for the Lompoc plain, 1935-44

	Acre-feet a year
Inflow:	
Santa Ynez River by underflow and seepage loss	3, 100
Runoff from streams entering the valley on the south	5, 400
Infiltration of rainfall on the plain	4, 800
Infiltration of excess irrigation water	1, 500
Orcutt, Paso Robles, and Careaga formations by underground transfer	2, 500
Total	17, 300
Outflow:	
Increment for net change of shallow-water storage converted to average	1, 000
Discharge of shallow ground-water body to the river	1, 500
Discharge by evaporation and transpiration	5, 100
Discharge of the main water-bearing zone to the sea	400
Pumpage	10, 000
Total	18, 000

Thus, the over-all equation approximately balances, with an excess of outflow over inflow amounting to an average of 700 acre-feet a year. Because many of the elements were estimated roughly, it is thought that the equation balances within possible limits of error. This is supported by the long-term records of water-level fluctuations, which show that there has been no net decline of either shallow or deep water level in the period 1935–44. Hence, there probably has been no large excess of outflow over inflow.

In order partly to check the elements in the computations, subequations were drawn up separately for the shallow water-bearing zone on the one hand and the main and secondary zones on the other. These equations are given in the two following tables:

Hydrologic equation for the shallow water-bearing zone of the Lompoc plain, 1935-44

	Acre-feet a year
Inflow:	
Runoff from streams entering the valley on the south	5, 400
Infiltration from the Santa Ynez River	250
Infiltration of rainfall on the plain	4, 800
Infiltration of excess irrigation water	1, 500
Total	11, 950
Outflow:	
Discharge of shallow ground water to the river	1, 500
Discharge by evaporation and transpiration	5, 100
Downward percolation to the deep water body	2, 200
Increment for net change of storage, converted to average	1, 000
Total	9, 800

Hydrologic equation for the main and secondary water-bearing zones of the Lompoc plain, 1935-44

	Acre-feet a year
Inflow:	
Santa Ynez River by underflow and seepage loss	2, 850
Orcutt, Paso Robles, and Careaga formations by underground transfer	2, 500
Downward percolation from the shallow water-bearing zone	2, 200
Total	7, 550
Outflow:	
Pumpage	10, 000
Discharge of the main water-bearing zone to the sea	400
Total	10, 400

These tables show an apparent excess of average inflow to the shallow water-bearing zone of about 2,150 acre-feet a year and an apparent deficiency of average inflow to the main and secondary water-bearing zones of about 2,850 acre-feet a year. These discrepancies suggest that the lack of balance of the equations may be due in part to an erroneously low estimate of the amount of percolation from the shallow to the main and secondary water-bearing zones. Also, however, the computed contribution from the river may be somewhat too low in that during moderately high stages, when gagings do not show small losses, the gradient away from the river may be steepened sufficiently that the seepage loss perhaps for several weeks at a time is somewhat greater than the estimated 3 second-feet. Furthermore, the estimated inflow to the main and secondary zones from the Orcutt, Paso Robles, and Careaga formations may also be considerably too low, However, if so, inflow from those formations is probably greater than the natural replenishment to them. For example, let it be assumed that all the rain that percolates below the influence of vegetation outside the Lompoc plain on the outcrop areas of the Orcutt, Paso Robles, and Careaga formations, and within the area of favorable hydraulic gradient, is able to reach the deep water body. The area of outcrop (see pl. 3) on both sides of the valley is roughly 20 square miles, or about 13,000 acres. The rainfall, as measured at Lompoc, averaged 19.28 inches for the years 1935–44, but probably only a small part of it has penetrated to the deep water body. Blaney (1930, pp. 30, 54) has shown that the consumptive use of water by native brush has been at least 1.5 acre-feet per acre per year in five areas in southern California.

Thus, any excess of rainfall over 1.5 feet, or 18 inches, is considered available for runoff and for deep percolation. Subtracting 18 inches from the seasonal rainfall at Lompoc gives an excess of 2.46, 7.40, 22.69, and 0.47 inches in the years 1937, 1938, 1941, and 1942, respectively. In other years the rainfall was less than 18 inches. These excesses average 3.3 inches per year for the 10-year period, or 3,600 acre-feet a year on the whole area. Part of this amount probably runs off, and the deep infiltration may have averaged somewhat less. If it amounts to 3,000 acre-feet the recharge to the deep water body is little more than the amount computed to pass from the underlying deposits to the main water-bearing zone (p. 139). If the computed amount is much too small a real deficiency may exist. Further, because the 10-year period here considered includes the year of greatest recorded rainfall the long-term average may be appreciably less.

If a deficiency exists it would be represented by unwatering in the outcrop areas of these older formations. Taking the total areas as 13,000 acres and the specific yield as 14 percent (the value for the younger alluvium, p. 133, which may be high for the older formations), a deficiency of replenishment in the outcrop areas amounting to 1,000 acre-feet in a year would cause a decline of water level on the order of 0.6 foot average over the entire area. Unfortunately, records of water levels in the outcrop areas are not available to check this inference. Furthermore, an excessive draft on the older formations would eventually cause a decrease of inflow with accompanying lowering of water levels in wells within the Lompoc plain. Continuing measurements of key observation wells to check this eventuality is highly desirable.

Thus, for the area as a whole there appears to be no sizeable available excess of replenishment over current withdrawals. Hence the current withdrawals are thought to be approximately at the perennial yield. Some increased pumpage might, by lowering water levels, induce additional depletion from the shallow zone and thus might salvage some of the natural loss by evapotranspiration and discharge to the river. It probably would also increase the contribution from the river, but the amount of that increase under existing knowledge cannot be stated definitely. However, such increased pumpage would also cause an additional draft on the water in the older formations which could not be sustained indefinitely.

QUALITY OF WATER

For preliminary study of the quality of ground waters in the Santa Ynez River basin, the Geological Survey assembled available antecedent analyses made by other agencies and in addition collected 123 water samples from representative wells. For these, complete analyses were made on 12 samples, and partial analyses—including determinations of chloride, hardness, and specific electrical conductance—were made on 111 samples. Of the partial analyses, 96 were for samples collected in the Lompoc subarea, 5 in the Santa Rita subarea, 7 in the Buellton subarea, and 3 in the Santa Ynez subarea. Of the complete analyses, 8 were of water from the Lompoc subarea and 2 each from the Santa Rita and Santa Ynez subareas. Of the complete analyses made by other agencies, 46 were for water samples taken from wells in the Lompoc subarea. These were made by the College of Agriculture of the University of California and supplied by the office of the Farm Advisor in Santa Barbara. In addition, 17 analyses were for samples of stream and well waters within the entire valley; these were made by the Bureau of Standards and were supplied by the Bureau of Reclamation.

For the ground water of the Lompoc subarea, where data on chemical quality are critical, nearly all the analyses are of water from the deep water body. The partial analyses indicate that chloride concentrations range from 77 to 2,050 parts per million but that concentrations of more than 300 parts are exceptional. The variation appears to be governed in large part by the different formations that contain the deep water in different parts of the area. For example, water in wells that tap the Paso Robles and Careaga formations in the extreme eastern part of the Lompoc plain has a chloride concentration that ranges from about 145 to about 200 parts per million. Water associated with the consolidated rocks has a chloride concentration of from 100 to 130 parts. Two shallow wells, 7/34–28F1 and 7/35–20J1, have abnormally high chloride concentrations. In these wells the concentrations have varied from time to time but consistently have been more than 800 and 1,500 parts per million of chloride, respectively. Two other shallow wells near the south side of the plain, 6/34–4D1 and 7/35–36Q2, also show chloride concentrations, which have been generally more than 500 and 800 parts per million, respectively. These may reflect progressive contamination of shallow water by deep penetration of irrigation water that has leached salts from the soil zone. The chloride concentration in water of the main water-bearing zone ranges from about 80 parts per million in the eastern part of the area to about 160 parts per million in the western part. This rather wide range doubtless is a result of the varied quality of water from the different underlying formations and perhaps of downward percolation locally of shallow water of high concentration.

The range in hardness of the deep water is generally comparable to the range in chloride content, doubtless from similar causes. The 96 partial analyses of ground water in the Lompoc area show a range of hardness from 190 to 3,750 parts per million. The water of the main zone ranges in hardness from 450 to 700 parts per million with local concentrations as high as 1,000 parts.

POSSIBILITY OF SEA-WATER ENCROACHMENT

Chemical data on encroachment of sea water are not available for the western 3 miles of the Lompoc plain, but data for the area farther inland show that oceanic contamination of the deep water body has not occurred there.

