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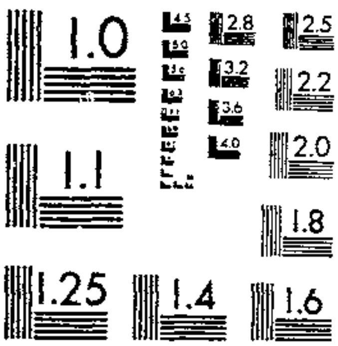

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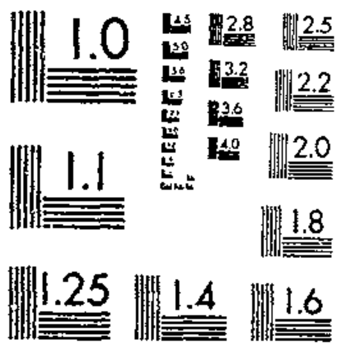

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Quality of Irrigation Waters of the Hollister Area of California

With Special Reference to Boron Content and Its Effect on Apricots and Prunes [1]

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INTRODUCTION

LOCATION AND PHYSIOGRAPHIC FEATURES OF THE HOLLISTER AREA

The Hollister area of California constitutes the upper or southern portion of the Santa Clara Valley in San Benito County (fig. 1). It is separated from the northern portion of the valley by the Pajaro

[1] Submitted for publication November 24, 1939.
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[3] The authors are indebted to Joseph W. Gross, consulting engineer, Hollister irrigation district, for compilation of the data reported under the heading Water Resources, and to V. P. Sokoloff, L. V. Wilcox, J. T. Hatcher, R. V. Higgins, and W. C. Nelson, of the Division of Irrigation Agriculture, Bureau of Plant Industry, for the analyses reported in this bulletin.

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River, which rises in a depression known as San Felipe or Soap Lake, and flows southwestward to its junction with the San Benito River and thence out of the valley to Monterey Bay. Hollister, the county seat, occupies a central position toward the southern end of the valley a few miles north of the point of entrance of the San Benito River and about 20 miles inland from Monterey Bay.

The San Benito River, after leaving the mountains and foothills, does not continue its northwestward course toward San Felipe Lake through what may be its own alluvial formation, but instead turns to the left to pass to the south of Lomerias Muertas (hills). These hills extend in a broadening triangular form westward for 7 or 8 miles toward the junction of the San Benito with the Pajaro River. They separate the San Juan section from the remainder of the area. The Gabilan Range forms the western boundary and the Diablo Range the eastern boundary of the Hollister area. The valley is roughly circular in outline with a diameter of about 12 miles.

There were 20,277 acres of land (*15*)[4] under irrigation in San Benito County in 1929 and practically all of this, divided between 572 farms, is in the Hollister area. The area includes valley lands along San Benito River and its tributary, Tres Pinos Creek, as well as those along Pacheco Creek, which enters the valley from the northeast.

The elevation of the valley floor near the county hospital south of Hollister is 324 feet above sea level, at Hollister 292 feet, and in the bed of the San Felipe depression as well as at the junction of the Pajaro and San Benito Rivers about 140 feet.

Water Supply and Use

The water supply for this irrigated land is derived principally by pumping from the underground reservoirs. According to the census there were 410 pumping plants in 1930 with an average lift of 71 feet and a total capacity of 226,727 gallons per minute (505 cubic feet per second or 1,004 acre-feet per day). In 1920 the average lift for the then existent 183 plants was 34 feet. The average annual drop in water levels[5] as observed in 105 wells for the period January 1924 to December 1935 was 3.0 feet in the lower Southside-upper Union section, 3.4 feet in the San Juan-Westside section, 4.0 feet in the central Hollister-Bolsa section, and 2.8 feet in the Fairview-Enterprise section.

Measurements by Pillsbury[5] involving a study of 66 pumps serving representative acreage show the following average use of irrigation water per acre in the Hollister area in 1935: Orchards, 11.2 acre-inches; alfalfa, 24.9 acre-inches; truck, field, and seed crops, 17.0 acre-inches.

Water Resources

Of the approximate 800 square miles of watershed tributary to the Hollister area, 584 are drained by San Benito River and its most important branch, Tres Pinos Creek (pl. 1, *A*). San Benito River flows into the valley from the south. Pacheco Creek, with 148 square miles of watershed, enters the valley from the northeast and turns to flow northwestward across the valley floor to San Felipe Lake depres-

[4] Italic numbers in parentheses refer to Literature Cited, p. 58.

[5] PILLSBURY, A. F. IRRIGATION STUDY OF THE HOLLISTER AREA—REPORT OF FIELD INVESTIGATIONS, AUGUST 11, 1934, TO JANUARY 31, 1936. Division of Irrigation Investigations and Practices, Univ. of California [multigraphed].

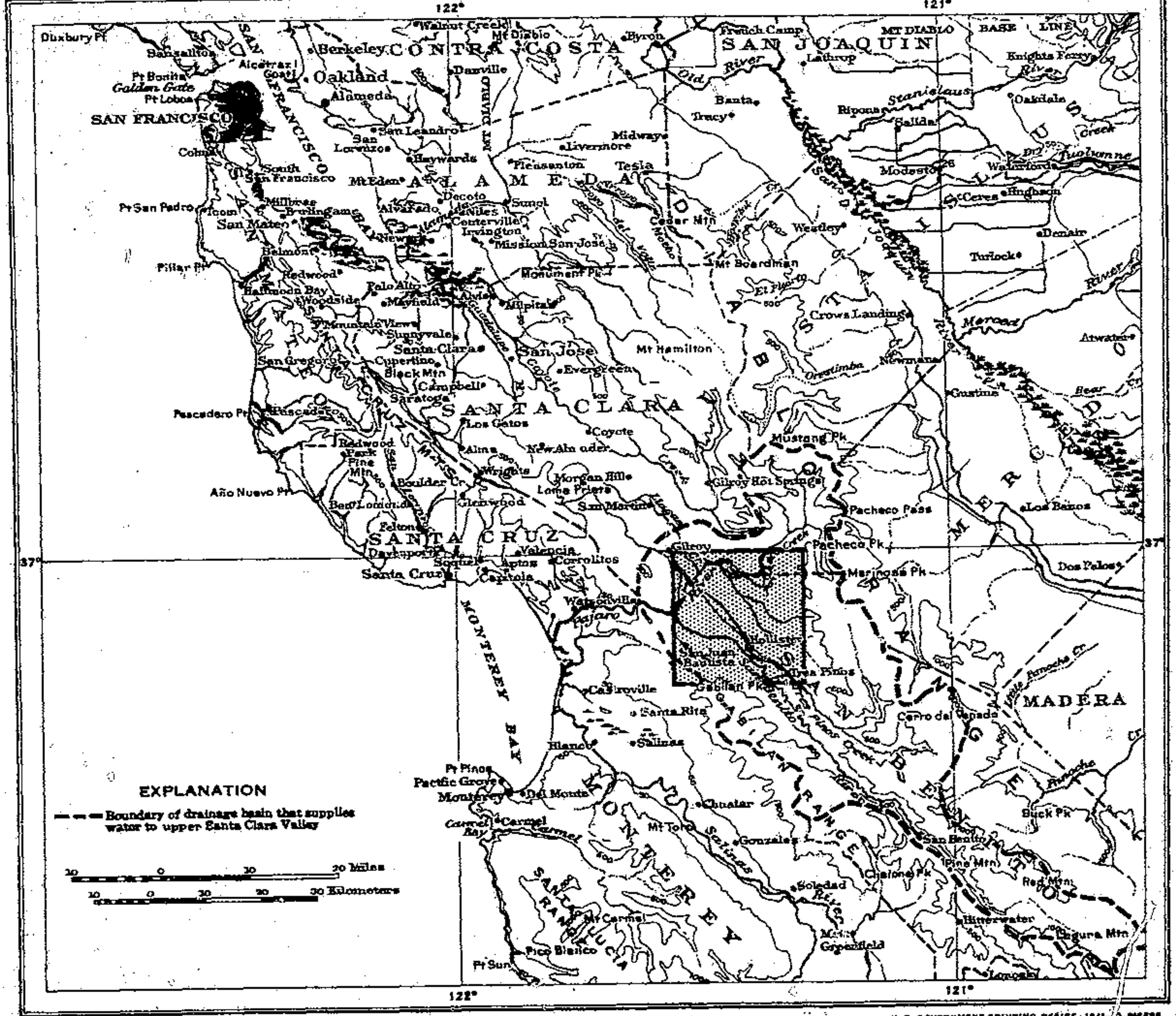

FIGURE 1.—Topographic map of drainage basin of Hollister area, California, showing area covered by detailed maps.

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A, Live oaks and grasslands along the dry bed of Tres Pinos Creek. Los Muertos Creek comes in from the left in background. *B*, Fruit plantings westward from Hollister. Lomerias Muertas (hills) in right background.

sion and thence out of the valley through Miller Canal and the Pajaro River. Three other creeks enter the valley from the east and drain northwestward through Tequisquita slough into San Felipe Lake. These creeks, Las Viboras, Dos Picachos, and Santa Ana, have drainage areas of respectively 22.3, 15.5, and 33.5 square miles.

San Juan Creek, which rises in the Gabilan Range, contributes substantially to the ground waters in the San Juan district. Usually no surface flow reaches the San Benito River. This stream is regarded by some as the main source of ground water in the northwestern portion of this district.

The seasonal discharges of the San Benito River, Tres Pinos Creek, and Pacheco Creek that have been recorded are reported in table 1.

TABLE 1.—*Seasonal discharge of San Benito River, Tres Pinos Creek, and Pacheco Creek for years recorded*

[Data by C. W. Levisee, engineer, Hollister irrigation district, except as noted]

Year	San Benito River at Carr Bridge	Tres Pinos Creek at Bolado Park	Pacheco Creek at Lester Bridge	Year	San Benito River at Carr Bridge	Tres Pinos Creek at Bolado Park	Pacheco Creek at Lester Bridge
	Acre-feet	*Acre-feet*	*Acre-feet*		*Acre-feet*	*Acre-feet*	*Acre-feet*
1922–23 [1]	10,600	3,492	------	1930–31	(3)	------	------
1923–24 [2]	1,755	760	------	1931–32	------	------	------
1924–25	1,348	3,040	3,007	1932–33	------	------	------
1925–26	2,694	1,570	3,237	1933–34	------	------	------
1926–27	11,240	4,155	21,802	1934–35	9,517	6,455	18,720
1927–28	------	------	15,098	1935–36	14,012	7,037	26,212
1928–29	(3)	------	------	1936–37	26,476	20,678	------
1929–30	(3)	------	------				

[1] Data by U. S. Geological Survey.
[2] Data by A. N. Burch, engineer, Hollister irrigation district.
[3] No flow.

The run-off expectancy from the San Benito-Tres Pinos watershed has been placed as equivalent to about 1 inch of water depth per season. In no year has as much as 2 inches been recorded. The Pacheco drainage area is somewhat more productive, the average yield being about 3 inches.

A storage reservoir on the north fork of Pacheco Creek with a capacity of 6,000 acre-feet was completed in 1939. This reservoir during coming years will be used to regulate the flow of the stream as an adjunct to effective spreading of storm water. Plans have been proposed at various times for check dams and reservoirs on the San Benito River to serve a similar purpose and possibly to supply some canal water. Spreading has been conducted on a small scale since 1937 on 60 acres of sandy bottom land along the San Benito River. A total of 4,300 acre-feet was spread in one season with beneficial effects on the water levels in adjacent wells. Water for Paicines Reservoir, which has a capacity of 3,100 acre-feet, is diverted from San Benito River above Paicines. This reservoir and the Brown ditch system are capable of serving several hundred acres of land during the winter and spring months, but the supply is usually exhausted by May 1. The seepage from the 6 miles of sidehill ditch leading to this reservoir and from the reservoir itself is relatively great. Without doubt seepage water from these sources contributes to the ground water and to the late-season flow of some of the streams.

A diversion reservoir with a capacity of 39 acre-feet was constructed on Las Viboras Creek in 1937. Water from this reservoir is spread.

There will be developed in connection with the discussion of the quality of ground waters evidence indicating that the San Benito River contributes substantially to the ground-water supplies underlying a large portion of the valley floor northwestward from Hollister.

Climate and Rainfall

The climate of the Hollister area is similar to that of other inland valleys in the coastal section of California. Killing frosts are occasionally experienced, particularly in lower portions of the valley, causing the culture of subtropical fruits to be impracticable, but a few sensitive trees, such as the lemon and avocado, are grown in family gardens. The more susceptible of the commercial fruits, such as apricots, are customarily planted on higher elevations. The minimum recorded temperature at Hollister is 18° F. in January, and the maximum, 112° in July. The summer nights are almost invariably cool and the coastal breeze tends to maintain equable temperatures during the day.

The most characteristic climatic feature, like that of other sections of the Pacific coast, is a comparatively rainless summer. The average annual precipitation in Hollister (table 2) over a 63-year period, 1873–1936, as recorded by the United States Weather Bureau, is 12.86 inches, 90 percent of which has fallen in the months of November to April, inclusive.

Table 2.—*Average monthly and annual temperatures and precipitation at Hollister, Calif., 1873–1936, and monthly mean maxima and minima, and monthly precipitation for the years 1935 and 1936*

[From records of the U. S. Weather Bureau]

Month	Temperature					Precipitation		
	63-year mean	1935 Monthly mean		1936 Monthly mean		63-year mean	1935	1936
		Maxima	Minima	Maxima	Minima			
	°F.	*°F.*	*°F.*	*°F.*	*°F.*	*Inches*	*Inches*	*Inches*
January	47.9	58.7	37.6	61.6	38.9	2.77	3.50	1.63
February	51.1	62.2	39.6	62.1	40.3	2.20	.41	5.64
March	53.9	62.8	37.8	69.6	41.2	2.19	2.53	1.35
April	57.0	68.4	45.2	73.1	43.7	.87	3.85	.85
May	60.3	73.2	46.5	77.8	47.7	.49	0	.22
June	64.3	82.8	49.2	81.7	50.8	.11	0	.37
July	66.2	83.5	50.3	85.5	51.5	.04	.04	.33
August	65.9	83.3	51.2	83.7	50.4	.01	.20	(1)
September	64.9	81.5	50.8	86.5	48.6	.26	.16	0
October	60.5	76.1	43.1	78.0	46.0	.47	.35	.70
November	54.0	71.1	37.3	69.2	36.2	1.30	.65	.01
December	48.6	62.6	35.6	58.1	33.3	2.17	.82	3.09
Year	57.9	72.3	43.7	74.0	44.1	12.88	12.50	14.19

[1] Trace.

Soils

The soils represented in the valley lands of the Hollister area are grouped on the basis of their mode of formation (*4*) as old transported soils and recently transported soils. In both of these groups there are a number of soil series, each of which is represented by one or more textural types.

The old transported soils are represented by the Pleasanton, Antioch, Montezuma, and Rincon series. These soils occur on flats, benches, or terraces, intermediate in elevation between the higher hills and mountains and the lower land. In the eastern portion of the valley, where there has been less erosion, old transported soils are also found on the valley floor at elevations only slightly higher than the recently deposited alluvial soils. These old transported soils are characterized by heavier or more compact subsoils caused by the leaching downward of the finer materials from the surface. In some places soil layers of distinct structure have developed. There is considerable variation in the importance of these old soils; and experience has shown them to be agriculturally less desirable than some of the recent alluvial soils.

The soils of the recent alluvial group are represented (1) by the Hanford and Chino series whose materials are derived mainly from granitic rocks; (2) by the Conejo gravelly clay loam, derived from basic igneous rocks; and (3) by the Yolo, Capay, and Dublin series, which originate mainly from sedimentary or metamorphosed sedimentary rocks. The latter three series are most abundantly represented, and of these the Yolo series has the greatest agricultural value. It ranges in texture from gravelly and sandy loam to clay adobe and is preferred for orchard and specialized plantings. The profiles of all the recently transported soils are more or less uniform in appearance. They occur on the stream flood plains, in low basinlike areas, and on low, recently built stream terraces and alluvial fans.

The low-lying portion of the Hollister area, known as Bolsa de San Felipe, is nearly coincident with the 25-square-mile area of artesian flowing wells as mapped by the United States Geological Survey in 1924 (*3, pl. XVIII*). At the present time there are only a few flowing wells in the Hollister area. The soils of the Bolsa district as reported by the soil survey are principally of the Dublin series, and of this series the Dublin clay adobe is the dominant type. This soil type generally occurs in low basinlike areas where drainage is deficient. The limits of the Bolsa are indefinite, as it grades into tillable lands. The Bolsa is covered by scanty growth of saltgrass, and much of the soil is too saline for uses other than pasture. An extensive effort was made to reclaim the Bolsa for the culture of sugar beets early in the present century, but the venture was abandoned. Some of the drainage ditches still remain.

Agricultural Development and Crops

The Hollister area is widely known for its production of vegetable and flower seeds, but, as may be observed in table 3, this specialized industry is secondary to the fruit industry (pl. 1, *B*) in terms of acreage. Acreage estimates as of 1937 (*2*) report a total of 13,534 acres of fruit trees, most but not all of which are irrigated. The census report gives the number of irrigated trees and vines of the several kinds, but the acreages of the different ones are not reported.