However, the head of water in the main water-bearing zone near the coast is comparatively low, seemingly a natural condition, and could not be lowered appreciably without incurring the danger of sea-water encroachment. The general relation between sea water and fresh water in contact within permeable materials was worked out in Europe by B. Ghyben and A. Herzberg and was applied by Brown (1925) to ground water along the Connecticut coast. The relation depends on the density differential of the fresh and salt waters so that a contact between them will be depressed about 40 feet below sea level for each foot of fresh-water head above sea level. Therefore, if the head of fresh water at the mouth of the Santa Ynez River is 3 feet (estimated from pl. 7), then the sea-water contact at that point should be about 120 feet below sea level. Thus, it is within the range of the main water-bearing zone. (See pl. 5.) However, at the 5-foot contour the contact theoretically is 200 feet below sea level, or within the consolidated rocks below the probable bottom of the main water-bearing zone at that place. Thus, under present conditions there is evidently only a very small wedge of sea water within the extreme lower end of the main water-bearing zone; and sea-water contamination cannot occur if water levels near the coast are maintained at present levels.

However, greatly increased pumpage, or possibly continued pumpage at the current rate during a period of dry years, might so reduce the head in the main zone near the ocean that sea water would penetrate farther inland within the main water-bearing zone. The extent of such movement would depend in part on the amount and distribution of lowering of fresh-water head and conceivably might constitute a limiting factor in the ultimate yield of the Lompoc subarea.

FUNCTION OF THE GROUND-WATER BODIES IN A FULL UTILIZATION OF WATER RESOURCES

A program for ultimate full utilization of water resources of the Santa Ynez River basin has been largely developed by the Bureau of Reclamation of the United States Department of the Interior. As developed to date, this program is understood to involve early construction of a dam and reservoir on the Santa Ynez River below the mouth of Cachuma Creek, and later construction of additional reservoirs on the river and possibly certain of the main tributaries as seems necessary or desirable. The program also includes plans for the optimum utilization of ground-water bodies. For example, the operation of the contemplated reservoirs is intended in part to afford additional means of replenishment to ground-water bodies over and above replenishment available under the existing conditions of little-regulated river flow. Therefore, the natural relation between the several ground-water bodies and the river, described in this report, is critical in regard to this part of the program.

It has been shown that most of the ground-water bodies occur along the river and that between San Lucas Bridge and The Narrows they are interconnected with and open to replenishment from the river. A large part of the current withdrawals for irrigation is taken almost immediately from river flow; and ultimately greater withdrawals can be supplied by the river through unwatering of deposits in summer and replenishment from the river in each ensuing winter. Therefore, in the over-all program, the most effective utilization of ground-water resources between San Lucas Bridge and The Narrows seems to involve treatment of the alluvial tongue in that reach as a natural conduit whose underflow is intercepted and whose storage is drawn down each irrigation season by pumping from wells. In contrast, the ground-water body beneath the Santa Ynez upland has no hydraulic connection with the river and hence would not be affected by further regulation of river flow. However, greatly increased and sustained withdrawals from wells in the upland area would eventually cause a decline of natural inflow to the river.

Downstream from The Narrows, within the Lompoc plain, the ground-water bodies seem to derive about one-third of their total current replenishment from the river. The remaining two-thirds are derived from tributary inflow and underground seepage from lateral bodies which in turn are replenished by infiltration of rain.

Ground-water withdrawals have been estimated in this report for current conditions, but it seems practicable to anticipate substantial increases in demand in future years. Considerably increased withdrawals doubtless could be sustained from all the ground-water bodies in the basin except perhaps the Lompoc area. Data gathered in the course of the present investigation do not quantitatively reveal the extent to which replenishment from the river would be increased as a result of much-increased withdrawals. Therefore, in all areas along the river further intensive work would be necessary to determine in detail the ultimate yield of the ground-water bodies.

Such intensive work would have as its specific objectives for the Lompoc subarea the refinement of estimates of replenishment to the main water-bearing zone from the older formations on the north and east and from the shallow water-bearing zone by downward percolation throughout the Lompoc plain. It also would cover investigation of the possibility of utilizing the tongue of alluvium along the river upstream from The Narrows as an underground storage reservoir that could be pumped down in summer and allowed to be replenished from the river in winter, thus increasing both the water supply for the Lompoc area and the ultimate yield of the areas upstream.

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TABLE 26.—*Materials penetrated by water wells in the Santa Ynez subarea*

[Based on drillers' records unless otherwise indicated. Stratigraphic correlations by J. E. Upson. Altitudes approximate and with respect to sea level]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
6/30-30A1. Rancho Juan y Lolita. On alluvial plain. Altitude 458 feet					
Younger alluvium:			Consolidated Tertiary rocks:		
Top soil	18	18	Shale	--------	--------
Gravel	44	62			
6/30-30B1. Rancho Juan y Lolita. On alluvial plain. Altitude 454 feet					
Younger alluvium:			Consolidated Tertiary rocks:		
Top soil	19	19	Shale	3	75
Gravel	53	72			
6/31-1B2. Harold Imbach. On Santa Ynez upland. Altitude 675 feet					
Terrace deposits:			Paso Robles formation—Con.		
Top soil	22	22	Gravel	3	143
Clay	80	102	Clay and gravel	57	200
Paso Robles formation:			Clay	57	257
Gravel	2	104	Clay and gravel	18	275
Clay and gravel	8	112	Clay	123	398
Gravel	2	114	Careaga sand: Quicksand	4	402
Clay and gravel	26	140			
6/31-1F1. J. R. Drake. On Santa Ynez upland. Altitude 688 feet					
Terrace deposits:			Paso Robles formation—Con.		
Top soil	10	10	Clay and gravel	2	190
Clay, blue, sandy	2	12	Clay	9	199
Clay	16	28	White sandy clay "or rock"	9	208
Gravel	8	36	Clay, soft	2	210
Clay	52	88	Clay, sandy, hard	2	212
Paso Robles formation:			Sand and clay, some gravel	3	215
Clay, sandy	2	90	Clay	10	225
Clay	18	108	Sand, white, hard	1½	226½
"Sand Rock"	1	109	Gravel	1½	228
Clay	29	138	Clay, sandy	10	238
Clay, gravelly	1	139	Clay	7	245
Clay	49	188			
6/31-1L2. Lenn Saulsbury. On Santa Ynez upland. Altitude 650 feet					
Younger alluvium:			Younger alluvium—Continued		
Soil	7	7	Clay	14	40
Clay	9	16	Gravel	15	55
Gravel	2	18	Clay	5	60
Clay	6	24	Gravel, compact	12	72
Gravel	2	26	Clay, and gravel	9	81
6/31-11E1. T. Petersen. In the valley of Alamo Pintado Creek. Altitude 559 feet					
Younger alluvium:			Careaga sand (?)—Continued		
Adobe and gravel	6	6	Clay, yellow, sticky	6	278
Clay, brown and gravel	18	24	Clay, blue, sticky	6	284
Clay, sandy, brown	6	30	Clay, blue, sandy	11	295
Clay, brown and gravel	8	38	Clay, yellow, sandy	7	302
Paso Robles formation:			Sand, blue-gray	71	373
Clay, yellow and gravel	67	105	Clay, blue, sticky	4	377
Sand and gravel	6	111	Sand, blue-gray	10	387
Clay, yellow and pebbles	54	165	Clay, blue, sticky	4	391
Clay, sandy, yellow	15	180	Sand, blue-gray	5	396
Clay, yellow and pebbles	52	232	Clay, blue, sticky	1	397
Careaga sand(?):			Sand, blue-gray	21	418
Sand, yellow	40	272			

TABLE 26.—*Materials penetrated by water wells in the Santa Ynez subarea*—Con.

6/31-12B1. A. Henning. On Santa Ynez upland. Altitude 653 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Terrace deposits: Soil, compact gravel	80	80	Paso Robles formation—Con.		
Paso Robles formation:			Clay	2	116
Gravel	4	84	Gravel and sand	14	130
Clay	21	105	Sand	12	142
Gravel	9	114	Clay	4	146

6/31-12Q1. Mrs. Lopez. On Santa Ynez upland. Altitude 615 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Terrace deposits: Clay and cobbles	108	108	Paso Robles formation—Con.		
Paso Robles formation:			Clay	6	126
Gravel	2	110	Gravel	4	130
Clay and gravel	8	118	Clay and gravel	5	135
Gravel	2	120	Gravel	2	137
			Clay and gravel	1	138

6/31-12Q2. James Raft. On Santa Ynez upland. Altitude 621 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Terrace deposits:			Terrace deposits—Continued		
Clay and compact gravel	112	112	Clay, sandy	6	126
Gravel	8	120	Clay, sandy, and gravel	7	133

6/31-13C1. Captain Campbell. On Santa Ynez upland. Altitude 614 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Terrace deposits:			Paso Robles formation:		
Top soil	30	30	Gravel	12	111
Clay and boulders	69	99	Gravel, water-bearing	39	150

6/31-13L1. A. Hunt. On Santa Ynez upland. Altitude 513 feet

[Casing perforated from 130 to 134 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Terrace deposits:			Terrace deposits—Continued		
Soil	5	5	Gravel and clay, water-bearing	23	90
Clay, yellow	35	40	Clay, blue	32	122
Clay, soft	2	42	Careaga sand:		
Clay, blue	20	62	Sand, coarse	5	127
Gravel and blue clay	5	67	Gravel, fine	8	135

7/30-31F1. F. G. Stevens. On Santa Ynez upland. Altitude 735 feet

[Casing perforated 130 to 290 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Terrace deposits:			Paso Robles formation—Con.		
Top soil	3	3	Clay, brown	25	190
Fine gravel and soil-packed	17	20	Clay, thin beds of gravel	12	202
Paso Robles formation:			Clay	16	218
Clay, yellow, sandy, thin beds of pebble-gravel	145	165	Clay, yellow; thin beds of pebble-gravel	82	300

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TABLE 26.—*Materials penetrated by water wells in the Santa Ynez subarea*—Con.

7/30-31H1 William Murphy. On Santa Ynez upland. Altitude 727 feet

[Casing perforated 140 to 185 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Terrace deposits: Clay	116	116	Paso Robles formation—Con.		
Paso Robles formation:			Clay	2	156
Clay and gravel	5	121	Gravel, good	8	164
Clay	5	126	Clay	4	168
Clay, soft	3	129	Gravel	4	172
Clay	11	140	Clay	2	174
Clay, soft	4	144	Gravel	2	176
Gravel	4	148	Clay	2	178
Clay	5	153	Gravel	6	184
Gravel	1	154	Clay	6	190

7/30-31L2. H. B. Sanderson. On Santa Ynez upland. Altitude 723 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Terrace deposits:			Paso Robles formation—Con.		
Soil	6	6	Gravel	16	203
Clay and compact gravel	70	76	Clay	2	205
Paso Robles formation:			Gravel	5	210
Gravel	5	81	Clay	12	222
Clay	20	101	Gravel	2	224
Gravel	4	105	Clay	2	226
Clay	13	118	Gravel	23	249
Gravel	2	120	Clay	5	254
Clay	9	129	Gravel	7	261
Gravel	12	141	Clay	5	266
Clay	10	151	Gravel	8	274
Gravel and clay	25	176	Clay	14	288
Gravel	5	181	Clay, soft	2	290
Clay	6	187	Clay	10	300

7/30-32H1. T. W. Sully. On Santa Ynez upland. Altitude 767 feet

[Casing perforated 181 to 406 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Terrace deposits:			Paso Robles formation—Con.		
Soil	3	3	Conglomerate	1	263
Clay and gravel	66	69	Gravel, fine	5	268
Clay and some gravel	42	111	Clay, yellow, sandy	40	308
Clay and gravel	45	156	Streaks of gravel and clay	38	346
Paso Robles formation:			Clay	8	354
Clay, soft, sandy	16	172	Sand	4	358
Gravel, water-bearing	7	179	Conglomerate	2	360
Clay, yellow	2	181	Gravel	4	364
Gravel, coarse	17	198	Clay	34	398
Streaks of clay and gravel	52	250	Gravel	8	406
Gravel, coarse	12	262	Conglomerate	6	412

7/31-25F1. John Grgich. On Santa Ynez upland. Altitude 843 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Terrace deposits: Soil and clay	113	113	Paso Robles formation—Con.		
Paso Robles formation:			Clay	7	184
Gravel	12	125	Gravel	2	186
Clay	9	134	Clay	20	206
Gravel, water-bearing	3	137	Gravel	6	212
Clay	12	149	Clay	7	219
Gravel	2	151	Gravel	8	227
Clay	7	158	Clay	3	230
Gravel	7	165	Gravel	42	272
Clay	5	170	Clay	30	302
Gravel	7	177			

TABLE 26.—*Materials penetrated by water wells in the Santa Ynez subarea*—Con.

7/31-25L1. Russell Smith. On Santa Ynez upland. Altitude 806 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Terrace deposits: Clay	94	94	Paso Robles formation—Con.		
Paso Robles formation:			Gravel	7	181
Clay, sandy	3	97	Clay	6	187
Clay	13	110	Gravel	7	194
Gravel	8	118	Clay	3	197
Clay	24	142	Gravel	6	203
Gravel and clay	13	155	Clay	2	205
Clay	6	161	Gravel	10	215
Gravel	3	164	Clay	11	226
Clay	10	174			

7/31-25Q1. S. R. Dabney. On Santa Ynez upland. Altitude 788 feet

[Casing perforated 0 to 189 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Terrace deposits: Soil	100	100	Paso Robles formation—Con.		
Paso Robles formation:			Gravel	5	173
Gravel	3	103	Clay	5	178
Clay	35	138	Gravel and conglomerate	4	182
Gravel	3	141	Clay	7	189
Conglomerate	27	168			

7/31-26C3. C. H. Crawford. In the valley of Alamo Pintado Creek. Altitude 810 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Paso Robles formation—Con.		
Soil	50	50	Conglomerate	23	108
Gravelly soil	23	73	Clay	4	112
Paso Robles formation:			Clay, soft	5	117
Gravel	4	77	Clay	3	120
Clay	8	85	Gravel	26	146

7/31-36H2. W. A. Coons. On Santa Ynez upland. Altitude 722 feet

[Casing perforated 103 to 109 and 154 to 157 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Terrace deposits:			Paso Robles formation—Con.		
Soil	54	54	Gravel and clay	2	163
Gravel	2	56	Clay	14	177
Clay and gravel	47	103	Gravel	1	178
Paso Robles formation:			Clay	27	205
Gravel	6	109	Conglomerate	9	214
Clay	45	154	Gravel	15	229
Gravel	3	157	Clay	1½	230½
Clay	4	161			

7/31-36P2. H. I. Stark. On Santa Ynez upland. Altitude 703 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Terrace deposits:			Paso Robles formation—Con.		
Top soil	6	6	Clay	34	92
Clay, hard	10	16	Gravel	11	103
Clay and gravel	12	28	Clay	17	120
Paso Robles formation:			Gravel	6	126
Gravel	12	40	Clay	2	128
Clay	11	51	Gravel	11	139
Gravel	3	54	Clay	1	140
Clay	2	56	Gravel	6	146
Gravel	2	58	Clay	19	165

TABLE 27.—*Materials penetrated by wells in the Buellton subarea*

[Based on drillers' records. Stratigraphic correlations by J. E. Upson. Altitudes above approximate mean sea level.]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
6/31-7M8. S. K. MacMurray. On alluvial terrace. Altitude 371 feet					
Younger alluvium:			Paso Robles formation:		
Top soil	28	28	Clay	5	82
Gravel, water-bearing	4	32	Sand	6	88
Paso Robles formation (?):			Clay	14	102
Clay	41	73			
Clay, sandy, water-bearing	4	77			
6/31-16N2. H. G. Petersen. In river flood channel. Altitude 368 feet					
River channel deposits:			River channel deposits—Con.		
"Sediment"	12	12	Gravel, silty	9	42
Gravel, coarse	20	32	Gravel and sand	8	50
Clay	1	33			
6/31-17F2. J. R. Orton. On alluvial terrace. Altitude 377 feet					
[Casing perforated 31 to 78 feet]					
Younger alluvium:			Younger alluvium—Continued		
Soil	21	21	Gravel	57	78
6/31-17K1. Alfred Jacobsen. On alluvial terrace. Altitude 377					
[Cement plug below 75 feet]					
Younger alluvium:			Paso Robles formation:		
Soil	23	23	Clay	3	75
Gravel	49	72	Sand and gravel	3	78
			Sand	5	83
6/31-17L2. W. McGuire. On alluvial terrace. Altitude 376 feet					
Younger alluvium:			Younger alluvium—Continued		
Soil	25	25	Sand, water-bearing	22	47
6/32-9A2. O. E. Hollister. On alluvial terrace. Altitude 306 feet					
Younger alluvium:			Younger alluvium—Continued		
Soil and sand	39	39	Gravel	14	63
Gravel and blue mud	10	49	Paso Robles formation: Clay	9	72
6/32-9B2. P. A. Beattie. On alluvial terrace. Altitude 305 feet					
[Stone seal placed below 52 feet; and casing perforated above 52 feet.]					
Younger alluvium:			Paso Robles formation (?): Sand	38	90
Soil and "sediment"	50	50			
Gravel	2	52			
6/32-10C2. Eskil Skytt. On alluvial terrace. Altitude 280 feet					
Younger alluvium:			Younger alluvium—Continued		
Soil	5	5	Mud, blue	12	33
Sand	5	10	Gravel	19	52
Gravel	11	21	Paso Robles formation: Clay	½	52½