TABLE 3.—*Acreages of irrigated crops, 1929,*[1] *and more important irrigated crops, 1937,*[2] *in San Benito County, Calif.*

Irrigated crops 1929		Irrigated crops 1937	
Kind	Acres	Kind	Acres
Corn, total	195	Garlic	1,109
Cereals, threshed	50	Lettuce	1,150
Hay crops:		Peas	1,475
Alfalfa	2,721	Potatoes	148
Small grain	641	Seeds	1,450
Clover	17	Sugar beets	2,293
Annual legumes	2	Tomatoes	4,100
Potatoes	51	Berries	46
Sorghums	1	Apricots	5,150
Seeds:		Apples	167
Grass	30	Peaches	168
Vegetable and flower	1,010	Pears	1,212
Vegetables	1,927	Prunes	6,290
Fruits, nuts, vineyard	11,705	Walnuts	745
Berries	14		
Pasture and unaccounted	1,922		
Total	20,238		

[1] Fifteenth census of the United States: 1930. Irrigation of Agricultural Lands.
[2] Obtained from W. B. Saunders, San Benito County agricultural commissioner.

The agricultural development of the Hollister area was begun with the founding of the San Juan Bautista Mission in 1797. As summarized by Cosby and Watson (*4, p. 647*):

> About 10 acres of the lowland at the base of the small plateau on which the mission is situated, were set out at an early date to an orchard of mixed fruits, mainly pears and apples. The mission had small herds of cattle and sheep, and a 30-acre vineyard, and a few olive and peach trees were planted on the higher land 1 mile south of the mission. Referring to this early orchard one writer stated in 1881: "All the apple trees have decayed; but several hundred of the pear trees are still standing, yielding annually an abundance of fruit, and are, apparently, still vigorous enough to outlive the present generation of man." At the present time (1923) about 30 of the pear trees which are probably more than 100 years old are still living and each year produce a small quantity of fruit of inferior quality.

A slow agricultural development is reported during the first half of the nineteenth century. It consisted almost entirely of the raising of livestock on the larger land grants by Spanish and Mexican owners. The founding of the town of Hollister in 1868 and the construction of the Southern Pacific Railroad in 1870, following the admittance of California to the Union in 1850, accelerated agricultural development, but until 1880 most of the land was still devoted to the grazing and livestock industries. Subsequently the livestock industry was displaced by grain and hay farmers, and these in turn were crowded to higher land with the development of the fruit industry and other more intensive types of agriculture.

IRRIGATION DEVELOPMENT

The first land to be irrigated in San Benito County was located in the northern part, in a section known as the San Felipe district. In 1878 William Buck drilled the first well on property located on Lovers' Lane adjacent to Pacheco Creek. This well was about 90 feet deep and supplied artesian water for his experimental plantings. The following year, E. A. Sawyer developed an artesian well on his property along the San Felipe Road. Water was plentiful in this locality, and in succeeding years many other artesian wells were developed for use on alfalfa and other field crops. The wells were usually 50 to 100 feet deep and at least one of them supplied as much as 3,000 gallons per minute in artesian flow. It was not until 1898 that the artesian flow was reduced to the point that pumping was resorted to—the first pump being installed by R. I. Orr in that year.

The development of irrigation agriculture in the Hollister area began with the incorporation in 1889 of the Hollister Irrigation Co. This company constructed diversion works on the San Benito River and in 1891 began delivering water through a canal system to serve about 2,000 acres of land adjacent to the town of Hollister. This canal system was practically identical to the Brown ditch system now owned by the San Benito Land & Water Co., successors to the Hollister Irrigation Co. Water from this system was available only for winter and spring irrigation as there were no storage reservoirs constructed until 1914, the year the Paicines Reservoir was built.

Although most of the water diverted from the San Benito River was used for the irrigation of alfalfa, some was used to irrigate the first deciduous fruit plantings in the county. In 1891 F. L. Barnhisel, Jessie Ross, and William Kelly planted the first orchards south of Hollister and irrigated them from the canal. Additional plantings were made in 1892, some of which are still bearing.

Without a reservoir to extend the irrigation season, the water supply from the San Benito River was not dependable, and gradually wells were developed to supplement the river water. The first successful well from which water was pumped was installed in 1898 by Dan McCloskey, about 2 miles northeast of Hollister. This well was 80 feet deep and delivered about 700 gallons per minute. At the time the well was drilled the water stood at 35 feet below the surface. This well was in operation until 1926.

Between 1898 and 1914 there was a gradual increase in the number of wells drilled. A more rapid expansion in the irrigated acreage took place after electrical energy was made available to the farmers in the Hollister Valley in 1914. This increase was continued until the present date when practically all of the irrigable land is supplied with well water. The Federal census provides the following data on irrigated land in San Benito County: 1900—2,870 acres; 1910—7,186 acres; 1920—12,463 acres; 1930—20,277 acres.

The Hollister irrigation district was organized in 1923 for the purpose of replenishing the underground water supply by means of dams to be constructed on the San Benito River and Tres Pinos and Pacheco Creeks for the conservation of floodwaters. Although the Hollister irrigation district as originally formed has not accomplished its objectives, the Pacheco Pass water district has been more successful. Originally a part of the Hollister irrigation district, this district comprising 5,389 acres of land in the northern section of San Benito County and the Pacheco Pass area of Santa Clara County withdrew and in 1931 organized a separate district. In 1939 the Pacheco Pass water district completed construction of a dam on the north fork of Pacheco Creek. The reservoir formed by the dam has a capacity of 6,000 acre-feet of water, which will be used for controlled percolation.

QUALITY OF WATER SUPPLIES

The investigations reported in this bulletin were undertaken in 1931 for the principal purpose of determining the extent to which excessive concentrations of boron in irrigation waters were responsible for the poor condition of orchard and other plantings in portions of the Hollister area. Prior to these investigations it had been found (*5, 10, 13*) that boron was not uncommonly an important constituent of the irrigation waters in the Western States. The concentrations encountered, though usually not sufficiently high to be directly injurious to plants (pl. 1, *B*), in some localities are such that with continued use soil-solution concentrations are built up to a point where crop growth is depressed or lands become unsuitable for the culture of other than the most tolerant plants (pl. 2). In 1931 W. R. Schoonover observed that the symptoms of injury shown by walnut trees interplanted in an unprofitable prune orchard on the Martin Luther property near Hollister were like those found elsewhere and known to be due to an excess of boron. Analyses of samples of the irrigation water and of the walnut leaves confirmed the field conclusion. Analyses of additional water samples from other portions of the area showed the boron concentrations to be highly variable, and in some cases the concentrations of chloride were such as to attract attention.

Methods of Analysis and Expression of Results

The analytical procedures were those customarily employed in water analysis. HCO_3, Cl, and SO_4 were determined by the Association of Official Agricultural Chemists (*1*) methods, Ca by the titration of calcium oxalate, Mg by weighing magnesium pyrophosphate, and Na by weighing the uranyl zinc acetate hexahydrate. Boron in water and soil solutions was determined by electrometric titration in the presence of mannitol.

Electrical conductance ($K\times10^6$ at 25° C.) is reported in reciprocal ohms, multiplied by 10^6 to avoid awkward decimals. The electrical conductance of waters is dependent upon the number and kinds of dissolved salt constituents and accordingly provides an index to total salinity. Knowing the conductance of a water sample, as here pointed off five places to the right, an approximation of the total milliequivalents per liter of the anions (acid radicals) or of the cations (bases) may be had by dividing the conductance by 10. If the conductance is multiplied by 7, the resulting value approximates total dissolved solids expressed in parts per million (p. p. m.). Thus, in a water with a conductance of 100, the sum of the milliequivalents (m. e.) of CO_3, HCO_3, SO_4, and NO_3 will be about 10, and total dissolved solids will be about 700 p. p. m.

The expression "percent sodium" (*5*) is used to designate the relation:

$$\text{Sodium-total base ratio}=\frac{\text{milliequivalents Na}\times100}{\text{milliequivalents of total bases}}.$$

The cations: Calcium (Ca), magnesium (Mg), sodium (Na), and the anions: Bicarbonate (HCO_3), sulfate (SO_4), chloride (Cl), and nitrate (NO_3) are expressed in milliequivalents per liter (abbreviated m. e.). Carbonate (CO_3) is included in the value reported for bicarbonate. This unit of measurement, which reflects the number of ions, is adopted in the interest of an understanding of the chemistry of waters and the interpretation of analyses. Concentrations expressed in units of weight such as parts per million are sometimes desired for particular purposes. The concentrations of constituents expressed in milliequivalents per liter may be converted to parts per million by multiplying them by an appropriate factor as follows:

Cations:	Factor	Anions:	Factor
Calcium (Ca)	20	Carbonate (CO_3)	30
Magnesium (Mg)	12. 2	Bicarbonate (HCO_3)	61
Sodium (Na)	23	Sulfate (SO_4)	48
Potassium (K)	39. 1	Chloride (Cl)	35. 5
		Nitrate (NO_3)	62

These factors are the atomic weights of the ions divided by their valences. The atomic weight of chloride, for example, is 35.5 and the valence is 1; accordingly 5 m. e. of chloride is the same as 177.5 p. p. m. The atomic weight of the sulfate radical (SO_4) is 96, and it has a valence of 2; accordingly 5 m. e. of sulfate is the same as 240 p. p. m.

Agricultural Interpretation of Analyses

BORON

As a general consideration, above 0.3 p. p. m. the less boron in an irrigation water the better. Some boron is essential to the growth of many if not all plants, but it is not implied that as much as 0.3 p. p. m. is generally essential or advantageous. As will be developed in conjunction with table 18 (p. 55), plants show marked variability in their sensitivity to boron injury. In that table a series of agricultural plants are classified as sensitive, semitolerant, and tolerant.

Little, if any, injury can be expected when sensitive crops are irrigated with water containing less than 0.4 p. p. m. of boron. Pronounced injury can be expected when the most sensitive of the sensitive crops are irrigated with a water supply with 1 p. p. m. of boron. Boron is considered an adverse factor in the culture of walnuts when injury appears as early as August, but when these symptoms are not evident until October they may be disregarded.

Walnuts are placed toward the end of the sensitive group because they sometimes remain alive under boron condition that would kill such plants as the navy bean. Walnuts nevertheless show leaf symptoms at boron concentrations as low as those that are injurious to the lemon.

Under the climatic and soil conditions in the Hollister area a water supply containing 1.5 p. p. m. of boron is regarded as hazardous for the culture of apricots and prunes. A few orchards have developed mild symptoms of boron injury when the water supply contained less than 1 p. p. m. of boron and a few have shown only mild symptoms after having been irrigated for 15 years with water supplies containing more than 3 p. p. m. of boron.

Water with as much as 2 p. p. m. of boron can be considered promising over a long period for the culture of only those crops classified as tolerant. It is not implied, however, that the production of sensitive and semitolerant crops is not sometimes profitable under favorable conditions when water carrying 2 p. p. m. of boron is used. This is particularly true in areas of substantial rainfall when the soil is deep, permeable, and well drained.

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Soils show outstanding differences in the proportion of the boron, added by irrigation water, that is fixed in forms of low solubility. The injurious effects of boron become evident and pronounced on some soils after a few years' use of water, whereas on other soils the evidence of injury remains slight after many years. There is accordingly a factor of uncertainty in the interpretation of water analyses that is related to the soil.

Climate likewise appears to be a factor of some importance, since a greater degree of injury can be expected in the hot and more arid sections than can be expected along the coast. The relative proportions of rain and irrigation water must likewise be taken into account.

PERCENT SODIUM

Waters with high percentages of sodium have an adverse effect upon the physical structure of the soil. Soils irrigated with such waters become difficult to work, penetration of water into the root zone is retarded, and the leaching of salt from the root zone impeded.

CALCIUM, MAGNESIUM, AND SODIUM

Waters high in calcium are to be preferred to waters that are high either in magnesium or sodium. Some calcium and magnesium are essential to crop growth and a little sodium is not considered disadvantageous, but a high concentration of any of these ions is undesirable. Potassium rarely occurs in sufficient concentration in natural waters to require consideration.

CARBONATE AND BICARBONATE

The presence of much carbonate or bicarbonate in irrigation waters is not desirable, as these ions tend to increase soil alkalinity. With the loss of CO_2 from bicarbonate ion during the drying of soils calcium and magnesian carbonate are precipitated.

SULFATE AND CHLORIDE

A little sulfate is essential to plant growth, but few irrigated soils are deficient in this ion. Although chloride is not generally regarded essential to plant growth, some few plants have been found to respond favorably to low concentrations.

It is to be recognized that different crop plants show marked variability in their tolerance to the salts carried by irrigation waters. Furthermore, some plants, as illustrated by beets, show greater sensitivity to sulfate than to chloride, whereas the converse is ordinarily the case. Unfortunately, the information available on either the relative or actual tolerances of crop plants to these common salt constituents is very limited. The results of exploratory experiments discussed in part elsewhere (7) indicate that there is a tendency for some of the common crops to be about twice as tolerant to sulfate as to chloride as measured in milliequivalents and that the effects of these two ions are additive. In other words, with some crops a water containing 5 m. e. per liter of chloride plus 10 m. e. of sulfate should produce about the same degree of injury as a water containing either 10 m. e. of chloride or 20 m. e. of sulfate. The solubility of calcium sulfate in the soil solution does not ordinarily exceed 30 or 35 m. e., but sodium and magnesium sulfate are highly soluble. Nearly all irrigation waters carry chloride and sulfate salts in solution. The extent to which these, as well as other salts, accumulate in soil solutions to the detriment of crops, rests not alone on the concentrations in the irrigation waters, but also on the abundance of root-zone leaching. The degree of productivity of potentially fertile irrigated land depends more upon this factor of salt accumulation, which is related to maintenance of soil permeability and drainage conditions as well as to the adequacy of the water supply (both quantity and quality), than upon any other factor.

As a result of evaporation from the soil and of greater withdrawal of water than of salt by plants, the concentrations of salt constituents in the root zone are greater than those in the irrigation water. Under good irrigation practice the soil solution of the root zone can be expected to be from three to eight times as concentrated as the irrigation water. The concentration of the soil solution may, however, exceed that of the irrigation water many times as a result of inadequate leaching of the root zone by insufficient use of water, improper methods of application, impermeable soils, or the presence of hardpan layers. In evaluating the probable effects of a water upon crops, due consideration must be given the fact that plants are not subject to the salt concentrations as they exist in the water supply, but rather to the concentrations as they exist in the soil solution of the root zone.

It is well known that poorly drained lands sometimes go out of production as a result of salt accumulation even though irrigated with remarkably pure waters and, conversely, profit not infrequently results when relatively saline waters are used abundantly on open and well-drained soils. With the foregoing considerations in mind, it should be fully evident that in any classification of water quality general terms must be used and the limits of concentration ranges must be in a measure arbitrary. The data in table 4 are offered merely for purpose of orientation. The soils, drainages, and climatic and cultural conditions are diverse in irrigated regions, and there are such marked differences in the salt reactions of different crops that each water supply, in the final analysis, must be regarded in terms of the relations existing in the locality in which it is to be used.

TABLE 4.—*Classification of irrigation waters*

Classification	Percent sodium	Boron		Chlorides (m. e. per liter)	Sulfates (m. e. per liter)
		Sensitive plants (p. p. m.)	Tolerant plants (p. p. m.)		
Class 1, excellent to good	0 to 40	Less than 0.40	Less than 1	Less than 2	Less than 4.
Class 2, good to injurious	40 to 70	0.40 to 1	1 to 2	2 to 6	4 to 12.
Class 3, injurious to unsatisfactory.	70 to 100	1 and above	2 and above	6 and above	12 and above.

If a water approaches the upper limit in a number of respects it is not to be regarded as being as good as one that is high with respect to only one constituent. Sulfates must be considered in conjunction with the percent sodium. If waters are high in calcium, higher concentrations of sulfate can be tolerated.

With increasing concentrations of salt constituents in the soil solution of the root zone there is increasing injury to the plants growing on the land. The first growth depression occurs at relatively low concentrations, and at each successively higher concentration there is a further decrease in growth and yield. Thus injury is a matter of degree and it is not possible to assign a critical significance to particular soil-solution concentrations.

Some salt injury may exist on many well-managed farms and orchards without being evident. Plant appearance can rarely be taken as a criterion of salt injury. The growth of many field and orchard crops may be greatly depressed by salt accumulation without the appearance of visible evidence of the cause of injury. Leaf markings or other morphological abnormalities are commonly not in evidence even when a substantial depression of growth has been produced. The walnut leaves illustrated in plate 6 show what is usually regarded as chloride injury, but salt symptoms of this character are exceptional.

MISCELLANEOUS WATERS IN CENTRAL COASTAL AREA OF CALIFORNIA

A number of analyses of water samples from the central coastal area of California are reported in table 5 and the following pages for the purpose of recording them and for the additional reason that they serve in some measure to relate the conditions pertaining in the Hollister area to those of the general region in which it is situated. Some of these samples were collected as a part of a reconnaissance survey of the Southwest, and others were collected in collaboration with county agents and other public officials for more specific reasons. Although the analyses are indicative of the water-quality conditions existing in this area, the samples are so few in number and the territory embraced is so large that a discussion of the results has seemed inadvisable.