TABLE 27.—*Materials penetrated by wells in the Buellton subarea*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
6/32-11B1. E. W. Lewis. On alluvial terrace. Altitude 355 feet					
Younger alluvium:			Paso Robles formation—Con.		
Sand	10	10	Clay, sandy	5	125
Clay	14	24	Clay	10	135
Gravel, compact	34	58	Clay, sandy	7	142
Paso Robles formation:			Clay	20	162
Clay	62	120			
6/32-11H1. W. M. Hunt. In river flood channel. Altitude 299 feet					
River-channel deposits:			River-channel deposits—Con.		
Gravel	15	15	Gravel	12	30
Mud, blue	3	18	"Conglomerate"	12	42
6/32-11L1. Doty and Mercer. In river flood channel. Altitude 309 feet					
River-channel deposits: Gravel	52	52	Undifferentiated Tertiary rocks:		
			Shale	(?)	(?)
6/32-12J8. O. R. Skinner. On alluvial terrace. Altitude 353 feet					
Younger alluvium: Soil	65	65	Paso Robles formation—Con.		
Paso Robles formation:			Sand	1	104
Clay, soft	5	70	Clay	1	105
Clay	7	77	Clay, sandy	3	108
Clay, sandy, water-bearing	8	85	Clay	84	192
Clay	10	95	Sand, water-bearing	4	196
Clay, sandy	5	100	Clay	69	265
Clay	3	103	Clay, soft	3	268

TABLE 28.—*Materials penetrated by water wells in the Santa Rita subarea*

[Based on drillers' records unless otherwise indicated. Stratigraphic correlations by J. E. Upson. Altitudes are above approximate mean sea level]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
6/33-8G3. S. N. Pettit. On alluvial terrace. Altitude 170 feet					
Younger alluvium:			Younger alluvium—Continued		
Soil	2	2	Gravel and clay	3	48
Sand	24	26	Gravel, good	23	71
Clay, sandy	19	45			
6/33-9J1. W. H. Cooper. On alluvial terrace [Report by owner]					
Younger alluvium:			Undifferentiated Tertiary rocks:		
Sandy soil	30	30	Shale, blue	(?)	(?)
Gravel, sand, and boulders	38	68			

TABLE 28.—*Materials penetrated by water wells in the Santa Rita subarea*—Con.

6/33-11P1. William Rennie. On alluvial terrace. Altitude 235 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil	5	5	Clay, blue	15	59
Clay, yellow	9	14	Gravel	11	70
Clay, blue	27	41	Undifferentiated Tertiary rocks:		
Muck, black	3	44	Shale, brown	6	76

6/33-12L1. J. Corbillini. On alluvial terrace. Altitude 227 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Undifferentiated Tertiary rocks:		
Soil	6	6	Shale, brown	(?)	(?)
Gravel	72	78			

6/33-16A1. W. H. Cooper. On alluvial terrace. Altitude 206 feet

[Report by owner]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Undifferentiated Tertiary rocks:		
Soil	45	45	Clay, compact, fragmentary	1	79
Gravel, coarse, water-bearing	33	78			

6/34-2A1. Chris Madsen. Test well 2 by city of Santa Barbara. On alluvial terrace. Altitude 129 feet

[Casing perforated 105 to 184 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil	38	38	Sand, blue	9	90
Clay, sandy	3	41	Clay, blue; and gravel	13	103
Sand, coarse	3	44	Clay, gravel, and wood	2	105
Clay and gravel	3	47	Main water-bearing zone:		
Gravel	15	62	Gravel, "good"	79	184
Clay, blue; boulders	3	65	Undifferentiated Tertiary rocks:		
Clay, blue	6	71	Shale, brown	1	185
Clay, sandy, blue; small gravel and wood	10	81			

6/34-2A2. Chria Madsen. Test well 1 by city of Santa Barbara. On alluvial terrace. Altitude 127 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil	23	23	Gravel, coarse	17	58
Clay, sandy	9	32	Gravel and clay	2	60
Sand	6	38	Gravel, coarse	20	80
Sand and gravel	3	41			

7/33-21H1. Robert Sudden. On hill summit in Santa Rita Valley. Altitude 505 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Paso Robles *formation*:			Paso Robles *formation*—Con.		
Top soil	4	4	Sand with some clay and gravel	48	418
Sand and clay in alternating layers	346	350	Sand, fine, water-bearing	54	472
Clay	20	370	Clay, blue	(?)	(?)

TABLE 29.—*Materials penetrated by water wells in the Lompoc subarea*

[Based on drillers' records unless otherwise indicated. Stratigraphic correlations by J. E. Upson]

6/34-3A2. Joe Scolari. At edge of Lompoc plain. Altitude 113 feet

[Casing perforated 48 to 75 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Undifferentiated Tertiary rocks:		
Soil	30	30	Shale, brown	3	75
Clay	18	48			
Gravel, good	24	72			

6/34-4D1. Peter Tognatti. Near edge of Lompoc plain. Altitude 84 feet

[Record from owner's memory]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Clay	21	21	Gravel and sand	(?)	(?)
Soil, light	7?	28?	Gravel, heavy	86	(?)

6/34-4G1. City of Lompoc. On Lompoc plain. Altitude 92 feet

[Casing perforated 57.5 to 73 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil	7	7	Clay and gravel	3	65
Gravel, dry	13	20	Gravel, good	3	68
Clay, yellow, soft	13	33	Gravel and sand	3	71
Clay, yellow, solid	5	38	Careaga sand:		
Clay, yellow, sandy	9	47	Rock ledge	2	73
Sand	9	56	Conglomerate, sandstone	7	80
Sand and gravel, water-bearing	3	59	Shells, sand, and some small gravel	15	95
Gravel, good	3	62	Sand, white; some shells	5	100

6/34-4R1. Santa Barbara County. On floor of San Miguelito Canyon. Altitude 154 feet

[Casing perforated 19 to 24 feet, and 36 to 65 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil and gravel	15	15	Boulders	3	63
Gravel	9	24	Undifferentiated Tertiary rocks:		
Clay, blue, sticky	11	35	Rock ledge	2	65
Gravel	21	56	Shale, brown	16	81
Clay, blue	4	60			

6/34-6C2. Bank of America. Near edge of Lompoc plain. Altitude 100 feet

[Casing perforated 115 to 155 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Careaga sand:		
Soil	15	15	Gravel with shells	40	155
Clay, yellow	75	90	Clay, hard	10	165
Clay, yellow; gravel and boulders	25	115	Sand and shells	20	185

TABLE 29—*Materials penetrated by water wells in the Lompoc subarea*—Continued

7/33-17N1. R. E. Sudden. On floor of Cebada Canyon. Approximate altitude 343 feet

[Casing perforated 282 to 287 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Paso Robles formation:			Paso Robles formation—Con.		
Clay	26	26	Sand	(?)	275
Clay, hard and gravel	29	55	Clay, blue	10	285
Sand, white	35	90	Sand	38	323
Streaks of blue clay	5	95	Clay, blue	7	330
Sand	23	118	Clay and sand	5	335
Clay, yellow	1	119	Clay, blue	5	340
Sand	61	180	Sand	10	350
Clay, blue	35	215	Sandstone	5	355
Sand	35	250	Sand	45	400
Streaks of clay	(?)	(?)			

7/34-19J1. War Department. On Lompoc plain. Altitude 61 feet

[Log by J. E. Upson, compiled from cuttings. Casing perforated 130 to 165 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil, silty	13	13	Clay, grayish-blue and greenish; silty, uniform; contains some pebbles, compact	40	140
Clay, silty; slight yellow color	25	38	Main water-bearing zone: Sand and gravel; cobbles up to 3 inches	32	172
Sand, coarse, dirty; with some pebbles	7	45	Careaga sand: Sand, gray, fine, uniform; with tiny shell fragments	14	186
Clay, gray blue, sticky, with some pebbles	13	58			
Clay, silty; uniform; yellowish color	27	85			
Sand, fine; and fine gravel	15	100			

7/34-19L1. War Department. On Lompoc plain. Altitude 49 feet

[Log by J. E. Upson, compiled from cuttings. Casing perforated 42 to 56, 95 to 100, and 138 to 164 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Sand, fine to medium, uniform; light brown	22	22	Sand, greenish gray; some pebbles	32	106
Clay, gray with small pebbles	20	42	Clay, greenish blue	16	122
Sand, and gravel (fine grained at top, moderately coarse near bottom)	14	56	Main water-bearing zone:		
Sand and gravel; clayey	12	68	Sand, clayey, gray; with some pebbles	20	144
Silty clay, gray, compact; some pebbles	6	74	Gravel, coarse	24	168
			Sand, fine, silty; gray	16	184

7/34-20K4. War Department. On Lompoc plain. Altitude 75 feet

[Log by J. E. Upson, compiled from cuttings. Casing perforated 90 to 174 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil, clayey in lower part	14	14	Main water-bearing zone:		
Silt and pebbles	20	34	Sand, fine, passing down into gravel	15	114
Sand, gravel medium	14	48	Clay, compact	5	119
Clay, compact	4	52	Sand and pebbles	6	125
Sand and pebbles	2	54	Gravel and coarse sand	26	151
Clay, sandy	10	64	Orcutt (?) sand: Clay, white at top; blue below	5	156
Silt and fine sand	12	76	Careaga sand: Gravel, passing down into sand; shell fragments	30	186
Clay, compact	23	99			

TABLE 29.—*Materials penetrated by water wells in the Lompoc subarea*—Continued

7/34-20M2. War Department. On Lompoc plain. Altitude 58 feet

[Log by J. E. Upson, compiled from cuttings. Casing perforated 77 to 177 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Orcutt sand—Continued		
Sandy soil, brown, compact	13	13	Gravel, gray, well sorted; rounded cobbles and pebbles	57	158
Sand and pebbles; red-buff	18	31	Careaga sand:		
Orcutt sand:			Gravel, bluish gray; a few shell fragments	9	167
Clay, yellow-buff; compact	40	71	Sand, gray; fine to medium; some pebbles near top; shell fragments throughout	25	192
Gravel, coarse; rounded cobbles	22	93			
Clay, gray; compact	8	101			

7/34-20N1. A. Armas. On Lompoc plain. Altitude 68 feet

[Casing perforated 93 to 107 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil, sandy	29	29	Clay, sandy; blue	20	85
Clay, sandy; blue	10	39	Sand, blue, "heaving"	10	95
Sand, blue, "heaving"	20	59	Main water-bearing zone:		
Clay, yellow	6	65	Gravel	12	107

7/34-24N1. State of California. In mouth of Purisima Canyon. Altitude 130 feet

[Casing perforated 130 to 143 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Paso Robles formation—Con.		
Adobe	6	6	Clay, blue	7	115
Clay, sandy	43	49	Sand	9	124
Sand	4	53	Shale, hard	1	125
Clay	2	55	Clay, yellow	5	130
Sand and clay	13	68	Gravel, water-bearing	13	143
Sand, fine	17	85	Clay and gravel	16	159
Paso Robles formation:			Clay and sand	10	169
Clay, yellow	23	108	Sand, fine, hard	14	183

7/34-26A2. Kate McConnell. On Lompoc plain. Altitude 113 feet

[Casing perforated 52 to 62 and 135 to 153 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Paso Robles formation—Con.		
Soil, sandy	47	47	Gravel	5	140
Gravel and sand	15	62	Sandy muck and gravel	13	153
Sand, fine	6	68	Sand, fine	5	158
Sandy muck	58	126	Sand and fine gravel	4	162
Paso Robles formation:			Sand	10	172
Clay, yellow, soft	9	135			

7/34-26F1. Union Sugar Co. On Lompoc plain. Altitude 109 feet

[Casing perforated 130 to 143 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Paso Robles formation:		
Sand	35	35	Sand	26	126
Clay	2	37	Clay	5	131
Sand	11	48	Gravel, sandy	18	149
Clay, soft, and blue, sand	52	100			

TABLE 29.—*Materials penetrated by water wells in the Lompoc subarea*—Continued

7/34-26F2. Union Sugar Co. On Lompoc plain. Altitude 91 feet

[Casing perforated 130 to 150 and 185 to 188 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Paso Robles formation—Con.		
Sand	34	34	Rocks, large	4	134
Clay, sandy	16	50	Gravel	21	155
Clay, blue	21	71	Sand	11	166
Clay, soft; some sand	20	91	Shale, blue, ("hard drilling")	16	182
Paso Robles formation:			Sand, hard; some gravel	7	189
Sand, white	34	125	Careaga (?) sand: Sand	5	194
Clay, blue	5	130			

7/34-27F1. M. G. and W. G. Moore. On Lompoc plain. Altitude 94 feet

[Casing perforated 105 to 170 feet. Cement plug below 178 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil	20	20	Main water-bearing zone:		
Clay, yellow	24	44	Gravel, good	7	95
Clay, blue, solid	4	48	Gravel, fine; some sand	10	105
Sand	27	75	Gravel, good	75	180
Clay, blue, soft	10	85	Careaga sand: Sand, and fine gravel; blue; fossil shells	5	185
Clay, sandy; some fine gravel	3	88			

7/34-27J1. L. H. Schuyler. On Lompoc plain. Altitude 102 feet

[Casing perforated 123 to 153 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Paso Robles formation:		
Soil	28	28	Clay	18	116
Gravel	22	50	Sand	4	120
Clay	8	58	Clay	4	124
Sand	16	74	Sand	17	141
Clay	2	76	Gravel	5	146
Sand and gravel	2	78	Sand	3	149
Clay	14	92	Clay	4	153
Gravel	6	98	Careaga (?) sand: Sand	13	166

7/34-27K1. L. H. Schuyler. On Lompoc plain. Altitude 100 feet

[Casing perforated 111 to 162 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil	20	20	Main water-bearing zone:		
Clay, sandy; yellow	6	26	Gravel, fair	12	80
Gravel and sand	3	29	Gravel and coarse sand; blue	18	98
Gravel and clay, yellow	7	36	Gravel, fine; blue	3	101
Clay, sandy; yellow	12	48	Gravel, coarse; blue	63	164
Clay, sandy; some gravel	20	68			

7/34-28C1. Lompoc Produce Co. On Lompoc plain. Altitude 83 feet

[Casing perforated 138 to 192 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil	6	6	Main water-bearing zone—Continued		
Clay, yellow	29	35	Sand	33	129
Clay, sandy	51	86	Gravel	66	195
Main water-bearing zone:			Careaga sand: Sandstone	5	200
Gravel, sandy, water-bearing	10	96			

TABLE 29.—*Materials penetrated by water wells in the Lompoc subarea*—Continued

7/34-28G1. G. H. Summers. On Lompoc plain. Altitude 81 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium: No record	86	86	Main water-bearing zone:		
			Gravel	28	114
			Gravel, coarse	(?)	(?)

7/34-28L1. D. Daniels and A. Lehman. On Lompoc plain. Altitude 84 feet

[Casing perforated 147 to 167 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Main water-bearing zone?:		
Soil	23	23	Gravel and clay, sandy	10	115
Sand, hard	9	32	Clay, sandy	8	123
Clay, yellow, soft	14	46	Main water-bearing zone:		
Clay, blue, solid	20	66	Sand and gravel	2	125
Clay, sandy; blue	39	105	Gravel, fine	22	147
			Gravel, coarse	20	167

7/34-29J1. Moses Bianchini. On Lompoc plain. Altitude 75 feet

[Casing perforated 133 to 186 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil	26	26	Muck, blue; with some sand and gravel	9	128
Clay, sandy; yellow	4	30	Main water-bearing zone:		
Clay, yellow	8	38	Gravel, fine	9	137
Clay, bluish yellow	21	59	Gravel	6	143
Sand and muck, blue	8	67	Conglomerate	4	147
Clay, blue, solid	19	86	Gravel	33	180
Clay, sandy; yellow	30	116	Sand, water-bearing	6	186
Clay, blue	3	119			

7/34-30A1. G. F. Sanor. On Lompoc plain. Altitude 65 feet

[Casing perforated 140 to 192 feet. Cement plug below 192 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil	9	9	Clay, hard, blue	10	100
Clay	9	18	Clay, sandy; blue	15	115
Sand	4	22	Main water-bearing zone:		
Clay, hard and yellow	8	30	Sand and gravel	5	120
Sand and gravel	8	38	Gravel, medium	5	125
Sand and clay	10	48	Gravel, fine	7	132
Clay, hard, blue	12	60	Gravel and clay	8	140
Clay, sandy	20	80	Gravel, coarse	45	185
Clay, hard, blue	5	85	Careaga sand: Sand with fossil shells	13	198
Sand, coarse, and fine gravel	5	90			

7/34-30J1. Manuel Manfrina. On Lompoc plain. Altitude 64 feet

[Casing perforated 140 to 180 feet. Cement plug below 182 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil	24	24	Main water-bearing zone:		
Sand, fine	3	27	Sand conglomerate, hard	12	135
Sand and gravel	6	33	Sand	3	138
Clay, sandy; blue	25	58	Sand and fine gravel	3	141
Clay, sandy; blue and yellow	14	72	Clay, blue; and coarse gravel	3	144
Clay, blue	3	75	Gravel, coarse	24	168
Clay, blue; and gravel	7	82	Gravel and boulders	9	177
Clay, solid blue	26	108	Gravel and sand, coarse	9	186
Clay, blue; and gravel	15	123			

TABLE 29.—*Materials penetrated by water wells in the Lompoc subarea*—Continued

7/34-30L1. Union Sugar Co. On Lompoc plain. Altitude 56 feet

[Casing perforated 130 to 180 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil	8	8	Main water-bearing zone:		
Clay	9	17	Gravel, sandy	52	182
Sand	13	30	Orcutt sand (?): Gravel and clay, cemented	7	189
Clay, blue	100	130			

7/34-30L2. Union Sugar Co. On Lompoc plain. Altitude 59 feet

[Casing perforated 119 to 134 and 148 to 178 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil	8	8	Main water-bearing zone:		
Clay, soft	16	24	Clay, sandy	5	119
Clay, sandy	12	36	Sand, clay, and gravel	15	134
Gravel, fine; some sandy clay	24	60	Sand, hard	4	138
Clay, solid	18	78	Clay, sandy; and gravel	10	148
Clay, sandy; soft	22	100	Gravel, coarse	30	178
Clay, blue, solid	14	114	Careaga sand: Sand, white, hard	16	194