TABLE 5.—*Quality of surface and ground waters sampled in central coastal area including Santa Clara, Santa Cruz, San Benito (other than Hollister drainage area), Monterey, San Luis Obispo, and Santa Barbara (north of Santa Ynez River) Counties*

Location	Laboratory No.	Date	Depth	Discharge	$Kx10^5$ at 25°C.	Boron	Percent sodium	Quantity per liter of—						
								Ca	Mg	Na	HCO_3	SO_4	Cl	NO_3
Santa Clara County:														
Surface waters:			*Feet*	*Cu.ft./sec.*		*P.p.m.*		*M.e.*	*M.e.*	*M.e.*	*M.e.*	*M.e.*	*M.e.*	*M.e.*
Coyote Creek at Coyote	2952	June 25, 1930	-------	4	61.7	0.16	23	2.32	2.36	1.37	3.85	1.30	0.90	-------
Gilroy Hot Springs	4878	Sept. 19, 1931	-------	.02	200	15.10	47	.66	11.12	10.63	19.55	(1)	3.70	0
Ground waters:														
Associated Seed Growers	12011	Mar. 21, 1938	150	-------	70.1	.42	-------	-------	-------	-------	5.62	-------	.80	-------
Saunders Bros.	7795	Aug. 15, 1933	180	-------	38.4	.13	17	1.77	2.09	.68	3.65	.30	.34	.02
Santa Cruz County:														
Surface waters:														
Pajaro River	5004	Oct. 16, 1931	-------	8	77.3	.34	41	2.25	2.50	3.35	4.90	.95	2.25	-------
Ground waters:														
Watsonville city water	2953	June 25, 1930	-------	-------	53.9	.13	17	2.79	2.00	.98	4.30	.97	.50	-------
G. Errard Co.	5003	Oct. 15, 1931	190	-------	68.2	.09	20	4.00	2.03	1.48	5.05	1.23	.80	.43
San Benito County (other than Hollister drainage area):														
Surface waters:														
Creek east of Pinnacles	6354	June 24, 1932	-------	.3	42.5	.11	43	1.42	.73	1.63	2.05	.49	1.50	.02
Hepsedam Springs	4843	Sept. 10, 1931	-------	-------	54.7	1.15	80	.57	.60	4.75	3.05	1.49	1.05	.01
Panoche Creek	2767	May 22, 1930	-------	1	270	4.89	49	7.11	9.36	15.83	5.20	22.25	4.85	-------
Do	4833	Sept. 9, 1931	-------	2	289	6.52	56	5.59	9.04	18.38	5.10	22.21	5.70	(1)
Ground waters:														
Well near Panoche	2768	May 22, 1930	30	-------	129	1.54	36	5.13	3.56	4.92	3.75	8.81	1.05	-------
J. H. Morgan	6673	Aug. 3, 1932	20	-------	618	7.44	47	24.21	19.69	39.05	5.65	71.10	5.50	.07
Manuel Ortiz	11167	Dec. 3, 1936	90	-------	133	1.14	38	4.75	4.16	5.48	3.37	9.51	1.21	.28
Bitterwater	4842	Sept. 10, 1931	35	-------	819	4.64	50	25.13	29.08	55.59	5.70	80.35	23.05	.70
Monterey County:														
Surface waters:														
Salinas River, Soledad	2794	May 23, 1930	-------	6	87.3	.32	18	4.94	3.03	1.76	3.40	4.23	2.10	-------
Do	10762	May 26, 1936	-------	75	97.4	.19	22	5.20	3.05	2.26	4.23	4.19	2.18	.02
Salinas River, Bradley	5000	Oct. 14, 1931	-------	10	85.6	.24	36	3.22	2.82	3.39	2.70	4.73	1.45	0
San Antonio River	5002	Oct. 15, 1931	-------	-------	49.1	.03	20	2.80	1.39	1.05	3.20	1.49	.55	0
Nacimiento River, underflow	4999	Oct. 14, 1931	-------	-------	41.3	.03	14	1.97	1.85	.62	3.15	.72	.50	.07
San Lorenzo Creek	6355	June 24, 1931	-------	.3	645	3.08	55	12.19	23.37	42.84	5.70	51.07	22.05	0
Ground waters:														
M. & G. Tavernetti	12076	May 9, 1938	208	-------	152	.20	29	7.03	4.68	4.86	8.07	4.01	4.45	.03
J. G. Trescony	6663	Sept. 2, 1932	80	-------	207	.62	97	.51	.32	23.28	21.55	.33	1.60	0
California Orchard Co.	1880	Sept. 28, 1929	235	-------	101	.29	30	4.95	.48	2.36	4.50	4.99	1.80	-------
Piedmont Land & Cattle Co.	5001	Oct. 14, 1931	135	-------	117	.83	93	.43	.38	11.28	5.00	5.15	1.35	.04

[1] Trace.

TABLE 5—*Quality of surface and ground waters sampled in central coastal area including Santa Clara, Santa Cruz, San Benito (other than Hollister drainage area), Monterey, San Luis Obispo, and Santa Barbara (north of Santa Ynez River) Counties*—Continued.

Location	Laboratory No.	Date	Depth	Discharge	Kx10[5] at 25°C.	Boron	Percent sodium	Quantity per liter of—						
								Ca	Mg	Na	HCO_3	SO_4	Cl	NO_3
San Luis Obispo County:														
Surface waters:														
Estrella Creek	2795	May 23, 1930		.04	151	.69	57	2.80	4.20	9.47	4.30	7.02	5.15	
Sulphur Springs	1981	Sept. 28, 1929			186	1.46	85	1.97	1.35	19.10	12.70	2.82	6.90	
Santa Rosa Creek	10014	July 6, 1935		.5	103	.22	12	4.44	6.16	1.48	7.37	3.28	1.39	(1)
Paso Robles Creek	6356	June 24, 1932		.3	85.6	.10	14	5.38	2.96	1.31	4.80	3.65	1.00	.01
Arroyo Grande Creek	6808	Nov. 11, 1932			98.3	.12	13	5.87	4.47	1.50	8.20	3.20	.90	0
Tar Springs Creek	6809	do			163	.27	20	7.58	6.95	3.60	11.40	5.81	2.50	.18
Ground waters:														
J. B. Livingston	11121	Nov. 12, 1936	50		162	.42	32	5.91	6.06	5.76	4.85	6.97	5.53	.29
Cambria Municipal	10015	June 6, 1935	45		111	.21	15	4.84	6.00	1.89	3.26	3.13	1.63	.01
Do	10016	do	45		134	.16	16	5.50	7.63	2.57	9.83	3.16	2.82	0
Shell Beach	4469	July 5, 1931			149	.30	36	5.03	5.26	5.79	7.25	3.74	5.05	.04
Santa Barbara County (north of Santa Ynez River):														
Surface waters:														
Cuyama River	2735	May 19, 1930		1	357	.76	21	18.69	14.91	9.04	3.90	35.44	3.30	
Cuyama ranch reservoir	2736	do		3	184	.23	9	12.21	7.31	1.94	3.30	17.81	.35	
Santa Ynez River	2734	do			105	.36	26	4.88	4.96	3.53	6.30	4.22	1.20	
Do	4997	Oct. 13, 1931			115	.36	20	5.30	5.23	2.68	6.75	5.15	1.40	0
Ground waters:														
Santa Maria city	4998	Oct. 14, 1931	700		34.4	.03	51	.93	.73	1.76	1.05	.75	1.20	.41
Packard ranch, Lompoc	11046	Oct. 8, 1936			153	.18	41	4.96	4.28	6.43	4.94	3.41	6.77	.43
Spanni well, Lompoc	11047	do	80		198	.67	49	5.98	4.99	10.50	8.21	6.08	6.97	.14
Calm ranch, Lompoc	11060	Oct. 15, 1936			156	.27	50	5.44	2.82	8.30	5.84	3.13	7.17	.21
Packard ranch, Lompoc	11061	do	133		160	.29	31	6.33	5.70	5.49	7.96	4.50	4.95	.20
Do	11062	do	173		140	.30	28	5.86	5.51	4.36	8.76	3.42	3.68	.14
Southern Pacific R. R.	11063	do			266	.24	31	12.10	7.47	8.81	6.16	6.03	15.71	0

DESCRIPTIONS OF SURFACE AND GROUND WATERS SAMPLED IN CENTRAL COASTAL AREA

Santa Clara County

Surface waters:

2952. Coyote Creek at Coyote. Discharge, 4 cubic feet per second.

4878. Gilroy Hot Springs. SE¼, sec. 36, T. 9 S., R. 4 E. Mount Diablo base and meridian. Discharge, 0.02 cubic foot per second. Temperature, 112° F.

Ground waters:

12011. Associated Seed Growers, Inc., well. 0.5 mile west of Milpitas. Depth, 150 feet; 10-inch casing; discharge, 405 gallons per minute.

7795. Saunders Bros. well. SE¼, sec. 13, T. 10., R. 3 E. 4 miles north and east of Gilroy, on Lena Avenue. Depth, 180 feet, upper perforations at 110 feet; 13-inch casing; discharge, 495 gallons per minute; static level, 65 feet.

Santa Cruz County

Surface waters:

5004. Pajaro River. Location corresponds to SW corner sec. 12, T. 12 S., R. 3 E. At highway crossing above Chittenden. Discharge, 8 cubic feet per second.

Ground waters:

2953. Watsonville city water. From streams north of city and wells near reservoir.

5003. G. Errard Co. well. Location corresponds to SE corner sec. 26, T. 11 S., R. 2 E., 3 miles northeast of Watsonville. Depth, 190 feet; casing perforated full length; extending into red sandstone; discharge, 1,003 gallons per minute.

San Benito County (Other Than Hollister Drainage Area)

Surface waters:

6354. Creek east of Pinnacles. Sec. 35, T. 16 S., R. 7 E. Unnamed stream flowing southward to Chalone Creek at highway crossing 1 mile east of Pinnacles. Discharge, 0.3 cubic foot per second.

4843. Hepsedam Springs. T. 19 S., R. 10 E., 8 or 10 springs below Hepsedam Peak piped to Associated pipe line station No. 4 on Lewis Creek.

2767. Panoche Creek. Near center W½, sec. 27, T. 15 S., R. 11 E. Discharge, 1 cubic foot per second.

4833. Resample. Discharge, 2 cubic feet per second.

Ground waters:

2768. Irrigation well near center sec. 30, T. 15 S., R. 11 E. Small centrifugal pump in 30-foot pit.

6673. J. H. Morgan well. SW¼, sec. 1, T. 16 S., R. 10 E. Dug well; depth, 20 feet. On Griswold Creek, south of Panoche.

11167. Manuel Ortiz well, Panoche. SW¼, SW¼, sec. 30, T. 15 S., R. 11 E. Depth, 99 feet; perforated at 20 and 75 feet; 10-inch casing; discharge, 99 gallons per minute. Static level, 20 feet.

4842. Stock well at Bitterwater. Near center sec. 9, T. 18 S., R. 9 E. Stock well at King City road turn-off. Depth, 35 feet.

Monterey County

Surface waters:

2794. Salinas River, Soledad. Discharge, 6 cubic feet per second.

10762. Salinas River, Soledad. Discharge, 75 cubic feet per second.

5000. Salinas River, Bradley. Discharge, 10 cubic feet per second.

5002. San Antonio River, Pleyto Bridge. No surface flow. Sample obtained below surface of sand.

4999. Nacimiento River, underflow. SE¼, sec. 33, T. 24 S., R. 11 E. Shallow power-operated irrigation well. Many surface pools in river, but no surface flow.

6355. San Lorenzo Creek. NW¼, sec. 23, T. 19 S., R. 8 E. 5 miles northeast of King City on Bitterwater Road. Discharge 0.3 cubic feet per second.

Ground waters:

12076. M. & G. Tavernetti well, 2 miles south of Salinas on Salinas-Spreckles Road. Depth, 208 feet; upper perforations, 90 feet; 12-inch casing; discharge, 1,003 gallons per minute; static level, 45 feet; draws down to 60 feet; temperature, 55° F. No odor, no gas, clear.

6663. J. G. Trescony well. SW corner sec. 33, T. 21 S., R. 9 E. 7 miles southwest of San Lucas. Depth, 80 feet; upper perforations, 30 feet; 10-inch casing; discharge, 2.5 gallons per minute. Domestic.

1880. California Orchard Co., well No. 1. Probably sec. 26, T. 19 S., R. 7 E. Well at headquarters, domestic and irrigation. Depth, 235 feet; static level, 74 feet; draws down 20 feet; discharge, 1,890 gallons per minute. All perforations in gravel; probably all below 100 feet.

5001. Piedmont Land & Cattle Co. well. Center, SE¼, sec. 10, T. 24 S., R. 9 E. Depth, 135 feet. Formerly a flowing well, 0.5 mile south of San Antonio River.

San Luis Obispo County

Surface waters:

2795. Estrella Creek. Sec. 22, T. 25 S., R. 12 E. 2 miles southeast of San Miguel. Discharge, 0.04 cubic foot per second.

1881. Sulphur Springs. Paso Robles Hotel, Paso Robles. Temperature, 99° F.

10014. Santa Rosa Creek, Cambria. Discharge, 0.5 cubic foot per minute.

6356. Paso Robles Creek at highway crossing. 3½ miles north of Atascadero. Discharge, 0.3 cubic foot per second.

6808. Arroyo Grande Creek, 0.5 mile west of Arroyo Grande below junction of Tar Springs Creek.

6809. Tar Springs Creek, 3 miles northeast of Arroyo Grande above junction with Arroyo Grande Creek.

Ground waters:

11121. J. B. Livingston well. SE¼, sec. 8, T. 25 S., R. 12 E. 1 mile north of San Miguel. Combined flow of 5 wells pumped into reservoir. Depth, 50 feet; discharge, 950 gallons per minute.

10015. Cambria Municipal, Old Town. Depth, 45 feet; upper perforations, 15 feet; 12-inch casing.

10016. Cambria Municipal, New Town. Depth, 45 feet; upper perforations, 15 feet; 12-inch casing.

4469. Shell Beach well. Subdivision No. 2. 2.2 miles northeast of Pismo. T. 32 S., R. 12 E.

Santa Barbara County (North of Santa Ynez River)

Surface waters:

2735. Cuyama River, at highway bridge 11 miles east of Santa Maria. Discharge, 1 cubic foot per second.

2736. Cuyama ranch reservoir. T. 10 N., R. 26 W. San Bernardino base and meridian. Composite of 14 springs (discharge, 3 cubic feet per second) and water pumped from stream bed of Cuyama River. Some of springs reported as warm, with sulfur odor.

2734. Santa Ynez River, at bridge at Buellton.

4997. Santa Ynez River, at bridge at Buellton. No surface flow.

Ground waters:

4998. Santa Maria city well, 3½ miles south of city. Depth, about 700 feet. Surface water shut out.

11046. Packard ranch well, Lompoc. 0.75 mile west of Artesia Street, 1.6 miles north of Central Avenue. Windmill at north edge of valley. Top of casing is 4 feet above surface. Approximate elevation, 35 feet. Domestic use.

11047. Spanni well, Lompoc. 1 mile north of Central Avenue, 200 feet east of Artesia Street. Windmill at tank house. Elevation, 56 feet. Depth, 80 feet. Domestic use.

11060. Calm ranch well, Lompoc. On north bank of Santa Ynez River on 70-acre tract of bottom land. West of Douglass Avenue extended across river from south. Deep-well turbine pump, 16-inch casing. Static level before pumping, 34.2 feet below pump base, which is 0.3 foot above ground. Level after pumping 15 minutes, 35.2 feet.

11061. Packard ranch well, west of Lompoc. 50 feet north of north bank of Santa Ynez River and one-half mile west of Renwick Avenue crossing. Depth, 133 feet, 16-inch casing. Static level, 19.6 feet below hole in pump bowl 1 foot above ground at elevation of discharge outlet. Level after pumping 15 minutes, 19.9 feet.

11062. Packard ranch well, west of Lompoc. On north bank of Santa Ynez River 3 miles from Pacific Ocean, 50 feet west of Renwick Avenue crossing. Depth, 173 feet.

11063. Southern Pacific Railroad west well. West of Lompoc, 3¼ miles from Pacific Ocean. 150 feet west of Renwick Avenue, 40 feet north of tracks.

SURFACE WATERS OF THE HOLLISTER AREA

The compositions of the surface waters of the Hollister area as represented by the samples collected during the course of this investigation are reported in table 6. In this table discharge values are customarily reported, but it is not implied that these are accurate. In most instances only rough approximations were possible and these only for the purpose of providing information on the general magnitude of the flow. The discharges assigned to the samples collected in 1936 at Malone diversion and Paicines intake from the San Benito River, those at Lester Bridge from Pacheco Creek, and at Bolado Park from Tres Pinos Creek are within the limits of accuracy associated with stream estimates by experienced stream gagers. The descriptions of the sources of these waters are given in table 7.

TABLE 6.—*Analyses of surface waters of the Hollister area*

SAN BENITO WATERSHED

Location	Location	Laboratory No.	Date	Discharge	Kx10[5] at 25° C.	Boron	Percent sodium	Quantity per liter of—							
								Ca	Mg	Na	HCO_3	SO_4	Cl	NO_3	pH
				Cu. ft./sec.		*P. p. m.*		*M. e.*	*M. e.*	*M. e.*	*M. e.*	*M. e.*	*M. e.*	*M. e.*	
San Benito River:															
At bridge 2½ miles north of San Juan	17-12S-4E	2793	May 23, 1930	0.02	258	1.33	32	4.34	10.77	6.73	12.20	4.49	5.15	------	7.7
Hollister-San Juan Bridge	33-12S-5E	11937	Mar. 2, 1938	7,000	59.0	.35	50	1.56	1.50	3.07	2.50	2.90	.46	0.02	8.0
Above Tres Pinos Creek junction	30-13S-6E	5586	Jan. 19, 1932	500	84.0	.63	38	2.22	3.73	3.72	4.30	3.46	1.40	.19	8.2
Malone diversion	26-14S-6E	9747	Apr. 10, 1935	94	81.2	.49	31	2.14	4.43	2.66	[1] 6.02	2.57	.89	.03	8.3
Paicines intake	1-15S-6E	6199	May 27, 1932	----------	133	.96	38	2.33	6.21	5.23	[1] 6.60	5.21	3.00	0	8.6
		9480	Jan. 11, 1935	----------	66.3	.48	27	1.90	3.46	2.00	4.72	1.99	.64	.04	7.7
		9485	Jan. 20, 1935	75	93.2	.26	33	2.36	4.72	3.48	[1] 5.61	3.86	1.04	.04	7.9
		9555	Feb. 10, 1935	20	123	.99	------	------	------	------	------	------	------	------	---
		10532	Feb. 3, 1936	----------	51.8	.38	30	1.29	2.56	1.68	3.44	1.47	.53	.02	7.6
		10546	Feb. 14, 1936	1,583	42.3	.26	31	1.27	1.95	1.48	3.14	1.13	.31	.03	7.6
		10575	Feb. 25, 1936	581	80.1	.41	26	2.12	4.70	2.41	[1] 5.48	2.71	.88	.05	8.6
		10612	Mar. 3, 1936	20	113	.79	33	2.26	6.93	4.44	[1] 7.82	4.07	1.76	.04	8.8
		10621	Mar. 17, 1936	10	144	1.17	39	2.46	7.70	6.48	[1] 7.72	6.30	2.59	.01	8.8
		10688	Apr. 14, 1936	75	125	.97	37	1.94	7.08	5.29	[1] 7.16	5.28	2.00	.02	8.6
Stone ranch	7-15S-7E	10453	Jan. 16, 1936	3	178	1.37	42	2.56	9.48	8.78	[1] 8.16	8.82	3.72	.02	8.4
		10646	Apr. 1, 1936	17	91.9	.60	26	1.80	6.34	2.84	6.92	2.66	1.34	.04	7.7
		10730	May 5, 1936	6	162	1.45	47	2.09	8.18	7.91	[1] 7.81	7.83	3.16	.01	8.5
Bridge below Willow Creek	21-15S-7E	4841	Sept. 10, 1931	.3	291	2.73	85	3.31	1.60	28.80	[1] 6.70	18.16	8.85	0	8.7
Above Smoker Canyon	5-16S-8E	10734	May 7, 1936	5	102	1.18	29	1.59	7.40	3.67	[1] 8.46	3.11	1.29	[2]	8.6
Above Clear Creek junction	22-18S-11E	10787	May 29, 1936	5	94.6	.87	8	.66	10.54	.95	[1] 10.50	.87	.53	0	8.5
San Benito tributaries:															
San Juan Creek	9-13S-4E	10783	May 28, 1936	2	75.8	.12	18	4.24	2.51	1.48	[1] 5.12	1.91	1.29	.02	8.2
Bird Creek below spring	28-13S-5E	10033	July 1, 1935	----------	74.3	.08	22	5.09	1.26	1.62	4.52	2.62	1.00	.01	7.1
Bird Creek above spring	28-13S-5E-a	10034	do	----------	73.1	.13	20	5.16	1.29	1.45	[1] 4.37	2.68	1.05	.01	8.3
Tres Pinos Creek:															
Southside Road bridge	19-13S-6E	5587	Jan. 19, 1932	75	54.4	.55	25	1.99	2.16	1.33	2.60	1.97	.75	.21	8.1
Bolado Park	34-13S-6E	10530	Feb. 3, 1936	11	50.9	.11	32	1.74	2.05	1.76	2.84	1.45	.92	.05	7.6
Do	34-13S-6E	10547	Feb. 14, 1936	207	22.0	.11	18	1.03	1.22	.43	1.59	.38	.31	.11	7.4
		10573	Feb. 25, 1936	126	34.1	.21	24	1.34	1.53	.92	2.39	.62	.57	.07	7.5
		10611	Mar. 3, 1936	2	60.1	.46	38	2.18	2.00	2.54	[1] 3.93	1.73	.75	.11	8.0
		10620	Mar. 17, 1936	.7	68.7	.54	37	2.39	2.49	2.84	4.38	2.18	.88	.02	7.8
		10645	Apr. 1, 1936	6	56.4	.42	29	2.45	2.28	1.93	3.68	1.99	.98	.01	7.8
		10687	Apr. 14, 1936	1	73.0	.50	35	2.43	2.81	2.87	4.33	2.45	1.11	.02	7.8
		10729	May 5, 1936	.7	86.2	.54	35	2.81	3.20	3.30	[1] 4.63	3.37	1.38	.05	8.3
Paicines	11-14S-6E	9481	Jan. 12, 1935	2	65.6	.69	31	2.14	2.89	2.23	[1] 4.13	1.63	1.24	.07	7.9
		9486	Jan. 18, 1935	15	32.1	.61	29	1.21	1.29	1.00	1.87	.84	.40	.14	7.4
		9748	Apr. 10, 1935	22	31.1	.15	30	1.24	1.19	.87	2.70	.34	.40	.02	7.6
Los Muertos Creek (tributary)	20-14S-7E	9487	Jan. 22, 1935	4	30.4	.32	27	1.27	1.77	1.14	2.56	.69	.74	.18	7.6
Quien Sabe Creek (tributary)	1-14S-7E	9521	Jan. 31, 1935	20	64.8	.65	28	2.12	2.84	1.95	[1] 4.23	1.35	1.19	.18	7.9
		9562	Feb. 4, 1935	4	55.9	.34	23	1.95	2.84	1.43	4.43	.67	.99	.01	7.7

Other San Benito tributaries:															
Stone Canyon (1 mile above junction)	18-15S-7E	10736	May 7, 1936	.1	60.1	.30	31	2.51	1.83	1.97	3.53	.84	1.78	.04	7.5
Deyarmin Spring (Stone Canyon)	10-15S-6E	10758	May 20, 1936		819	137.	81	6.39	10.17	70.92	35.07	.57	52.73	0	6.7
Melindy Spring	4-16S-7E	8147	Dec. 11, 1933	.02	89.4	.14	35	3.61	2.94	3.28	[1] 5.65	1.41	3.01	.02	8.3
Smoker Canyon	5-16S-8E	10735	May 7, 1936	.02	188	1.54	47	3.04	8.38	10.30	[1] 8.01	12.30	1.78	.14	8.4
Sulphur Canyon	5-16S-8E	10753	May 16, 1936		932	14.4	75	15.02	12.11	82.42	[1] 6.37	69.49	34.71	(2)	8.2
Clear Creek	17-18S-11E	10786	May 29, 1936	6	93.7	1.01	3	.50	12.09	.41	[1] 11.84	.49	.67	(2)	8.8

DIABLO RANGE DRAINAGE

Pacheco Creek:															
At Lester Bridge	13-11S-5E	9746	Apr. 10, 1935	223	32.0	0.14	22	1.53	1.35	0.70	2.70	0.59	0.40	0.01	7.9
		10452	Jan. 16, 1936	27	34.1	.14	19	1.64	1.29	.68	2.24	.71	.57	.11	7.6
		10531	Feb. 3, 1936	18	33.4	.08	19	1.63	1.30	.69	2.44	.65	.44	(2)	7.5
		10545	Feb. 14, 1936	827	20.2	.11	27	.96	.85	.67	1.49	.34	.26	.05	7.3
		10574	Feb. 25, 1936	1,165	21.1	.10	19	1.04	.93	.45	1.69	.24	.35	.04	7.4
		10610	Mar. 2, 1936	134	37.1	.09	30	2.04	.57	1.11	2.84	.58	.48	.07	7.7
		10623	Mar. 17, 1936	6	40.0	.10	20	2.14	1.15	.84	2.99	.72	.48	.07	7.6
		10649	Apr. 1, 1936	16	41.9	.09	19	2.10	1.57	.87	3.18	.54	.58	.11	7.4
		10686	Apr. 15, 1936	5	42.4	.10	19	2.10	1.67	.90	3.23	.74	.62	.03	7.9
2 miles below Bell Station	32-10S-6E	2792	May 23, 1930		44.3	.16	28	2.00	1.79	1.50	3.25	1.50	.35		7.0
North Fork	23-10S-6E	8551	Apr. 19, 1934		59.0	.31	19	2.87	2.22	1.26	4.32	1.05	.81	(2)	7.6
Other creeks:															
Las Viboras Creek	29-11S-6E	11873	Jan. 20, 1938	6	55.1	.43	25	1.97	2.50	1.51	3.99	.67	.95	.01	7.9
Las Viboras Lake	22-11S-6E	7194	Mar. 23, 1933		56.7	.42	25	2.01	2.48	1.45	[1] 4.00	.81	1.05	.14	8.3
Dos Picachos Creek	16-12S-6E	5007	Oct. 15, 1931	.5	33.7	.11	20	1.13	1.35	1.02	2.30	.60	.60	(2)	7.6
Do	13-12S-5E	5588	Jan. 19, 1932		23.2	.06	22	.95	1.03	.56	1.25	.41	.45	.06	7.2
Do	13-12S-6E	6281	May 27, 1932		57.8	.24	19	2.27	2.50	1.15	[1] 4.00	1.14	1.10	(2)	8.5
Do	12-12S-5E	9745	Apr. 8, 1935		20.7	.43	46	.65	.63	1.05	2.06	.03	.18	.03	7.3
Santa Ana Creek	30-12S-6E	11908	Feb. 3, 1938	10	30.2	.46	43	.99	1.07	1.58	1.87	.51	.90	.04	7.9
Springs:															
Flint spring (Picachos drainage)	10-12S-6E	6286	May 31, 1932	.02	29.8	.08	18	.70	1.74	.54	2.05	.29	.60	.11	7.9
Ladd's spring (Santa Ana drainage)	5-13S-6E	10414	Dec. 17, 1935	.01	341.0	5.12	60	3.92	10.80	21.65	[1] 12.85	6.88	17.27	0	8.4

PAJARO RIVER

Pajaro River	4-12S-4E	10772	May 27, 1936	10	112	0.33	23	4.37	5.40	2.99	4.68	6.35	1.65	0.05	7.8

[1] Includes carbonate.
[2] Trace.

TABLE 7.—*Description of sources of surface waters of the Hollister area*

Laboratory No.	Location	Symbol	Description
2793	17-12S-4E	432-S	San Benito River. Center, S½ sec. 17, T. 12 S., R. 4 E. Discharge, 0.02 cubic foot per second.
11937	33-12S-5E	223-S	San Benito River. Location corresponds to NW¼ sec. 33, T. 12 S., R. 5 E. Floodwater taken at San Juan, Hollister Bridge. Stream flow undetermined but running banks full. Sample taken from surface of the middle of stream. Estimated discharge, 7,000 cubic feet per second at time sample was taken.
5586	30-13S-6E	322-S	San Benito River, at Southside, ½ mile south of Tres Pinos Creek junction. Location corresponds to NW¼ sec. 30, T. 13 S., R. 6 E. Discharge, 500 cubic feet per second.
9747	26-14S-6E	322-S	San Benito River, at Malone diversion. Location corresponds to SW¼ sec. 26, T. 14 S., R. 6 E. Discharge, 94 cubic feet per second.
6199	1-15S-6E	333-S	Cumulative samples from Paicines Reservoir. Location corresponds to NE¼ sec. 11, T. 13 S., R. 5 E. Winter run-off of San Benito River. Sample taken from outlet ditch.
9480	1-15S-6E	322-S	San Benito River, at Paicines Intake Dam. SE¼ sec. 1, T. 15 S., R. 6 E.
9485			Resample. Discharge, 75 cubic feet per second.
9555			Resample. Discharge, 20 cubic feet per second.
10532			Resample.
10546			Resample. Discharge, 1,583 cubic feet per second.
10575			Resample. Discharge, 581 cubic feet per second.
10612			Resample. Discharge, 20 cubic feet per second.
10621			Resample. Discharge, 10 cubic feet per second.
10688			Resample. Discharge, 75 cubic feet per second.
10453	7-15S-7E	333-S	San Benito River, at Stone ranch. SE¼ sec. 7, T. 15 S., R. 7 E. Discharge, 3 cubic feet per second.
10646			Resample. Discharge, 17 cubic feet per second.
10730			Resample. Discharge, 6 cubic feet per second.
4841	21-15S-7E	445-S	San Benito River. Center sec. 21, T. 15 S., R. 7 E. Between Live Oak and Willow Creek Schools. Discharge, 0.3 cubic foot per second.
10734	5-16S-8E	332-S	San Benito River, above Smoker Canyon. NW¼ sec. 5, T. 16 S., R. 8 E. Discharge, 5 cubic feet per second.
10787	22-18S-11E	331-S	San Benito River. SE¼ sec. 22, T. 18 S., R. 11 E. Two miles above junction with Clear Creek. Discharge, 5 cubic feet per second.
10783	9-13S-4E	311-S	San Juan Creek. Center E. line NE¼ sec. 9, T. 13 S., R. 4 E. Discharge, 2 cubic feet per second.
10033	28-13S-5E	212-S	Bird Creek, sampled below where the sulfur spring empties into the creek. Location corresponds to SW¼ sec. 28, T. 13 S., 5 E. 10 miles south of Hollister, 1 mile west of junction of Bird Creek Road and Canyon. Use, irrigation.
10034	28-13S-5E-a	211-S	Bird Creek, sampled 50 feet upstream from No. 10033, or above where sulfur spring empties into creek. Location corresponds to SW¼ sec. 28, T. 13 S., R. 5 E. 10 miles south of Hollister. 1 mile west of junction of Bird Creek Road and Canyon. Use, irrigation.
5587	19-13S-6E	222-S	Tres Pinos Creek. SW¼ sec. 19, T. 13 S., R. 6 E. Discharge, 75 cubic feet per second.
10530	34-13S-6E	222-S	Tres Pinos Creek, Bolado Park. NE¼ sec. 34, T. 13 S., R. 6 E. Discharge, 11 cubic feet per second.
10547			Resample. Discharge, 297 cubic feet per second.
10573			Resample. Discharge, 126 cubic feet per second.
10611			Resample. Discharge, 2 cubic feet per second.
10620			Resample. Discharge, 0.7 cubic foot per second.
10645			Resample. Discharge, 6 cubic feet per second.
10687			Resample. Discharge, 1 cubic foot per second.
10729			Resample. Discharge, 0.7 cubic foot per second.
9481	11-14S-6E	222-S	Tres Pinos Creek, at Paicines. NE¼, sec. 11, T. 14 S., R. 6 E. Discharge, 2 cubic feet per second.
9486			Resample. Discharge, 15 cubic feet per second.
9748			Resample. Discharge, 22 cubic feet per second.
9487	20-14S-7E	222 S	Los Muertos Creek, at junction with Tres Pinos Creek. SW¼, sec. 20, T. 14 S., R. 7 E. Discharge, 4 cubic feet per second.
9521			Resample. Discharge, 20 cubic feet per second.
9562	1-14S-7E	222-S	Quien Sabe Creek. Tributary to Los Muertos Creek. Location corresponds to center, sec. 1, T. 14 S., R. 7 E. At junction of Quien Sabe Creek and road. Discharge, 4 cubic feet per second.
10736	18-15S-7E	222-S	Stone Canyon Creek, 1 mile above San Benito River junction. NW¼ sec. 18, T. 15 S., R. 7 E. Discharge, 0.1 cubic foot per second.
10758	10-15S-6E	555-S	H. C. Deyarmin spring. SW¼ sec. 11, T. 15 S., R. 6 E. Alviso Canyon.
8147	4-16S-7E	312-S	Henry Melindy spring. Sec. 4, T. 16 S., R. 7 E. Discharge, 0.02 cubic foot per second. Water seems to be corrosive in action on pipes.