7/34-31A2. Burpee Seed Co. On Lompoc plain. Altitude 68 feet

[Casing perforated approximately 132 to 175 feet. Cement plug below 175 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil	28	28	Clay	32	132
Sand	14	42	Main water-bearing zone:		
Clay	8	50	Gravel, fine, water-bearing	8	140
Sand	40	90	Gravel, coarse	35	175
Clay	7	97	Careaga sand: Sand, fine; white	6½	181½
Sand	3	100			

7/34-31H1. A. C. Zvolanek. On Lompoc plain. Altitude 66 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
No record	30	30	Clay	5	129
Water	5	35	Gravel	1	130
Gravel	7	42	Clay	19	149
Clay	27	69	Main water-bearing zone:		
Sand	12	81	Gravel	2	151
Clay	4	85	Clay	2	153
Sand	10	95	Gravel	16	169
Clay	28	123	Careaga sand: Sand	1	170
Gravel	1	124			

7/34-31J1. J. F. De Costa. On Lompoc plain. Altitude 70 feet

[Casing perforated 80 to 97 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Terrace deposits (?): Gravel	20	100
Soil	30	30	Careaga sand: "Quicksand"	109	209
Gravel and sand	20	50			
Clay and sand	30	80			

TABLE 29.—*Materials penetrated by water wells in the Lompoc subarea*—Continued

7/34-31Q2. A. Leege. On Lompoc plain. Altitude 71 feet

[Casing perforated 50 to 68, and 80 to 95 feet]

	Thickness (feet)	Depth (feet)
Younger alluvium:		
Soil, "adobe"	11	11
Clay, yellow, solid	3	14
Clay, blue, solid	4	18
Clay, yellow, sandy	3	21
Clay, yellow, solid	14	35
Gravel, yellow; and clay	12	47
Clay, blue	6	53
Gravel, coarse; and blue clay	9	62
Younger alluvium—Continued		
Gravel and boulders	6	68
Clay, yellow; and boulders	12	80
Terrace deposits (?): Gravel, coarse	15	95
Careaga sand:		
Clay, white, solid	2	97
Sand, white	10	107

7/34-33L1. Mrs. Meecham. On Lompoc plain. Altitude 89 feet

[Casing perforated 49 to 96 feet]

	Thickness (feet)	Depth (feet)
Younger alluvium:		
Soil	35	35
Clay, sandy	3	38
Sand; some gravel	6	44
Clay, blue, solid	5	49
Gravel, fine	4	53
Gravel and clay	9	62
Gravel, coarse	8	70
Younger alluvium—Continued		
Gravel and clay	13	83
Terrace deposits (?): Gravel, coarse	6	89
Careaga sand:		
"Cement conglomerate"	12	101
Sand	19	120

7/34-33P1. D. Douglas. On Lompoc plain. Altitude 93 feet

	Thickness (feet)	Depth (feet)
Younger alluvium:		
No record	54	54
Gravel	14	68
Clay	2	70
Gravel	4	74
Younger alluvium—Continued		
Clay	4	78
Terrace deposits (?):		
Gravel	16	94
Clay	6	100

7/34-34H1. Margaret Balaam. On Lompoc plain. Altitude 112 feet

[Casing perforated 118 to 156 feet]

	Thickness (feet)	Depth (feet)
Younger alluvium:		
Soil	35	35
Clay, sandy; yellow	3	38
Sand	6	44
Clay, sandy, and gravel	3	47
Gravel, yellow	17	64
Sand; some fine gravel	10	74
Clay, sandy; blue	18	92
Clay, blue, solid	6	98
Clay, blue, and gravel	12	110
Sea muck, blue; some sand and fine gravel	6	116
Younger alluvium—Continued		
Main water-bearing zone:		
Gravel, coarse; blue	4	120
Muck, blue; and fine gravel	4	124
Gravel, blue	26	150
Clay, white, and gravel	2	152
"Chalk rock", and gravel	2	154
Undifferentiated Tertiary rocks:		
"Chalk rock", white	3	157
Gravel and clay, white (?)	6	160

7/34-35F5. Milton Schuyler. On Lompoc plain. Altitude 120 feet

[Casing perforated 110 to 164 feet]

	Thickness (feet)	Depth (feet)
Younger alluvium:		
Soil	3	3
Clay	12	15
Gravel, dry	2	17
Clay, sandy; blue	27	44
Gravel, water-bearing	26	70
Clay, blue	13	83
Main water-bearing zone:		
Sand; "P" gravel	7	90
Sand, fine	5	95
"P" gravel	5	100
"P" gravel; some sand	10	110
Gravel, coarse	54	164

TABLE 29.—*Materials penetrated by water wells in the Lompoc subarea*—Continued

7/35-16F1. Department of the Army. On Lompoc plain. Altitude 13 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil	5	5	Sandstone, hard	10	40
Clay, yellow	10	15	Sand, blue	2	42
Clay, blue, soft	10	25	Undifferentiated Tertiary rocks:		
Muck and sand	5	30	Shale, brown	18	60

7/35-16N1. Department of the Army. Test hole. On Lompoc plain. Altitude 17 feet

[Casing not perforated; well abandoned when drilled]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil	6	6	Gravel, water-bearing	6	110
Sand, gravel, and clay	36	42	Undifferentiated Tertiary rocks:		
Clay, solid; blue	48	90	Shale, brown	6	116
Gravel and clay	14	104			

7/35-18J1. Department of the Army. On Lompoc plain. Altitude 6 feet.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil	4	4	Clay, blue	61	115
Sand	16	20	Main water-bearing zone:		
Clay, blue	30	50	Gravel	5	120
Sand, blue	4	54			

7/35-20J4. Department of the Army. On Lompoc plain. Altitude 19 feet

[Casing perforated 116 to 140 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil	8	8	Main water-bearing zone:		
Sand, white	12	20	Sand	6	116
Clay, yellow	12	32	Gravel	18	134
Clay, blue	42	74	Undifferentiated Tertiary rocks:		
Sand, water-bearing	4	78	Shale, brown	26	160
Clay, sandy	32	110			

7/35-21H1. Department of the Army. On Lompoc plain. Altitude 24 feet

[Casing perforated 137 to 153 and 166 to 174 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Sand and soil	32	32	Main water-bearing zone:		
Clay, soft, blue	4	36	Gravel and clay	6	125
Sand, fine	9	45	Gravel, fine; and sand	12	137
Sand and gravel	13	58	Gravel, coarse	10	147
Gravel and clay (water-bearing)	4	62	Clay, blue	2	149
			Gravel, coarse	9	158
Clay, blue	6	68	Sand, blue	4	162
Sandstone, "hard pan"	9	77	Gravel, coarse	12	174
Gravel, coarse	5	82	Clay, blue	2	176
Clay, sandy; blue, hard	4	86			
Clay, blue, solid	33	119			

7/35-22F1. Department of the Army. On Lompoc plain. Altitude 26 feet

[Casing perforated 132 to 170 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil and clay	38	38	Gravel, sand, and clay	13	113
Sand, fine, blue; with clay	35	73	Sand, fine, blue	12	125
Clay, blue	4	77	Main water-bearing zone:		
Sand, fine, "clay rocks"	7	84	Gravel, coarse	46	171
Sand, fine; with clay	16	100	Clay, blue	2	173

TABLE 29.—*Materials penetrated by water wells in the Lompoc subarea*—Continued

7/35-22J1. Union Sugar Co. On Lompoc plain. Altitude 32 feet

[Casing perforated 133 to 180 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil	8	8	Main water-bearing zone:		
Clay, sandy	22	30	Gravel, water-bearing	6	133
Sand	18	48	Sand and gravel, coarse	11	144
Gravel	2	50	Gravel	36	180
Clay, sandy	31	81	Undifferentiated Tertiary rocks:		
Sand	6	87	Shale, blue	5	185
Sand and clay	40	127			

7/35-22L1. Department of the Army. On Lompoc plain. Altitude 30 feet

[Casing perforated 172 to 189 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil	28	28	Main water-bearing zone:		
Sand	13	41	Clay, blue; gravel	22	158
Muck, sandy	9	50	Clay, sandy, soft	12	170
Clay, sandy	11	61	Sand and fine gravel	6	176
Clay, soft; yellow	25	86	Gravel	9	185
Clay, yellow; fine gravel	5	91	Undifferentiated Tertiary rocks:		
Clay, blue	45	136	"Chalk rock"	34	219

7/35-23B1. Department of the Army. On Lompoc plain. Altitude 38 feet

[Casing perforated 57 to 178 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil and sandy clay	31	31	Sand and gravel, coarse	103	170
Clay, yellow	17	48	Undifferentiated Tertiary rocks:		
Clay, blue	19	67	Shale, hard, black	20	190

7/35-24B2. Department of the Army. On Lompoc plain. Altitude 48 feet

[Log by J. E. Upson, compiled from cuttings]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Orcutt (?) sand:		
No record	9	9	Sand, coarse; with small pebbles	61	133
Sand, coarse, gritty; with pebbles; drab gray color	18	27	Clay, silty, compact, massive	4	137
Clay, tough, compact, plastic when wet; whitish gray to bluish gray color	45	72	Gravel, fine, pebbly	43	180
			Clay, white, compact, tough	(?)	(?)