TABLE 7.—*Description of sources of surface waters of the Hollister area*—Continued

Laboratory No.	Location	Symbol	Description
10735	5-16S-8E-a	443-S	Smoker Canyon, at junction with San Benito River. SE¼, sec. 5, T. 16 S., R. 8 E. Discharge, 0.02 cubic foot per second.
10753	5-16S-8E-b	554-S	Sulphur Canyon, at junction of San Benito River. NW¼, sec. 5, T. 16 S., R. 8 E.
10786	17-18S-11E	331-S	Clear Creek. SE¼, sec. 17, T. 18 S., R. 11 E. San Benito County, 61 miles south of Hollister. Discharge, 6 cubic feet per second. Clear rapid water.
9746	13-11S-5E	211-S	Pacheco Creek, at Lester Bridge. Location corresponds NW¼, sec. 13, T. 11 S., R. 5 E. Discharge, 223 cubic feet per second.
10452			Resample. Discharge, 27 cubic feet per second.
10531			Resample. Discharge, 18 cubic feet per second.
10545			Resample. Discharge, 827 cubic feet per second.
10574			Resample. Discharge, 1,165 cubic feet per second.
10610			Resample. Discharge, 134 cubic feet per second.
10623			Resample. Discharge, 3 cubic feet per second.
10649			Resample. Discharge, 16 cubic feet per second.
10686			Resample. Discharge, 5 cubic feet per second.
2792	32-10S-6E	212-S	Pacheco Creek, below Cedar Creek, 2 miles below Bell station and 17 miles from Gilroy. Location corresponds to SE¼, sec. 32, T. 10 S., R. 6 E. River bed pools; some flow. White incrustation on rocks in river bed.
8551	23-10S-6E	221-S	Pacheco Creek, on north fork, ¼ mile north of the junction of north and south forks. Santa Clara County. Location corresponds to SW¼, sec. 23, T. 10 S., R. 6 E. Sample was taken from water hole where water was barely moving downstream.
11873	29-11S-6E	221-S	Las Viboras Creek, at Hawkins ranch. Location corresponds to NW¼, sec. 29, T. 11 S., R. 6 E. Discharge, 5 cubic feet per second. Sample represents south fork flow only.
7194	22-11S-6E	222-S	Lake on headwaters of Las Viboras Creek. Location corresponds to SW¼, sec. 22, T. 11 S., R. 6 E. Artificial lake. Volume, 600 acre-feet. Temperature, 15° C. Use, irrigation.
5007	16-12S-6E	212-S	Arroyo Dos Picachos. Location corresponds to center, sec. 16, T. 12 S., R. 6 E. Discharge, 0.5 cubic foot per second.
5588			Resample at crossing of Fairview Road. NE¼, sec. 13, T. 12 S., R. 5 E.
6281			Resample.
9745	12-12S-5E	123-S	Dos Picachos Creek—floodwater. This is floodwater which passed over the Luther ranch from Dos Picachos Creek. Picked up on Fred Hawkins ranch (SW¼, sec. 12, T. 12 S., R. 5 E.).
11908	30-12S-6E-g	221-S	Santa Ana Creek, at crossing of Fairview Road. SW¼, sec. 30, T. 12 S., R. 6 E. Discharge, 10 cubic feet per second.
6286	10-12S-6E	212-S	W. P. Flint spring. Location corresponds to NW¼, sec. 10, T. 12 S., R. 6 E. Elevation, 1,400 feet; discharge, 0.02 cubic foot per second; no odor; no gas; clear. In drainage basin of Dos Picachos Creek.
10414	5-13S-6E	554-S	Ladd spring, near Santa Ana Creek. NW¼, NW¼, sec. 5, T. 13 S., R. 6 E. Used for stock. Discharge, 0.01 cubic foot per second.
10772	4-12S-4E	322-S	Pajaro River. Location corresponds to center, W½, sec. 4, T. 12 S., R. 4 E. Near Sargent and above junction with San Benito River. This water rises from stream bed a little above this point representing drainage from a number of sources. Discharge, 10 cubic feet per second.

The comparative characteristics of the waters of San Benito River and Tres Pinos and Pacheco Creeks, as represented by the averages of seven samples from each of these sources collected on like dates during the spring of 1936, are shown in table 8. The water of the San Benito River above its junction with Tres Pinos Creek has a total salinity and a concentration of boron and of chloride almost twice as high as those found in the water of Tres Pinos Creek. The waters of San Benito River and Tres Pinos Creek, either separately or combined, are superior to the ground waters adjacent to the San Benito River in the Hollister area. These ground waters as used on deep well-drained alluvial soils have supported a creditable agriculture for many years. The waters of Pacheco Creek are of superior quality and in all respects better than those of San Benito River and Tres Pinos Creek.

TABLE 8.—*Quality of 1936 spring run-off from San Benito River (above junction with Tres Pinos Creek), Tres Pinos Creek, and Pacheco Creek as represented by averages of seven samples from each source collected between Feb. 3 and Apr. 14, 1936 (from table 6)*

Source	$K \times 10^5$ at 25° C.	Boron	Percent sodium	Quantity per liter of—							pH
				Ca	Mg	Na	HCO_3	SO_4	Cl	NO_3	
		P. p. m.		*M. e.*	*M. e.*	*M. e.*	*M. e.*	*M. e.*	*M. e.*	*M. e.*	
San Benito River above Tres Pinos Creek	92.9	0.65	32	1.88	5.32	3.52	5.95	3.37	1.34	0.03	8.7
Tres Pinos Creek	52.2	.33	30	1.93	2.05	1.90	3.31	1.54	.79	.06	7.7
Pacheco Creek	33.7	.09	22	1.71	1.15	.79	2.55	.54	.46	.05	7.5

In the water of the San Benito River the concentration of magnesium tends to approach the sum of the calcium and sodium concentrations and sodium exceeds calcium. In Tres Pinos Creek the concentrations of the three ions tend to be equal. In Pacheco Creek calcium exceeds magnesium and magnesium exceeds sodium. In all of these waters bicarbonate exceeds sulfate and sulfate exceeds chloride. These findings point to important distinctions between the dominant rock and alluvial materials of the three watersheds.

The storm water impounded in reservoirs on any of these streams would more nearly resemble in quality that of samples collected during periods of heavy run-off than the averages of samples collected at all times. The underflow of streams, however, like the surface discharges at times of lesser flow, would be intercepted by reservoirs, and these contributions would materially influence the mean quality of impounded waters. Though the general characters of the respective waters are signified by the samples collected, it was not feasible to undertake the collection of the kind of data that would have made possible computations of the mean compositions of any of those waters on the basis of averages weighted both as to quantity of water and variations in quality.

Explorations along the upper course of the San Benito River and its tributaries have pointed to the existence of a number of minor water sources that carry relatively high concentrations of boron. Deyarmin spring yields a water with 137 p. p. m. of boron, but a sample from Stone Canyon into which the spring discharges contained only 0.30 p. p. m. of boron. Sulphur Canyon as sampled in May 1936 was very saline and it contained 14.4 p. p. m. of boron. The San Benito River as sampled in September 1931 at Willow Creek School, 22 miles southeast of Hollister, when the discharge was very low contained 2.73 p. p. m. of boron, and there were relatively high concentrations of sodium and sulfate.

GROUND WATERS OF THE HOLLISTER AREA

The ground-water samples were customarily taken after pumps had been in operation long enough to provide representative samples. Analyses were sometimes made at the request of property owners when it was believed that the source of a sample was such that the information obtained would contribute to an understanding of water-quality conditions in the area as a whole. Others of the samples were

Figure 2

Located at end

of document

taken with permission of the owners for the purpose of supplying information on ground waters in portions of the valley that would otherwise not have been represented. The data on well characteristics are based almost entirely on the statements of owners. Well depths so ascertained, although generally reliable, do not provide information on the extent to which effective depths have been altered by sanding in of casings. The information on the elevation of the water table and on draw-down when pumps are in operation is likewise based on the statements of owners or operators.

A detailed chemical analysis is essential to the adequate description of a water supply, but in an area as large as that embraced by the Hollister map it is difficult if not impossible to visualize the characteristics of the waters underlying the different sections by mentally transposing the complex data of tables of analyses and descriptions to map locations. In this bulletin as in an earlier one (*5*), an attempt has been made to facilitate visualization by placing a three-digit water-quality symbol on the map at the well location. By this trinomial each of the waters is characterized with respect to conductance, boron, and percent sodium. A fourth figure that follows a hyphen provides an index to the depth of the well. Each classification is on the basis of the 1 to 5 scales shown in table 9. A water and well described by the symbol 123–4, for example, has a conductance in range 1, i. e., 0 to 25; a boron concentration in range 2, i. e., 0.25 to 0.74 p. p. m.; a percent sodium in range 3, i. e., 40 to 59 percent, and a depth of the well between 200 and 399 feet. The letter S is used after the hyphen to indicate that the sample represents a surface water.

TABLE 9.—*Index of water quality and well-depth symbols*

Range	Conductance, $K \times 10^5$ at 25° C.	Boron (p. p. m.)	Percent sodium	Depth (feet)
1	0 to 24.9	0 to 0.24	0 to 19	0 to 49.
2	25 to 74.9	0.25 to 0.74	20 to 39	50 to 99.
3	75 to 149	0.75 to 1.49	40 to 59	100 to 199.
4	150 to 299	1.50 to 2.99	60 to 79	200 to 399.
5	300 and above	3.00 and above	80 to 100	400 and more.

The analyses of the ground waters of the Hollister area (table 10) are grouped on the basis of subdivisions corresponding to ranges, townships, and sections. Not all this area is subdivided by the United States General Land Office surveys, part of it being held on the basis of old Spanish land-grant descriptions. Property lines so described are generally shown on the map (fig. 2), but across these boundaries, ranges and townships are projected by dotted lines connecting with those established on either side. There is thus set up a uniform system to coordinates. Well locations are designated on the basis of section and township throughout, but in the descriptions the statement "location corresponds to" is made in advance of the land office location when the well is in an unsurveyed section (table 11). Not infrequently more than one well has been sampled within a section. In these cases the successive ones after the first are listed by suffixing a letter to the location number. These letters are shown within circles on the map.

TABLE 10.—*Analyses of quality of irrigation waters of the Hollister area*

Laboratory No.	Location No.	Date	Depth	Kx10[5] at 25° C.	Boron	Percent sodium	Quantity per liter of— Ca	Mg	Na	HCO_3	SO_4	Cl	NO_3
			Feet		*P. p. m.*		*M. e.*	*M. e.*	*M. e.*	*M. e.*	*M. e.*	*M. e.*	*M. e.*
10771	27-11S-4E	May 27, 1936	480	51.5	0.09	29	2.05	1.93	1.59	4.48	0.22	0.67	0.09
7041	16-11S-5E	Jan. 23, 1933	------	65.4	.64	55	12.33	18.29	38.10	14.75	7.06	45.35	.71
5056	21-11S-5E	Oct. 14, 1931	104	53.2	.36	31	1.79	2.13	1.73	4.15	.70	.75	.05
10769	21-11S-5E-a	May 27, 1936	200	142	.65	50	3.89	3.33	7.33	7.21	.30	6.99	0
6141	24-11S-5E	May 5, 1932	136	41.7	.08	16	1.99	1.92	.74	3.30	.60	.30	.23
6282	25-11S-5E	June 15, 1932	170	64.7	.54	26	2.41	2.76	1.82	5.30	.50	1.15	.04
5053	26-11S-5E	Oct. 9, 1931	250	143	2.91	62	2.51	3.10	9.22	6.85	1.53	6.45	0
6144	------	May 6, 1932	------	146	2.94	65	2.41	2.74	9.69	7.45	1.07	6.45	0
9237	------	Oct. 26, 1934	------	121	2.61	------	------	------	------	7.08	------	4.71	------
9347	26-11S-5E-a	Dec. 6, 1934	200	76.8	1.27	------	------	------	------	5.81	------	2.26	------
10865	26-11S-5E-b	June 4, 1936	125	61.5	.45	27	2.77	2.70	2.00	5.19	1.11	1.40	(2)
10866	27-11S-5E	do	177	61.5	.37	23	2.96	2.74	1.66	5.19	1.20	1.16	.01
9073	28-11S-5E	Sept. 4, 1934	90	903	8.47	------		------	------	[1] 20,37	------	25.30	------
9298	28-11S-5E-a	Nov. 13, 1934	103	116	.88	44	2.58	4.54	5.51	5.85	4.05	2.41	.02
9297	28-11S-5E-b	do	86	113.	.86	43	2.54	4.66	5.47	5.95	4.07	2.36	.01
10770	29-11S-5E	May 27, 1936	180	107	.82	72	1.36	1.72	7.88	4.73	3.79	2.45	(2)
10867	33-11S-5E	June 26, 1936	165	122	.98	40	2.77	5.27	5.47	6.33	4.52	2.61	.11
5055	34-11S-5E	Oct. 9, 1931	115	62.4	.47	25	2.52	2.41	1.64	4.75	.64	1.10	.08
5051	35-11S-5E	Oct. 7, 1931	185	63.8	1.27	31	2.17	2.31	2.04	4.35	.52	1.65	0
5052	35-11S-5E-a	Oct. 9, 1931	------	118	1.99	62	2.64	1.95	7.44	5.45	2.68	3.90	(2)
10670	35-11S-5E-b	Apr. 11, 1936	365	111	1.77	54	2.59	2.69	6.18	6.52	.65	4.14	.04
4916	36-11S-5E	Sept. 16, 1931	119	74.4	.61	26	2.80	2.97	2.08	5.50	.62	1.50	.23
5125	36-11S-5E-a	Nov. 3, 1931	------	164	4.39	64	3.06	2.65	9.98	6.50	.04	9.15	0
6145	36-11S-5E-b	May 6, 1932	300	179	3.17	61	3.60	3.29	10.62	6.60	.17	10.85	0
6196	36-11S-5E-c	May 23, 1932	300	143	3.20	68	2.57	2.01	9.61	6.95	(2)	7.25	0
6197	36-11S-5E-d	do	480	246	4.60	58	4.82	5.05	13.76	5.80	.30	17.70	0
6411	36-11S-5E-e	July 5, 1932	180	91.1	.94	29	3.13	3.54	2.71	5.40	.41	3.55	.11
6672	------	Aug. 25, 1932	275	171	3.32	60	3.98	2.98	10.48	6.55	.06	10.15	0
6409	36-11S-5E-f	June 24, 1932	180	68.9	.65	19	2.70	3.19	1.40	4.80	.39	1.70	.29
10362	36-11S-5E-g	Nov. 18, 1935	217	74.2	1.53	59	1.54	1.82	4.75	5.74	.39	2.06	(2)
10881	31-11S-6E	July 15, 1936	167	109	1.59	43	2.53	4.38	5.19	8.70	.75	2.71	.14
10773	20-12S-E	May 27, 1936	105	170	.89	42	4.64	6.45	8.08	9.35	6.24	3.78	0
10774	20-12S-4E-a	do	180	77.5	(2)	24	3.11	3.31	1.98	6.17	.47	1.69	.05
10785	27-12S-4E	May 28, 1936	300	217	1.17	36	4.50	12.08	9.25	10.45	10.77	4.49	0
5120	34-12S-4E	Oct. 22, 1931	302	281	.84	38	10.18	9.35	11.94	9.45	11.62	10.40	0
5118	34-12S-4E-a	Oct. 30, 1931	328	135	.90	37	2.78	6.72	5.66	7.35	5.41	2.40	(2)
5119	34-12S-4E-b	do	284	114	.31	35	4.61	3.04	4.16	6.90	2.46	2.45	(2)
10782	35-12S-4E	May 28, 1936	90	134	1.11	38	2.86	6.74	5.92	8.11	5.08	2.18	.02
6198	1-12S-5E	May 16, 1932	287	126	2.70	45	2.97	3.76	5.59	8.05	.30	4.75	.06
7196	1-12S-5E-a	Mar. 18, 1933	268	87.4	1.07	35	3.00	3.22	3.35	5.90	.67	2.76	.13
7197	------	do	------	81.2	1.06	31	2.89	3.23	2.77	5.80	.58	2.24	.21
6285	1-12S-5E-b	June 7, 1932	200	96.6	2.15	49	2.47	2.74	4.94	6.15	.84	3.30	.07

8506	1-12S-5E-c	Apr. 16, 1934	285	90.1	1.40	------	------	------	------	------	------	------	------
9856	1-12S-5E-d	May 23, 1935	410	122	8.90	86	1.08	.93	11.56	[1] 7.86	.42	5.02	.01
7240	2-12S-5E	Apr. 12, 1933	------	88.0	1.23	------	------	------	------	6.35	------	2.45	------
5054	2-12S-5E-a	Oct. 9, 1935	185	101	1.26	50	2.39	3.03	5.37	5.90	2.53	2.30	.06
10768	5-12S-5E	May 27, 1936	320	133	.87	39	2.89	6.05	5.79	6.92	5.06	2.76	.07
10766	8-12S-5E	do	165	130	.81	39	2.96	5.97	5.76	7.26	4.76	2.58	.04
10765	9-12S-5E	do	150	133	.88	39	2.88	6.11	5.84	7.41	4.64	2.89	.06
5048	12-12S-5E	Oct. 17, 1931	240	76.6	4.15	51	1.54	2.11	3.86	4.05	.26	3.20	0
7407	------	June 12, 1933	------	103	10.1	59	1.89	2.89	6.88	3.90	.22	7.21	0
5049	12-12S-5E-a	Oct. 17, 1931	------	63.1	.90	22	2.52	2.65	1.47	4.35	.48	1.75	.06
5050	12-12S-5E-b	do	93	74.2	5.37	58	1.33	1.82	4.31	4.60	.16	2.70	0
6669	12-12S-5E-c	Sept. 5, 1932	98	63.8	1.57	24	2.61	2.31	1.56	4.30	.28	1.60	.12
7241	------	Apr. 15, 1933	------	------	1.70	------	------	------	------	------	------	------	------
7409	12-12S-5E-d	June 7, 1933	125	87.2	4.10	36	2.68	3.09	3.38	5.35	.16	3.66	.02
5057	13-12S-5E	Oct. 9, 1931	300	110	2.45	43	2.96	3.50	4.80	6.25	1.29	3.65	.07
4783	13-12S-5E-a	Sept. 3, 1931	500	143	11.25	75	2.14	1.71	11.25	[1] 7.90	.05	6.75	0
4839	------	Sept. 11, 1931	------	104	16.2	74	1.24	1.42	7.62	5.20	.13	4.95	0
5046	------	Oct. 9, 1931	------	95.6	18.2	74	1.11	1.35	7.07	5.10	.03	4.40	0
4836	13-12S-5E-b	Sept. 10, 1931	100	80.3	2.92	31	2.54	3.36	2.65	4.30	2.45	1.80	[2]
4837	13-12S-5E-c	do	168	97.1	3.98	31	3.03	3.89	3.06	5.05	1.58	3.35	0
8536	------	Apr. 23, 1934	------	100	9.94	------	------	------	------	------	------	------	------
9089	------	Sept. 13, 1934	300	106	10.88	------	------	------	------	5.71	------	5.19	------
4915	13-12S-5E-d	Sept. 18, 1931	270	152	6.58	63	2.14	3.35	9.51	6.30	.75	7.95	0
8668	------	May 24, 1934	------	157	7.92	------	------	------	------	6.73	------	8.63	------
5047	13-12S-5E-e	Oct. 7, 1931	229	130	3.07	55	2.48	3.52	7.36	6.95	1.82	4.50	.09
6146	13-12S-5E-f	May 17, 1932	98	96.4	15.00	59	1.61	2.08	5.28	4.65	.12	4.05	.03
6201	13-12S-5E-g	May 26, 1932	320	88.3	2.96	44	2.23	2.57	3.77	4.85	.30	3.75	.04
11460	------	June 15, 1937	220	86.5	4.36	42	2.33	2.57	3.62	4.86	.03	3.50	0
6416	13-12S-5E-h	July 2, 1932	270	131	9.69	64	2.10	2.79	8.55	5.95	[2]	7.15	0
8541	13-12S-5E-i	Apr. 25, 1934	220	50.3	4.06	57	1.10	1.24	3.36	3.72	.33	1.34	[2]
8542	13-12S-5E-j	do	200	52.7	5.65	------	------	------	------	------	------	------	------
8733	13-12S-5E-k	May 19, 1934	430	769	7.09	------	------	------	------	------	------	------	------
9349	13-12S-5E-l	Dec. 8, 1934	211	45.5	.64	------	------	------	------	3.54	------	.79	------
9350	------	do	296	43.8	.49	------	------	------	------	3.39	------	.79	------
9417	------	Dec. 27, 1934	315	70.2	5.25	64	1.07	1.44	4.54	4.82	.15	2.43	[2]
9488	------	Jan. 25, 1935	240	53.1	2.79	------	------	------	------	------	------	------	------
9489	------	do	240	57.6	3.14	------	------	------	------	------	------	------	------
10392	13-12S-5E-m	Nov. 29, 1935	250	164	5.33	58	2.47	4.85	10.24	8.76	2.14	6.69	.02
5045	14-12S-5E	Oct. 9, 1931	400	134	1.48	43	2.90	5.29	6.25	6.45	4.16	3.75	.08
10402	14-12S-5E-a	Dec. 6, 1935	288	151	3.66	65	1.59	4.12	10.60	[1] 8.71	3.02	4.73	.11
10764	16-12S-5E	May 27, 1936	157	130	.85	39	2.86	5.93	5.65	6.82	5.09	2.67	.07
10767	17-12S-5E	May 29, 1936	211	128	.83	40	2.71	5.86	5.83	6.68	4.93	2.71	.04
4838	21-12S-5E	Sept. 10, 1931	315	132	.86	40	2.70	6.19	5.81	6.45	5.54	2.65	.06
9164	------	Oct. 1, 1934	315	133	.86	------	------	------	------	[1] 6.49	------	2.75	------
4914	22-12S-5E	Sept. 23, 1931	250	128	.82	22	2.54	5.76	2.32	2.95	5.01	2.60	.06
9563	22-12S-5E-a	Feb. 5, 1935	113	126	.89	40	2.62	5.86	5.58	6.30	5.04	2.44	.07
10763	22-12S-5E-b	May 27, 1936	------	125	.85	41	2.92	5.11	5.67	6.32	4.73	2.85	.03
10685	22-12S-5E-c	Apr. 15, 1936	235	131	.82	45	2.80	4.90	6.30	6.02	4.84	3.16	.07
6143	23-12S-5E	May 6, 1932	287	109	.97	45	2.42	4.25	5.42	6.10	3.92	2.30	.15
9284	------	Nov. 6, 1934	------	109	.95	------	------	------	------	5.71	------	2.21	------
6670	23-12S-5E-a	Sept. 5, 1932	186	108	1.02	49	2.45	3.38	5.56	5.05	3.74	2.35	.06

See footnotes at end of table.

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TABLE 10.—*Analyses of quality of irrigation waters of the Hollister area*—Continued

Laboratory No.	Location No.	Date	Depth	$K \times 10^5$ at 25° C.	Boron	Percent sodium	Quantity per liter of—						
							Ca	Mg	Na	HCO_3	SO_4	Cl	NO_3
			Feet		*P. p. m.*		*M. e.*	*M. e.*	*M. e.*	*M. e.*	*M. e.*	*M. e.*	*M. e.*
6671	24-12S-5E	Sept. 5, 1932	196	118	1.37	51	1.79	3.61	5.72	5.95	2.72	2.80	0.11
9090		Sept. 14, 1934		120	1.41					6.40		3.79	
7272	24-12S-5E-a	Apr. 20, 1933	400	104	1.09	51	2.20	3.58	6.11	5.35	3.14	2.89	.07
9057		Aug. 30, 1934	200	107	1.06	50	2.21	3.53	5.83	5.61	3.58	2.40	.01
6412	24-12S-5E-b	July 2, 1932	150	101	3.38	51	2.30	2.97	5.45	5.95	.24	4.20	(2)
6674	25-12S-5E	Sept. 7, 1932		111	1.06	65	2.25	1.71	7.34	4.50	3.42	3.00	(2)
9075		Sept. 6, 1934	284	110	1.23					4.77		3.19	
6847	25-12S-5E-a	Oct. 22, 1932	250	110	.97	48	2.06	4.15	5.71	5.50	2.56	3.55	.06
8968	25-12S-5E-b	July 15, 1934	325	108	1.08	60	1.61	1.80	7.43	4.74	3.16	3.05	.01
4911	26-12S-5E	Sept. 18, 1931	138	103	.95	45	2.48	3.54	5.02	5.20	3.59	2.20	.05
6846	26-12S-5E-a	Sept. 23, 1932	265	105	.92	41	2.97	3.99	4.74	5.65	3.63	2.11	.05
7195	26-12S-5E-b	Mar. 24, 1933	410	103	.90	44	2.66	3.71	5.01	5.40	3.78	2.09	.06
4913	26-12S-5E-c	Sept. 18, 1931	210	114	.83	43	2.59	4.59	5.34	5.65	4.38	2.35	.14
9944	26-12S-5E-d	June 7, 1935	304	119	.79								
4912	27-12S-5E	Sept. 23, 1931	140	126	.75	22	2.59	5.66	2.26	2.80	5.20	2.45	.06
6142	27-12S-5E-a	May 9, 1932	930	112	.76	49	2.09	3.88	5.81	5.10	4.20	2.65	.04
11252		Jan. 6, 1937		112	.12					1.36		2.74	
9076	28-12S-5E	Sept. 6, 1934	168	163	.99	37	3.70	8.29	6.94	7.58	7.58	3.44	.12
9296	28-12S-5E-a	Nov. 6, 1934	210	128	.80	39	2.72	6.24	5.63	[1] 6.79	4.97	2.46	.04
9001	29-12S-5E	Aug. 9, 1934	350	342	.99	74	3.17	5.50	24.57	11.41	0	22.85	.01
11096		Oct. 23, 1936	270	359	.94	70	3.54	7.35	24.94	12.21	.63	23.80	(2)
10781	31-12S-5E	May 28, 1936	178	135	.84	37	3.09	6.76	5.70	7.16	5.71	2.45	.09
10393	33-12S-5E	Dec. 1, 1935	88	244	1.54	73	1.55	5.25	18.76	8.66	9.18	7.98	(2)
4920	34-12S-5E	Sept. 26, 1931		68.7	.36	48	1.66	1.96	3.39	3.20	2.04	1.75	.02
8456	35-12S-5E	Apr. 5, 1934	207	104	.91	48	2.73	3.72	5.70	5.79	4.43	2.20	.04
9207	35-12S-5E-a	Oct. 20, 1934	213	125	.90	38	3.02	5.61	5.35	6.25	4.88	2.55	.02
9867	35-12S-5E-b	May 30, 1935	337	111	.84	42	2.78	4.31	5.00	6.00	4.00	2.22	.07
7408	35-12S-5E-c	June 12, 1933	250	151	.91	35	3.69	7.50	6.05	6.80	6.78	3.22	.54
4908	36-12S-5E	Sept. 23, 1931	305	110	1.34	51	2.20	3.38	5.97	5.50	3.71	2.40	.03
4909	36-12S-5E-a	do	212	105	1.26	50	2.18	3.41	5.63	5.45	3.63	2.10	.04
4910	36-12S-5E-b	do	205	106	1.35	51	2.45	3.01	5.68	5.40	3.23	2.45	.06
5043	36-12S-5E-c	Oct. 29, 1931	230	109	1.11	48	2.49	3.51	5.65	5.55	3.66	2.40	.04
8079	36-12S-5E-d	Nov. 23, 1933	353	116	1.22								
8439	36-12S-5E-e	Mar. 26, 1934	555	134	1.74	91	.77	.45	11.71	6.07	.46	6.08	0
8505	36-12S-5E-f	Apr. 17, 1934	185	115	1.16								
9152	36-12S-5E-g	Sept. 24, 1934	400	110	1.12	69	1.59	1.93	7.78	4.58	2.90	3.73	.03
6410	6-12S-6E	June 24, 1932	200	60.8	.78	26	2.32	2.70	1.75	4.75	.55	.75	.50
4918	6-12S-6E-a	Sept. 18, 1931	310	88.4	.91	40	2.47	3.14	3.68	6.40	.72	2.10	.07
9040	6-12S-6E-b	Aug. 21, 1934	190	86.9	1.95	43	2.45	3.07	4.09	7.58	.46	2.00	.04
12244		Aug. 1, 1938		78.5	1.26	37	2.64	3.11	3.42	5.82	.64	1.32	.07
5124	6-12S-6E-c	Oct. 30, 1931	120	62.5	2.00	60	1.16	1.43	3.83	4.85	.17	1.40	0
5122	7-12S-6E	do	333	44.6	.19	24	1.70	1.80	1.11	3.40	.55	.65	.01

5123	7-12S-6E-a	do	120	30.4	.11	23	1.38	1.67	.93	2.70	.64	.60	.04
6845	7-12S-6E-b	Sept. 22, 1932	160	81.9	1.04	41	2.52	2.74	3.70	6.20	.52	2.11	.04
9086	7-12S-6E-c	Sept. 11, 1934	172	54.3	1.41	64	1.06	1.03	3.68	4.72	0	1.35	.01
6678	7-12S-6E-d	Sept. 9, 1932	460	108	7.58	----	----	----	----	[1] 6.50	----	4.40	----
10260	7-12S-6E-e	Oct. 5, 1935	200	82.2	2.04	51	2.09	2.35	4.57	6.68	.05	2.25	.02
6286	10-12S-6E	May 31, 1932	----	29.8	.08	18	.70	1.74	.54	2.05	.20	.60	.11
4919	18-12S-6E	Sept. 23, 1931	155	116	19.6	62	2.03	2.21	6.96	4.80	.05	6.35	(2)
6200	18-12S-6E-a	May 16, 1932	----	89.3	12.8	53	1.80	2.59	5.02	[1] 5.60	(2)	3.80	0
6283	18-12S-6E-b	June 14, 1932	90	38.6	.10	25	1.35	1.67	.98	2.80	.37	.80	.05
6284	18-12S-6E-c	June 12, 1932	125	37.6	.17	25	1.30	1.60	.99	2.85	.54	.55	.06
9072	18-12S-6E-d	Aug. 31, 1934	200	55.2	1.19	31	1.75	2.56	1.91	3.54	.53	1.70	.01
9041	18-12S-6E-e	June 4, 1935	136	69.9	6.21	----	----	----	----	----	----	----	----
9940	18-12S-6E-f	do	142	71.6	6.55	----	----	----	----	----	----	----	----
9188	18-12S-6E-g	Oct. 9, 1934	92	41.9	.22	27	1.34	1.84	1.15	2.90	.52	.79	.04
5044	19-12S-6E	Oct. 7, 1931	250	54.5	.96	31	1.82	2.27	1.86	3.65	.39	1.85	.06
6147	----	May 17, 1932	----	94.4	15.9	59	1.75	2.28	5.70	4.80	.41	4.00	(2)
6195	19-12S-6E-a	May 27, 1932	----	100	12.5	----	----	----	----	----	----	----	----
6413	19-12S-6E-b	July 2, 1932	300	135	19.2	61	2.49	3.04	8.64	6.95	.40	6.70	(2)
6414	19-12S-6E-c	do	150	60.0	.88	30	2.17	2.44	1.93	4.25	.34	1.50	.12
8632	----	May 18, 1934	----	56.8	.94	----	----	----	----	----	----	----	----
6415	19-12S-6E-d	July 2, 1932	113	59.8	.51	29	2.13	2.55	1.94	4.25	.45	1.50	.11
9074	----	Sept. 6, 1934	110	61.0	.70	----	----	----	----	4.28	----	1.70	----
6675	19-12S-6E-e	Aug. 1, 1932	400	128	24.90	73	1.82	1.57	9.30	7.05	(2)	5.85	0
7269	19-12S-6E-f	Apr. 20, 1933	190	211	5.45	60	2.21	6.55	13.24	9.30	4.12	8.66	.14
7545	----	Aug. 3, 1933	----	215	5.69	----	----	----	----	----	----	----	----
7419	19-12S-6E-g	June 24, 1933	60	118	2.67	----	----	----	----	5.60	----	5.53	----
8070	19-12S-6E-h	Oct. 21, 1933	65	121	2.48	----	----	----	----	----	----	----	----
8406	19-12S-6E-i	Mar. 21, 1934	143	188	8.02	74	1.88	3.48	14.80	[1] 10.35	1.69	8.47	0
8503	19-12S-6E-j	Apr. 19, 1934	120	60.1	.18	----	----	----	----	----	----	----	----
8732	19-12S-6E-k	May 28, 1934	170	88.8	9.23	----	----	----	----	----	----	----	----
9767	19-12S-6E-l	Apr. 15, 1935	100	95.9	5.58	56	1.82	2.53	5.57	5.80	.09	4.08	(2)
9868	19-12S-6E-m	May 30, 1935	500	88.4	6.09	46	2.25	2.81	4.05	5.50	.02	3.87	0
12195	----	July 5, 1938	----	83.7	5.31	39	2.38	2.88	3.37	4.77	.04	3.51	.01
6068	30-12S-6E	Aug. 19, 1932	400	287	4.88	52	4.13	11.14	16.26	9.40	10.22	11.50	0
7270	30-12S-6E-a	Apr. 20, 1933	190	253	5.83	78	1.80	3.77	19.52	7.60	2.72	15.30	(2)
7367	30-12S-6E-b	June 7, 1933	370	231	5.15	60	2.15	7.58	14.65	11.65	3.67	8.99	.07
7410	----	June 15, 1933	270	236	5.10	61	2.19	7.73	15.43	11.85	5.22	9.14	.01
8552	30-12S-6E-c	Apr. 25, 1934	210	236	4.05	----	----	----	----	----	----	----	----
8967	30-12S-6E-d	July 12, 1934	200	198	2.86	73	1.91	3.53	14.76	10.32	.99	9.24	.01
9249	30-12S-6E-e	Oct. 26, 1934	350	150	2.39	90	.73	.81	14.16	9.79	.41	5.74	.03
8564	30-12S-6E-f	May 4, 1934	370	228	2.96	----	----	----	----	8.63	----	12.15	----
4917	34-12S-6E	Sept. 17, 1931	----	57.2	.58	25	1.72	2.70	1.51	4.25	.63	1.00	.05
6279	34-12S-6E-a	June 13, 1932	130	54.1	.61	32	1.64	2.21	1.77	3.85	.90	1.00	.07
10647	2-13S-4E	Apr. 1, 1936	450	137	.36	42	5.17	3.77	6.44	7.71	4.34	3.29	.05
10784	4-13S-4E	May 28, 1936	80	76.7	.11	21	5.03	1.82	1.82	5.42	1.18	1.60	.28
9085	1-13S-5E	Sept. 11, 1934	276	136	1.79	59	2.14	3.66	8.43	6.59	3.44	4.39	.01
4907	2-13S-5E	Sept. 21, 1931	----	124	.83	9	3.05	9.33	1.19	5.80	5.10	2.55	.12
8504	2-13S-5E-a	Apr. 19, 1934	125	132	.81	39	2.91	5.84	5.50	6.13	5.25	2.92	.01
8540	2-13S-5E-b	do	254	123	.84	37	2.97	5.40	4.79	5.89	4.87	2.54	.03
5042	3-13S-5E	Oct. 9, 1931	----	135	.83	36	3.05	6.16	5.19	6.45	5.34	2.45	.16
10775	3-13S-5E-a	May 28, 1936	120	120	.94	40	2.41	5.54	5.29	[1] 6.17	4.65	2.45	.04

See footnotes at end of table.