7/35-24H1. Department of the Army. On Lompoc plain. Altitude 48 feet

[Casing perforated 129 to 175 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil, sandy	75	75	Main water-bearing zone:		
Gravel, fine; some sand	6	81	Gravel, fine: sand	3	123
Gravel	8	89	Gravel, good	56	179
Sand, fine	3	92	Undifferentiated Tertiary rocks:		
Clay, sandy	28	120	Shale, brown	3	182

TABLE 29.—*Materials penetrated by water wells in the Lompoc subarea*—Continued

7/35-24K2. A. B. Henning. On Lompoc plain. Altitude 51 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued.		
No record	34	34	Main water-bearing zone—Continued.		
Sand	35	69	Gravel	4	136
Sand, water-bearing	17	86	Sand	2	138
Clay	16	102	Gravel	7	145
Main water bearing zone:			"Perforating gravel"	33	178
Sand	13	115	Undifferentiated Tertiary rocks:		
Gravel	9	124	Shale	2	180
Sand	8	132			

7/35-24M3. W. R. Beattie. On Lompoc plain. Altitude 45 feet

[Casing perforated 97 to 101 and 140 to 158 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Blow sand	4	4	Sand and gravel	9	102
Soil	11	15	Sand	4	106
Sand	3	18	Clay, blue	3	109
Clay, soft, blue	7	25	"Sediment," sandy	11	120
Sand	9	34	Sand	5	125
Clay, blue	11	45	Sand, some gravel	11	136
Clay, sandy; blue	27	72	Main water-bearing zone:		
Sand, fine; blue	14	86	Sand and gravel	7	143
Clay, sandy, blue	4	90	Do	9	152
Sand	3	93	Gravel and rocks	9	161

7/35-25D1. H. E. Beattie. On Lompoc plain. Altitude 41 feet

[Casing perforated 145 to 194 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil	8	8	Main water-bearing zone:		
Sand, fine; yellow	15	23	Sand, fine	10	125
Sand, fine; blue	10	33	Sand, fine gravel	8	133
Sand and gravel	3	36	Gravel, fine	8	141
Clay, blue	3	39	Sand; fine gravel	19	160
Clay, soft; blue	31	70	Gravel	24	184
Sand	4	74	Orcutt (?) sand:		
Sand, fine; blue	25	99	Clay and gravel	5	189
Sand, fine; gravel	12	111	Gravel and fine sand	11	200
Clay, soft; blue	4	115			

7/35-25P1. Sudden Estate. On Lompoc plain. Altitude 48 feet

[Casing perforated 48 to 472 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Orcutt (?) sand:		
Sand, fine	22	22	Clay, sandy, blue; some gravel	11	210
Sand, coarse; some gravel	10	32	Sand and gravel	22	232
Clay, sandy	3	35	Clay, sandy, brown	8	240
Do	5	40	Clay, sandy, brown; some sand and gravel	30	270
Sand, gravel, and strata of sandy clay	48	88	Sand and gravel; strata of sandy clay	73	343
Clay, sandy	5	93	Clay, sandy; some gravel	27	370
Sand, gravel, and boulders	53	146	Gravel; strata of sandy clay	28	398
Clay, sandy, blue	11	157	Careaga (?) sand:		
Main water-bearing zone:			Sand, compact strata of clay	49	447
Sand, fine	6	163	Shell, cemented and hard	11	458
Boulders and gravel	8	171	Gravel, small strata of hard shell	17	475
Do	17	188	Clay and gravel	28	503
Gravel; a few small boulders	11	199			

TABLE 29.—*Materials penetrated by water wells in the Lompoc subarea*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
7/35–26A1. Charles Bondietti. On Lompoc plain. Altitude 38 feet					
Younger alluvium:			Younger alluvium—Continued		
No record	108	108	Main water-bearing zone—		
Gravel	2	110	Continued.		
Clay	17	127	Clay	2	144
Main water-bearing zone:			Gravel	24	168
Gravel	15	142	Orcutt (?) sand: Clay	8	176
7/35–26J1. County of Santa Barbara. On Lompoc plain. Altitude 41 feet					
Younger alluvium:			Younger alluvium—Continued		
Soil	20	20	Sand, blue	30	68
Clay, yellow	6	26	Clay, blue; and gravel	32	100
Clay, blue	12	38	Gravel; some sand	10	110
7/35–35C2. S. Colli. On Lompoc plain. Altitude 37 feet					
Younger alluvium:			Orcutt (?) sand—Continued		
Soil, black	3	3	Sand, hard	4	68
Clay, yellow	14	17	Clay, blue	4	72
Clay, blue	12	29	Gravel and clay	2	74
Clay, sandy, blue	12	41	Gravel	34	108
Orcutt (?) sand:			Sand and gravel	6	114
Sand, yellow	23	64	Sand, white	8	122

TABLE 30.—*Materials penetrated by shallow observation wells in the Lompoc subarea*

[Wells bored by the Geological Survey in the younger alluvium and river-channel deposits in the Lompoc plain. Materials classified through field inspection. Altitudes are above sea-level datum of 1929 by spirit levels]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
7/34–22J5. H. E. Harris. In river flood channel. Altitude 77.5 feet					
			River-channel deposits—Con.		
River-channel deposits:			Sand, medium	1½	6
Silt	1	1	Sand, coarse	2	8
Sand, fine	3	4			
Sand, fine; clayey	½	4½			
7/34–22Q1. A. Scolari. On Lompoc plain. Altitude 81.2 feet					
Younger alluvium:			Younger alluvium—Continued		
Soil	2	2	Clay	½	9½
Sand	6½	8½	Sand, coarse; little gravel	6½	16
Gravel and sand	½	9			
7/34–26D2. Union Sugar Co. On Lompoc plain. Altitude 83.5 feet					
Younger alluvium:			Younger alluvium—Continued		
Soil	3	3	Sand	1½	12½
Silt and clay	8	11			

TABLE 30.—*Materials penetrated by shallow observation wells in the Lompoc subarea*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
7/34–26F4. Union Sugar Co. On Lompoc plain. Altitude 93.8 feet					
Younger alluvium:			Younger alluvium—Continued		
Silt	2	2	Silt, uniform, buff	1½	9½
Sand, very fine	2	4	Clay, loose, drab brown	4½	14
Sand, medium	4	8	Clay, sand	5½	19½
7/34–26F5. Union Sugar Co. On Lompoc plain. Altitude 92.2 feet					
Younger alluvium:			Younger alluvium—Continued		
Soil, sand	2	2	Sand	4	13½
Sand	7	9	Clay	½	14
Gravel	½	9½	Sand and gravel	4	18
7/34–27A3. L. H. Schuyler. In river flood channel. Altitude 79.3 feet					
River-channel deposits:			River-channel deposits—Con.		
Silt	2	2	Clay, sandy at bottom	3	12
Sand, some gravel	7	9			
7/34–27H2. L. H. Schuyler. In river flood channel. Altitude 87.4 feet					
River-channel deposits:			River-channel deposits—Con.		
Sand, medium	2	2	Sand, medium	8	12
Sand and gravel	2	4			
7/34–27J5. L. H. Schuyler In river flood channel. Altitude 88.4 feet.					
River-channel deposits:			River-channel deposits—Con.		
Soil and clay	½	½	Silt, sandy, buff color; clay at base	1	10
Sand, coarse, with pebbles	5½	6	Sand, medium, uniform	3	13
Sand, fine, and silt	1	7	Clay, sticky, brown	1	14
Sand, medium; uniform	1½	8½	Sand, coarse, pebbly	3	17
Sand, medium, and pebbles	½	9			
7/34–27P2. Mary Skaarup. On Lompoc plain. Altitude 85.8 feet					
Younger alluvium:			Younger alluvium—Continued		
Road fill	1	1	Clay, blue, loose	2½	15½
Silt, clayey, light brown	4	5	Sand, coarse, and pebbles; gray-blue	1	16½
Silt, clayey, dark brown	5½	10½	Clay, blue, loose	1	17½
Clay, sticky, brown	2	12½			
Silt, clayey, loose	½	13			
7/34–28R2. A. C. Zvolanek. On Lompoc plain. Altitude 69.5 feet					
Younger alluvium:			Younger alluvium—Continued		
Soil	2	2	Sand, very fine, loose, uniform	2	14½
Clay, brown	4	6	Sand, fine, not loose	1½	16
Clay, blue	6½	12½			
7/34–29E5. G. F. Sanor. On Lompoc plain. Altitude 67 feet					
Younger alluvium:			Younger alluvium—Continued		
Soil, sandy	3	3	Clay, gray-brown	1	18
Sand, fine- to medium-grained	3	6	Sand, fine- to medium-grained	2½	20½
Clay and silt; gray-brown	11	17			