TABLE 10.—*Analyses of quality of irrigation waters of the Hollister area*—Continued

Laboratory No.	Location No.	Date	Depth	$Kx10^5$ at 25° C.	Boron	Percent sodium	Quantity per liter of—						
							Ca	Mg	Na	HCO_3	SO_4	Cl	NO_3
			Feet		*P. p. m.*		*M. e.*	*M. e.*	*M. e.*	*M. e.*	*M. e.*	*M. e.*	*M. e.*
10780	3-13S-5E-b	May 28, 1936	160	126	0.78	40	2.89	5.50	5.69	7.71	4.18	2.23	0.07
10779	10-13S-5E	do	150	134	1.08	40	2.86	6.14	6.12	6.42	5.41	2.98	.14
4840	11-13S-5E-a	Sept. 10, 1931	----	139	.91	17	7.03	5.40	2.56	5.45	5.93	3.55	.06
10777	11-13S-5E-b	May 28, 1936	200	140	1.08	43	2.68	5.94	6.02	6.32	5.63	3.16	.21
10778	11-13S-5E-c	do	225	131	.95	42	2.51	5.66	6.17	6.12	5.25	3.03	.03
4906	13-13S-5E	Sept. 21, 1931	142	129	.83	30	4.49	5.47	4.37	5.35	6.14	2.60	.24
9561	27-13S-5E	Feb. 4, 1935	8	124	.88	36	5.53	2.96	4.85	4.82	4.55	3.63	.21
9570	27-13S-5E-a	Feb. 12, 1935	30	103	.51	24	6.19	2.64	2.74	[1] 5.71	3.82	2.04	.01
10414	5-13S-6E	Dec. 17, 1935	----	341	5.12	60	3.92	10.80	21.65	[1] 12.85	6.88	17.27	0
7370	7-13S-6E	Apr. 28, 1933	260	410	5.99	84	1.46	5.24	35.45	11.45	11.09	20.68	0
10497	7-13S-6E-a	Jan. 20, 1936	150	239	2.70	64	2.50	6.63	16.30	[1] 7.02	9.92	8.25	.21
5121	20-13S-6E	Oct. 30, 1931	65	184	1.57	40	5.06	6.63	7.91	[1] 7.05	5.45	7.00	.10
7774	21-13S-6E	Sept. 5, 1933	160	129	.96	34	4.04	5.98	5.11	[1] 6.20	6.22	2.36	(2)
4835	11-14S-6E	Sept. 7, 1931	90	93.0	.87	----	2.88	3.69	----	4.40	4.22	1.40	.04
7368	12-14S-6E	June 7, 1933	375	99.2	.91	38	2.78	4.01	3.53	4.65	4.56	1.64	.07
7369	35-14S-6E	do	553	159	1.11	36	2.51	9.37	6.18	7.20	7.92	2.89	.71
7896	1-15S-7E	Nov. 11, 1933	35	137	2.34	39	4.62	4.79	5.86	6.30	7.00	2.28	0
4834	7-15S-9E	Sept. 10, 1931	180	124	2.15	----	3.33	4.65	----	10.05	2.01	1.95	.06
12144	7-15S-9E	June 7, 1938	85	155	1.09	34	6.27	5.48	6.13	4.50	12.13	1.15	.18

[1] Carbonate present.
[2] Trace.

TABLE 11.—*Descriptions of wells sampled in Hollister area*

Laboratory No.	Location	Symbol	Description
10771	27–11S–4E	212–5	D. G. Alvernaz. Location corresponds to NE¼, sec. 27, T. 11 S., R. 4 E. Depth, 480 feet. Discharge, 500 gallons per minute. Well formerly flowed. Acreage served, 219.
7041	16–11S–5E	523–1	V. Teani. Location corresponds to SW¼, sec. 16, T. 11 S., R. 5 E. Surface well.
5056	21–11S–5E	222–3	A. Cabrol. Location corresponds to SW¼, sec. 21, T. 11 S., R. 5 E. Depth, 104 feet; 3-inch casing. Discharge, 200 gallons per minute. Acreage served, 30.
10769	21–11S–5E–a	323–4	Geo. E. Hamilton. Location corresponds to NE¼, sec. 21, T. 11 S., R. 5 E. Depth, 200 feet. Discharge, 100 gallons per minute. Temperature normal. Sulfide odor; very little gas; color smoky. Domestic well nearby has static level of 6 feet.
6141	24–11S–5E	211–3	E. Sharp. Location corresponds to NW¼, sec. 24, T. 11 S., R. 5 E. Depth, 136 feet; strata at 40 to 60 feet, small strata below. Discharge, 900 gallons per minute. Acreage served, 60.
6282	25–11S–5E	222–3	W. I. Hawkins. Location corresponds to SW¼, sec. 25, T. 11 S., R. 5 E. Depth, 170 feet; 14-inch casing; upper perforations, 45 feet; draws down to 35 feet; static level, 30 feet. Discharge, 100 gallons per minute. Acreage served, 108. Temperature, 20° C.
5053	26–11S–5E	344–4	W. A. Maroney. Location corresponds to SE¼, sec. 26, T. 11 S., R. 5 E. Depth, 250 feet; 12-inch casing; perforated, 140 to 240 feet; strata 45 to 55 feet, 200 to 250 feet. Discharge, 450 gallons per minute. Acreage served, 20.
6144			Resample. Discharge, 700 gallons per minute.
9237			Resample.
9347	26–11S–5E–a	33X–4	Mrs. S. Stevens. Location corresponds to SE¼, sec. 26, T. 11 S., R. 5 E. Depth, 200 feet; 10-inch casing. Discharge, 76 gallons per minute. Static level, 60 feet, draws down to 80 feet. Sulfide odor; gas present; blue color. Acreage served, 20.
10865	26–11S–5E–b	222–3	Ed. Murphy. Location corresponds to SW¼, sec. 26, T. 11 S., R. 5 E. Depth, 125 feet; 13-inch casing, upper perforations, 65 feet. Discharge, 550 gallons per minute. Static level, 40 feet; draws down to 48 feet. Acreage served, 37.
10866	27–11S–5E	222–3	Dunne ranch. McCann field well. Location corresponds to NE¼, sec. 27, T. 11 S., R. 5 E. Depth, 177 feet; 12-inch casing. Discharge, 1,100 gallons per minute. Static level, 22 feet. Acreage served, 300.
9073	28–11S–5E	55X–2	Faustine Sequiera. Location corresponds to SW¼, sec. 28, T. 11 S., R. 5 E. Depth, 90 feet; 3-inch casing; windmill pump; static level, 25 feet. No odor; no gas; cloudy. Domestic.
9296	28–11S–5E–a	333–3	Faustine Sequiera. Well No. 1. Location corresponds to SW¼, sec. 28, T. 11 S., R. 5 E. Depth, 103 feet; upper perforations, 83 feet; 10-inch casing. Discharge, 500 gallons per minute. Static level, 20 feet; draws down to 30 feet. Acreage served, 60. Well is located 300 yards south of No. 9297.
9297	28–11S–5E–b	333–2	Faustine Sequiera. Well No. 2. Location corresponds to SW¼, sec. 28, T. 11 S., R. 5 E. Depth, 86 feet; not perforated; 10-inch casing. Discharge, 25 gallons per minute. Static level, 18 feet; draws down to 20 feet. Domestic and stock. Well located 200 yards south of No. 9073.
10770	29–11S–5E	3, 34–4	M. F. Sousa well. Location corresponds to NW¼, sec. 29, T. 11 S, R. 5 E. Depth, 180 feet; upper perforations, 40 feet; 13-inch casing. Discharge, 700 gallons per minute. Static level, 8 feet; draws down to 68 feet. Acreage served, 40.
10867	33–11S–5E	333–3	W. L. Little. Location corresponds to SE¼, sec. 33, T. 11 S., R. 5 E. Depth, 165 feet; 13-inch casing. Discharge, 600 gallons per minute. Static level, 22 feet; draws down to 36 feet. Acreage served, 36.
5055	34–11S–5E	222–3	Waldo Rohnert. Home well. Location corresponds to NE¼, sec. 34, T. 11 S., R. 5 E. Depth, 115 feet. Discharge, 275 gallons per minute. Total acreage served by all Rohnert wells, 395.
5051	35–11S–5E	232–3	Waldo Rohnert. Green well. Location corresponds to SE¼, sec. 35, T. 11 S., R. 5 E. Depth, 185 feet. Discharge, 800 gallons per minute.
5052	35–11S–5E–a	344	Waldo Rohnert. Well No. 4. Location corresponds to SW¼, sec. 35, T. 11 S., R. 5 E. 14-inch casing. Discharge, 1,200 gallons per minute.
10670	35–11S–5E–b	343–4	Geo. Nielson well. Location corresponds to SE¼, sec. 35, T. 11 S., R. 5 E. Depth, 365 feet; upper perforations, 60 feet; draws down to 74 feet; 16-inch casing. Discharge, 600 gallons per minute. Static level, 60 feet. Acreage served, 96.
4916	36–11S–5E	222–3	Jack Briggs. Location corresponds to NW¼, sec. 36, T. 11 S., R. 5 E. Depth, 119 feet; 13-inch casing. Discharge, 400 gallons per minute. Acreage served, 19.
5125	36–11S–5E–a	454	E. E. Porter. Location corresponds to SW¼, sec. 36, T. 11 S., R. 5 E. Acreage served, 60.

TABLE 11.—*Descriptions of wells sampled in Hollister area*—Continued

Laboratory No.	Location	Symbol	Description
6145	36-11S-5E-b	454-4	B. W. Barrett. Location corresponds to SW¼, sec. 36, T. 11 S., R. 5 E. Depth, 300 feet; strata, 160, 200, and 280 feet. Discharge, 650 gallons per minute. Water rather warm. Acreage served, 70.
6196	36-11S-5E-c	354-4	J. P. Davis. Location corresponds to NW¼, sec. 36, T. 11 S., R. 5 E. Depth, 300 feet; 14-inch casing; upper perforations, 50 feet. Discharge, 650 gallons per minute. Draws down to 90 feet; static level, 60 feet. Water rather warm. Acreage served, 70.
6197	36-11S-5E-d	453-5	F. Craheri. Location corresponds to SW¼, sec. 36, T. 11 S., R. 5 E. Depth, 480 feet; 12-inch casing. Discharge, 250 gallons per minute. Temperature, 60° F. Some gas; clear. Acreage served, 38.
6411	36-11S-5E-e	332-3	B. W. Barrett. Location corresponds to SW¼, sec. 36, T. 11 S., R. 5 E. Depth, 180 feet; 14-inch casing; upper perforations, 70 feet. Acreage served, 70.
6672			Resample, after permanent pump installation. Depth, 275 feet.
6409	36-11S-5E-f	221-3	A. O. Ames. Location corresponds to SW¼, sec. 36, T. 11 S., R. 5 E. Depth, 180 feet; upper perforations, 80 feet; 10-inch casing. Discharge, 500 gallons per minute. Static level, 70 feet; temperature, 58° F. Acreage served, 25.
10362	36-11S-5E-g	243-4	Mrs. S. H. Stevens. Location corresponds to NW¼, sec. 36, T. 11 S., R. 5 E. Depth, 217 feet; upper perforations, 65 feet; 12-inch casing. Discharge, 400 gallons per minute. Static level, 45 feet; draws down to 95 feet; water slightly warm; gas present; sulfide odor. Clear. Pumped 2½ hours before sample. Acreage served, 40.
10881	31-11S-6E	343-3	John J. Hogan. Location corresponds to SW¼, sec. 31, T. 11 S., R. 6 E. Depth, 167 feet; 12-inch casing. Discharge, 700 gallons per minute. Static level, 57 feet; draws down to 90 feet. Acreage served, 40.
10773	20-12S-4E	433-33	J. Z. Anderson. Miller well. SE¼, sec. 20, T. 12 S., R. 4 E. Depth, 105 feet; upper perforations, 80 feet; 8-inch casing. Discharge, 300 gallons per minute. Static level, 30 feet; draws down to 50 feet. Acreage served, 120.
10774	20-12S-4E-a	312-3	J. Z. Anderson. Canyon well. SW¼, sec. 20, T. 12 S., R. 4 E. Depth, 180 feet; upper perforations, 120 feet, 10-inch casing. Discharge, 120 gallons per minute. Static level, 40 feet; draws down to 55 feet. Used for spraying, garden, and domestic.
10785	27-12S-4E	432-4	Ben Flint. Location corresponds to SE¼, sec. 27, T. 12 S., R. 4 E. Depth, 300 feet. No water below 120 feet. Upper perforations, 100-120 feet; 13-inch casing. Discharge, 54 gallons per minute. Static level, 45 feet; draws down to 70 feet. Acreage served, 85.
5120	34-12S-4E	432-4	Morse seed farm. Well No. 5. SW¼, sec. 34, T. 12 S., R. 4 E. Depth, 302 feet. Discharge, 700 gallons per minute. Acreage served, together with well No. 1, 300.
5118	34-12S-4E-a	332-4	Morse seed farm. Well No. 2. SW¼, sec. 34, T. 12 S., R. 4 E. Depth, 328 feet. Discharge, 800 gallons per minute.
5119	34-12S-4E-b	322-4	Morse seed farm. Well No. 1. SW¼, sec. 34, T. 12 S., R. 4 E. Depth, 284 feet. Discharge, 1,000 gallons per minute.
10782	35-12S-4E	332-2	W. E. Burnett well. Location corresponds to SE¼, sec. 35, T. 12 S., R. 4 E. Depth, 90 feet; 6-inch casing. Domestic well, with windmill. Static level, 55 feet. No odor, no gas, clear.
6198	1-12S-5E	343-4	Fred Stevens. Location corresponds to NE¼, sec. 1, T. 12 S., R. 5 E. Depth, 287 feet. Discharge, 350 gallons per minute. Acreage served, 10.
7196	1-12S-5E-a	332-4	Tony Palumbo. Location corresponds to NW¼, sec. 1, T. 12 S., R. 5 E. Depth, 268 feet; upper perforations, 106 feet; 12-inch casing. Discharge, 200 gallons per minute. Static level, 48 feet; water cold. No odor; gas present; color blue. Acreage served, 30. Water pumped 4 hours before sample drawn.
7197			Resample. Water pumped 1 hour before sample drawn.
6285	1-12S-5E-b	343-4	M. J. Galvin. Location corresponds to NW¼, sec. 1, T. 12 S., R. 5 E. Depth, 200 feet; upper perforations, 50 feet; 14-inch casing. Discharge, 650 gallons per minute. Draws down to 52 feet. Acreage served, 45.
8506	1-12S-5E-c	33X-4	P. Bozzo. Location corresponds to NW¼, sec. 1, T. 12 S., R. 5 E. Depth, 285 feet; 10-inch casing. Discharge, 65 gallons per minute. Static level, 55 feet; draws down to 74 feet. Acreage served, 20.
9856	1-12S-5E-d	355-5	Robert Grant. Location corresponds to SE¼, sec. 1, T. 12 S., R. 5 E. Depth, 410 feet; 12-inch casing. Discharge, 250 gallons per minute. Temperature, warm. Slight odor; enough gas to burn; clear. Irrigation.
7240	2-12S-5E	33X-	Geo. Nielson. Location corresponds to NE¼, sec. 2, T. 12 S., R. 5 E.
5054	2-12S-5E-a	333-3	Waldo Rohnert. Pear pump. Location corresponds to NW¼, sec. 2, T. 12 S., R. 5 E. Depth, 185 feet. Discharge, 700 gallons per minute.