TABLE 30.—*Materials penetrated by shallow observation wells in the Lompoc subarea*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
7/34-30L3. Union Sugar Co. On Lompoc plain. Altitude 59 feet					
Younger alluvium:			Younger alluvium—Continued		
Soil	5	5	Sand, fine; with some silt	½	19½
Clay, with some silt; gray-brown	5	10	Clay, blue; firm	2½	22
Sand, fine; with some silt	1	11	Sand, medium- to coarse-grained; blue	1	23
Clay, reddish-brown; some sand	8	19			
7/34-34F1. Fred S. Anderson. On Lompoc plain. Altitude 106.8 feet					
Younger alluvium:			Younger alluvium—Continued		
Top soil	½	½	Sand, medium, gray and brown	2	27
Sand, fine, uniform, loose, buff color	8	8½	Clay, gray	3	30
Clay, sticky, brownish buff	4	12½	Sand, fine to medium; clay streaks	1½	31½
Silt, loose, uniform, sandy, buff	1	13½	Sand, medium	1½	33
Clay, sticky, buff	6½	20	Sand, blue and brown; little silt	1	34
Sand, medium, clayey, brown	3	23	Silt, blue, some sand, wet	2½	36½
Sand, medium	1	24	Silt, blue, some sand, water	1	37½
Sand, medium, and gray clay	1	25	Sand, coarse, few pebbles	1½	39
7/34-34H2. Mary Skaarup. On Lompoc plain. Altitude 112 feet					
Younger alluvium:			Younger alluvium—Continued		
Clay, baked, hardpan	½	½	Silt and clay	2½	26
Silt, fine, uniform; drab	5	5½	Clay, silty, damp	1	27
Clay, drab, dry, loose; fragments of carbonized wood	2	7½	Sand, medium grained, dry	1	28
Silt, clayey, drab, loose	½	8	Clay, silty	1	29
Silt, loose, drab	1½	9½	Sand, fine and silty	½	29½
Sand, fine, loose, uniform, drab	½	10	Clay and silt	1½	31
Clay, brown, uniform, loose	4	14	Sand, fine, and clay	1½	32½
Clay, brown, compact	6	20	Clay, sandy, damp	½	33
Silt and fine sand	3½	23½	Sand, fine	1½	34½
			Sand, fine and few pebbles	1	35½
			Sand, medium and pebbles	2	37½
7/34-34J1. E. Schuyler. On Lompoc plain. Altitude 117.8 feet					
Younger alluvium:			Younger alluvium—Continued		
Clay, brown	14	14	Sand, medium to coarse	1	25½
Silt, brown	1	15	Clay, brown	1	26½
Clay, brown	2½	17½	Clay, brown, and sand	1	27½
Silt, brown	3½	21	Sand, brown, medium	3	30½
Clay, brown	3	24	Sand, with few pebble stringers	7½	38
Sand, medium, with clay streaks	½	24½			
7/34-34K4. Fred Houk. On Lompoc plain. Altitude 113 feet					
Younger allumvium:			Younger alluvium—Continued		
Silt	5	5	Clay	1½	18½
Silt and gravel	5	10	Clay, sandy	1½	20
Sand, clayey	1½	11½	Clay	5	25
Sand, medium	½	12	Clay, sandy	9½	34½
Sand and clay	5	17	Sand, medium	6½	41
7/34-35B2. A. G. Hibbits. On Lompoc plain. Altitude 93.1 feet					
Younger alluvium:			Younger alluvium—Continued		
Silt, sandy; buff color	4½	4½	Silt, fine, sandy; buff	4½	10
Clay, compact; blue	1	5½	Clay, buff, somewhat loose; silty and sandy	8½	18½

TABLE 30.—*Materials penetrated by shallow observation wells in the Lompoc subarea*—Continued

7/34-35C2. Valla Bros. On Lompoc plain. Altitude 94.3 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Sand, loose	2	2	Clay, hard, blue	1	13
Sand, coarse	8	10	Sand, coarse, some gravel	3	16
Gravel and sand	2	12			

7/34-35C3. Mary Skaarup. In river flood channel. Altitude 96.1 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
River-channel deposits:			River-channel deposits—Con.		
Sand, fine buff-colored	9	9	Sand, coarse, and gravel	3	15½
Sand, medium, gray drab	2	11	Sand, coarse, pebbly	2	17½
Gravel and coarse sand	1½	12½			

7/34-35D3. Mary Skaarup. In river flood channel. Altitude 87.4 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
River-channel deposits:			River-channel deposits—Con.		
Silt	1	1	Sand, coarse, and loose gravel	5	11
Sand	5	6			

7/34-35D5. Mary Skaarup. On Lompoc plain. Altitude 112.6 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Silt, hard	1	1	Clay and sand	1	22½
Clay, silty	7	8	Clay	1	23½
Sand and silt	1½	9½	Sand, medium	2½	26
Clay and silt	2½	12	Sand, coarse and fine gravel	1	27
Clay, very little silt	2	14	Sand, medium	2½	29½
Sand and clay, mostly fine sand	6	20	Sand with some clay streaks	½	30
Clay	1½	21½	Sand with some gravel streaks	4½	34½
			Gravel, water	2	36½

7/34-35F6. M. Schuyler. On Lompoc plain. Altitude 119.5 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil	1½	1½	Sand, medium	2½	32½
Sand	1½	3	Gravel	½	33
Clay, brown	4	7	Clay and gravel	½	33½
Clay, brown, sandy	½	7½	Sand and gravel	1½	35
Sand, fine	2½	10	Silt	1	36
Sand and pebbles, clay streaks	3	13	Clay	1	37
Clay	3½	16½	Clay, sandy	½	37½
Sand, clayey	13½	30	Sand, fine	1½	39
			Sand, fine; sandy clay	1½	40½

7/34-35F8, Valla Bros. On Lompoc plain. Altitude 98.9 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Sand, medium, drab color	15½	15½	Clay, blue, compact	1½	17½
Sand, coarse and fine, gray	½	16	Sand, coarse, and fine gravel	3½	21

7/34-35F12. M. Schuyler. In river flood channel. Altitude 87.6 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
River-channel deposits:			River-channel deposits—Con.		
Sand, loose	½	½	Gravel, medium, and sand	½	6
Clay, hard, drab, dry	½	1	Sand, coarse	1	7
Sand, coarse, and pebbles	4½	5½			

TABLE 30. *Materials penetrated by shallow observation wells in the Lompoc subarea*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
7/34-35K7. W. P. and N. L. Robinson. In river flood channel. Altitude 90.6 feet					
River-channel deposits:			River-channel deposits—Con.		
Sand, fine, and silt; buff	3	3	Clay, loose, blue	1	6
Clay, blue, loose, wet	1	4	Sand, coarse, gray; and pebbles	1½	7½
Silt, loose, blue	1	5			
7/34-35L2. M. Schuyler. In river flood channel. Altitude 90.6 feet					
River-channel deposits:			River-channel deposits—Con.		
Soil and clay	½	½	Sand, coarse, and small pebbles	3	5½
Sand, fine, and silt	2	2½	Sand, coarse, and medium gravel	1½	7
7/34-35M1. E. Schuyler. On Lompoc plain. Altitude 117.5 feet					
Younger alluvium:			Younger alluvium—Continued		
Clay	3½	3½	Silt and clay	1	27
Sand, medium	1½	5	Sand and clay	½	27½
Clay and silt	2½	7½	Sand	5	32½
Clay	8	15½	Clay, wet	3	35½
Sand and streaks of clay	5½	21	Gravel, dry	1	36½
Clay	3	24	Sand, water	1½	38
Sand	2	26			
7/35-23E3. Union Sugar Co. On Lompoc plain. Altitude 37 feet					
Younger alluvium:			Younger alluvium—Continued		
Soil, sandy	1½	1½	Silt, sandy; brown	1	17
Silt, sandy; brown	13½	15	Sand, coarse	1	18
Silt, sandy; some clay; brown	1	16			
7/35-23N2. Union Sugar Co. On Lompoc plain. Altitude 33 feet					
Younger alluvium:			Younger alluvium—Continued		
Soil	1	1	Clay, with some coarse sand	4	12
Sand, fine, with some silt	5	6	Sand, medium- to fine-grained	7	19
Clay, dark brown	2	8			
7/35-24K3. A. B. Henning. On Lompoc plain. Altitude 51 feet					
Younger alluvium:			Younger alluvium—Continued		
Soil, sandy	3	3	Clay with some medium-grained sand	½	10½
Sand, medium-grained; some silt	1	4	Clay, gray-brown	6½	17
Silt and clay, sandy	2	6	Clay, silty; brown	4	21
Sand, medium-grained; some silt	2½	8½	Sand, coarse; some clay	1½	22½
Clay, sandy	1½	10	Clay, gray-brown	½	23
			Sand, medium-grained; some pebbles	1	24
7/35-25F6. Union Sugar Co. On Lompoc plain. Altitude 47 feet					
Younger alluvium:			Younger alluvium—Continued		
Soil	3	3	Sand, fine; and clay	3	15½
Soil, clayey	2	5	Sand, medium- to fine-grained; some silt	4	19½
Silt and fine sand	7½	12½			

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