TABLE 11.—*Descriptions of wells sampled in Hollister area*—Continued

Laboratory No.	Location	Symbol	Description
10768	5-12S-5E	332-4	Brown well. Location corresponds to NW¼, sec. 5, T. 12 S., R. 5 E. Sample from southernmost of 2 wells. Depth, 320 feet; 14-inch casing. Discharge, 1,000 gallons per minute. Static level, 10 feet; draws down to 40 feet. 60 feet to pump bowl (western turbine pump, 25 horsepower). Irrigates large acreage of field crops.
10766	8-12S-5E	332-3	Annie Hogan estate. Location corresponds to NE¼, sec. 8, T. 12 S., R. 5 E. Depth, 165 feet; 14-inch casing; discharge, 800 gallons per minute. Static level, 50 feet; draws down to 95 feet. Acreage served, 100.
10765	9-12S-5E	332-3	Bedford Lynn. Location corresponds to NW¼, sec. 9, T. 12 S., R. 5 E. Depth, 150 feet; perforation, below 100 feet; 13-inch casing head, 10-inch lower casing. Discharge, 650 gallons per minute. Static level, 86 feet; draws down 10 to 12 feet. Acreage served, 80.
5048	12-12S-5E	353-4	H. Hawkins. Location corresponds to SW¼, sec. 12, T. 12 S., R. 5 E. Depth, 240 feet. Acreage served, 22.
7407			Resample. Taken after pump had been running several days.
5049	12-12S-5E-a	232	H. A. Snibley. Location corresponds to NW¼, sec. 12, T. 12 S., R. 5 E. Acreage served, 40.
5050	12-12S-5E-b	253-2	Holthouse ranch. Location corresponds to SE¼, sec. 12, T. 12 S., R. 5 E. Depth, 93 feet; acreage served, 170.
6669	12-12S-5E-c	242-2	Jack Kydd. Location corresponds to SW¼, sec. 12, T. 12 S., R. 5 E. Depth, 98 feet; 13-inch casing. Discharge, 500 gallons per minute. Static level, 42 feet. Temperature, 63° F.
7241			Resample.
7409	12-12S-5E-d	352-3	W. F. Renz, Freitas well. Location corresponds to SW¼, sec. 12, T. 12 S., R. 5 E. Depth, 125 feet; upper perforation, 60 feet; 12-inch casing. Discharge, 300 gallons per minute. Temperature, 65° F.
5057	13-12S-5E	343-4	Morse seed farm. Location corresponds to SW¼, sec. 13, T. 12 S., R. 5 E. An abandoned well in southeast corner of south field. Depth, 300 feet.
4783	13-12S-5E-a	352-5	Martin Luther. Location corresponds to NE¼, sec. 13, T. 12 S., R. 5 E. Depth, 500 feet. Discharge, 75 gallons per minute. Acreage served, 388.
4839			Resample.
5046			Do.
4836	13-12S-5E-b	342-3	Martin Luther. Domestic well. Location corresponds to NE¼, sec. 13, T. 12 S., R. 5 E. Drilled to 160 feet; sanded in to 100 feet.
4837	13-12S-5E-c	532-3	Martin Luther. Abandoned well. Location corresponds to NE¼, sec. 13, T. 12 S., R. 5. E. Used until season of 1931. Drilled in 1920 to 200 feet; sanded into 168 feet; stands at about 50 feet. Bailing bucket lowered to about 140 feet.
8356			Resample. Pumped 4 hours before sampling.
9089			Resample. This sample taken after cleaning well and installing pump. Now described as follows: California Lands, Inc. Depth 300 feet; upper perforation, 50 feet; 14-inch casing. Discharge 500 gallons per minute. Static level, 60 feet; draws down to 135 feet. Some odor; some gas; some color. Acreage served, 50.
4915	13-12S-5E-d	454-4	S. F. Barnet. Location corresponds to SE¼, sec. 13, T. 12 S., R. 5 E. Depth, 270 feet; 14-inch casing. Discharge, 300 gallons per minute. Acreage served, 30.
5668			Resample.
5047	13-12S-5E-e	353-4	Morse seed farm. Well No. 2. Location corresponds to NW¼, sec. 13, T. 12 S., R. 5 E. Depth, 229 feet. Discharge, 850 gallons per minute. Acreage served, 100.
6146	13-12S-5E-f	353-2	W. A. Blacklock. Location corresponds to SE¼, sec. 13, T. 12 S., R. 5 E. Depth, 98 feet. Discharge, 350 gallons per minute. Acreage served, 29.
6201	13-12S-5E-g	343-4	W. A. Pack. Location corresponds to SE¼, sec. 13, T. 12 S., R. 5 E. Depth, 320 feet; upper perforations, 50 feet; 12-inch casing. Discharge, 300 gallons per minute. Acreage served, 60. Pumps sand.
11400			Resample. Sample taken after well had been running for 5 hours. Static level approximately 152 feet. Draw-down approximately 100 feet. Present capacity, 150 gallons per minute. Well is 420 feet deep, but lower 200 feet are filled with sand.
8416	13-12S-5E-h	354-4	W. A. Pack. Location corresponds to SE¼, sec. 13, T. 12 S., R. 5 E. Depth, 270 feet; draws down to 140 feet; static level, 70 feet. Temperature, 69° F.
8541	13-12S-5E-i	253-4	Frank T. Duncan. Location corresponds to NE¼, sec. 13, T. 12 S., R. 5 E. Depth, 220 feet; upper perforations, 80 feet; 10-inch casing. Discharge, 225 gallons per minute. Static level, 28 feet; draws down to 65 feet. Sulfide odor; no gas; blue color. Acreage served, 50. Sampled after 9 hours' run.
8542	13-12S-5E-j	25X-4	Frank T. Duncan. Well No. 2. Location corresponds to NE¼, sec. 13, T. 12 S., R. 5 E. 300 feet down creek from 8541 (i). Depth, 200 feet; 10-inch casing. Static level, 28 feet. Slight sulfide odor; no gas; clear. Domestic; has small pump.

TABLE 11.—*Descriptions of wells sampled in Hollister area*—Continued

Laboratory No.	Location	Symbol	Description
8733	13-12S-5E-k	35X-5	Frank T. Duncan. Abandoned well. Location corresponds to NE¼, sec. 13, T. 12 S., R. 5 E. Depth, 430 feet; static level, 60 feet; 14-inch casing. Discharge, 400 gallons per minute. Some odor; gas; color, blue.
9349	13-12S-5E-l	254-4	Frank T. Duncan. New well. Location corresponds to NE¼, sec. 13, T. 12 S., R. 5 E. About 6 feet from No. 8541 (i). Sample bailed from 211-foot stratum.
9350			Resample. Bailed from 296-foot stratum. Probably contains no water from 211-foot stratum.
9417			Resample. After completion. Depth, 315 feet; upper perforation, 211 feet; 14-inch casing. Discharge, 400 gallons per minute. Sulfide odor; no gas; clear.
9488			Resample. Well filled in from depth of 315 feet to 240 feet and pumped 2 hours before sampling.
9489			Resample. This sample was collected after the collection of No. 9488, and after well No. 8541, located 6 feet from this well, had been filled in from 215 feet to 180 feet.
10392	13-12S-5E-m	453-4	W. A. Pack. New well. Location corresponds to SW¼, sec. 13, T. 12 S., R. 5 E. Depth, 250 feet; perforation, 80 feet; 12-inch casing. Discharge, 500 gallons per minute. Static level, 65 feet; draws down to 115 feet. Temperature, 66° F. No odor; no gas; yellow color. Acreage served, 100.
5045	14-12S-5E	333-5	P. G. Galli. Location corresponds to NE¼, sec. 14, T. 12 S., R. 5 E. Depth, 400 feet. Discharge, 900 gallons per minute. Acreage served, 60.
10402	14-12S-5E-a	454-4	William Hooper. Location corresponds to SE¼, sec. 14, T. 12 S., R. 5 E. Depth, 285 feet; upper perforation, 175 feet; 12-inch casing. Discharge, 500 gallons per minute. Static level, 80 feet; draws down to 130 feet. No odor; no gas; yellow color.
10764	16-12S-5E	332-3	J. L. Sullivan. Location corresponds to NW¼, sec. 16, T. 12 S., R. 5 E. Depth, 157 feet; 13-inch casing. Discharge, 900 gallons per minute. Static level, 80 feet. Acreage served, 71.
10767	17-12S-5E	333-4	David Lundy. Location corresponds to NE¼, sec. 17, T. 12 S., R. 5 E. Depth, 211 feet; upper perforations, 30 feet; 13½-inch casing. Discharge, 400 gallons per minute. Static level, 80 feet. Draws down to 100 feet. Acreage served, 50.
4838	21-12S-5E	333-4	Martin Luther. Old Miller ranch. Location corresponds to SW¼, sec. 21, T. 12 S., R. 5 E. Drilled in 1927 to 315 feet; 14-inch casing. Static level, 90 feet.
9164			Resample. Described as follows: California Lands, Inc. Depth, 315 feet; upper perforations, 60 feet; 14-inch casing. Discharge, 400 gallons per minute. Static level, 95 feet; draws down to 145 feet. Irrigation and domestic. Acreage served, 130.
4914	22-12S-5E	332-4	W. A. Johnson. Location corresponds to SW¼, sec. 22, T. 12 S., R. 5 E. Depth, 250 feet; 14-inch casing. Perforated below 90 feet. Discharge, 475 gallons per minute. Acreage served, 90.
9563	22-12S-5E-a	333-3	W. A. Johnson and S. W. White. Location corresponds to SW¼, sec. 22, T. 12 S., R. 5 E. Depth, 113 feet; 18-inch casing. Discharge, 450 gallons per minute. Static level, 90.5 feet; draws down to 110 feet. Temperature, 65° F. Acreage served, 80.
10763	22-12S-5E-b	333-	Ladd-Lamberti-Hawkins. Location corresponds to the NW¼, sec. 22, T. 12 S., R. 5 E. Discharge, 700 gallons per minute. No draw-down. Acreage served, 132.
10685	22-12S-5E-c	333-4	W. A. Johnson. Location corresponds to SW¼, sec. 22, T. 12 S., R. 5 E. Depth, 235 feet; upper perforations, 90 feet; 14-inch casing. Discharge, 700 gallons per minute. Static level, 94 feet; draws down to 104 feet.
6143	23-12S-5E	333-4	Ray Hawkins. Location corresponds to NW¼, sec. 23, T. 12 S., R. 5 E. Depth, 287 feet; 4 strata, 125 to 287 feet. Discharge, 800 gallons per minute. Acreage served, 25.
9284			Resample.
6670	23-12S-5E-a	333-3	J. McCloskey & Inskeep. Location corresponds to SE¼, sec. 23, T. 12 S., R. 5 E. Discharge, 750 gallons per minute. Depth, 186 feet. Temperature, 67° F. Acreage served, 160.
6671	24-12S-5E	333-3	California Lands, Inc. McCloskey ranch. Location corresponds to SW¼, sec. 24, T. 12 S., R. 5 E. Depth, 196 feet; 14-inch casing. Discharge, 400 gallons per minute. Static level, 95 feet; draws down to 153 feet. Acreage served, 150. Temperature, 65° F.
9090			Resample.
7272	24-12S-5E-a	333-5	Mrs. Thos. McCloskey. Location corresponds to SW¼, sec. 24, T. 12 S., R. 5 E. Depth, 400 feet; perforated at 200 feet (none below 238 feet); 14-inch casing. Discharge, 700 gallons per minute. Draws down to 145 feet. Temperature, 70° F.
9057			Resample. Described as: California Lands, Inc. (Jas. McCloskey). Depth (about) 200 feet. Discharge, 650 gallons per minute. Upper perforations, 40 feet; 14-inch casing. Static level, 50 feet. Draws down to 50 feet. Acreage served, 80.
6412	4-12S-5E-b	353-3	J. S. Dermody. SE¼, sec. 24, T. 12 S., R. 5 E. Depth, 150 feet; upper perforations, 60 feet. Discharge, 330 gallons per minute. Temperature, 68° F. Acreage served, 10.

TABLE 11.—*Descriptions of wells sampled in Hollister area*—Continued

Laboratory No.	Location	Symbol	Description
6674	25-12S-5E	334-3	Geo. Clemens estate. Location corresponds to NW¼, sec. 25, T. 12 S., R. 5 E. Discharge, 300 gallons per minute. Acreage served, 40.
9075			Resample. Described as follows: California Lands, Inc., (Clemens well). Depth, 284 feet; 14-inch casing. Discharge, 200 gallons per minute. Static level, 80 feet; draws down to 140 feet. Acreage served, 30.
6847	25-12S-5E-a	333-3	Peter N. Gross. Location corresponds to NW¼, sec. 25, T. 12 S., R. 5 E. Depth, 250 feet. Discharge, 450 gallons per minute. Acreage served, 40.
8968	25-12S-5E-b	334-4	C. J. Lomonto, NE corner, SE¼, sec. 25, T. 12 S., R. 5 E. Depth, 325 feet; upper perforations, 165 feet; 12-inch casing. Discharge, 325 gallons per minute. Static level, 160 feet; draws down to 190 feet. Irrigation and domestic. Acreage served, 90.
4911	26-12S-5E	333-3	W. J. Campbell. Location corresponds to SE¼, sec. 26, T. 12 S., R. 5 E. Depth, 136 feet; 10-inch casing. Discharge, 150 gallons per minute. Acreage served, 21.
6846	26-12S-5E-a	333-4	Ben Rice. Location corresponds to NE¼, sec. 26, T. 12 S., R. 5 E. Depth, 265 feet; upper perforations, 90 feet; 12-inch casing. Discharge, 450 gallons per minute. Static level, 85 feet. Acreage served, 40.
7195	26-12S-5E-b	333-5	Mrs. Thos. McCloskey. Pump No. 1. Location corresponds to NE¼, sec. 26, T. 12 S., R. 5 E. Depth, 410 feet; upper perforations, 182 feet; 14-inch casing. Discharge, 800 gallons per minute. Draws down to 142 feet; best gravel 257 to 307 feet. Temperature, 70° F. Acreage served, 110.
4913	26-12S-5E-c	333-4	A. C. Centmayer. Location corresponds to SW¼, sec. 26, T. 12 S., R. 5 E. Depth, 210 feet; 13-inch casing. Discharge, 600 gallons per minute. Acreage served, 15.
9944	26-12S-5E-d	33X-4	R. O. Hardin. Location corresponds to SW¼, sec. 26, T. 12 S., R. 5 E. Depth, 304 feet; upper perforations, 106 feet; 10-inch casing. Discharge, 500 gallons per minute. Static level, 106 feet; draws down to 130 feet. Acreage served, 15.
4912	27-12S-5E	332-3	L. L. Thomas. Location corresponds to NW¼, sec. 27, T. 12 S., R. 5 E. Depth, 140 feet; perforated, 78 to 140 feet; 13-inch casing. Discharge, 850 gallons per minute. Acreage served, 22.
6142	27-12S-5E-a	333-5	Hollister city water. Location corresponds to SE¼, sec. 27, T. 12 S., R. 5 E. Depth, 930 feet; all strata below 222 feet. Discharge, 950 feet per minute.
12252			Resample.
9076	28-12S-5E	432-4	California Lands, Inc. R. E. Cole well. Location corresponds to SE¼, sec. 28, T. 12 S., R. 5 E. Depth, 168 feet; upper perforations, 40 feet; 14-inch casing. Discharge, 350 gallons per minute. Static level, 75 feet; draws down to 125 feet. Domestic and irrigation. Acreage served, 35.
9296	28-12S-5E-a	332-4	Bryan W. Jensen. Location corresponds to SE¼, sec. 28, T. 12 S., R. 5 E. Depth, 210 feet; upper perforations, 80 feet; 10-inch casing. Discharge, 650 gallons per minute. Static level, 70 feet. Draws down to 150 feet. Irrigation and domestic. Acreage served, 65.
9001	29-12S-5E	534-4	John G. Matulich. Location corresponds to NE¼, sec. 29, T. 12 S., R. 5 E. Depth, 350 feet; 12-inch casing. Discharge, 300 gallons per minute. Static level, 95 feet; draws down to 115 feet. Strata: 1st, 60 feet; 2d, 177 feet; 3d, 295 feet. Well run 3 days and nights before sampling. Acreage served, 14.
11096			Resample. Depth, 270 feet. Static level, 80 feet. Well has been plugged at bottom since previous sampling.
10781	31-12S-5E	332-3	W. T. Freitas. Location corresponds to NW¼, sec. 31, T. 12 S., R. 5 E. Depth, 178 feet; 13-inch casing. Discharge, 800 gallons per minute. Static level, 45 feet; draws down to 65 feet. Acreage served, 200.
10303	33-12S-5E	444-2	Wm. Arnold. Location corresponds to NW¼, sec. 33, T. 12 S., R. 5 E. Depth, 88 feet; 12-inch casing. Discharge, 300 gallons per minute. Static level, 55 feet; draws down to 67 feet. Sulfide odor; no gas; clear. Acreage served, 12.
4920	34-12S-5E	223-	Hollister city water. Drawn from tap in city.
8456	35-12S-5E	333-4	B. R. Loofburrow. Location corresponds to SE¼, sec. 35, T. 12 S., R. 5 E. Depth, 207 feet; 6-inch casing. Discharge, 250 gallons per minute. Temperature, 69° F. Acreage served, 30.
9207	35-12S-5E-a	332-4	James Sheriffs. Enterprise pumping plant. Location corresponds to NE¼, sec. 35, T. 12 S., R. 5 E. Depth, 213 feet; 13 inch casing. Discharge, 700 gallons per minute. Static level, 132 feet; draws down to 142 feet. Acreage served, 132.
9867	35-12S-5E-b	333-4	Frank Basuni. Location corresponds to NW¼, sec. 35, T. 12 S., R. 5 E. Depth, 337 feet; upper perforations, 150 feet; 10-inch casing. Discharge, 300 gallons per minute. Static level, 100 feet; draws down to 106 feet. Acreage served, 11.
7406	35-12S-5E-c	432-4	E. H. Overstreet. Location corresponds to NW¼, sec. 35, T. 12 S., R. 5 E. Depth, 250 feet. Discharge, 300 gallons, per minute.

TABLE 11.—*Descriptions of wells sampled in Hollister area*—Continued

Laboratory No.	Location	Symbol	Description
4908	36-12S-5E	333-4	C. Corrolo. Location corresponds to SW¼, sec. 36, T. 12 S., R. 5 E. Depth, 305 feet. Discharge, 250 gallons per minute. Acreage served, 28.
4909	36-12S-5E-a	333-4	H. Sevenman. Location corresponds to SW¼, sec. 36, T. 12 S., R. 5 E. Depth, 212 feet; 12-inch casing. Discharge, 400 gallons per minute. Acreage served, 65.
4910	36-12S-5E-b	333-4	F. Trowbridge. Location corresponds to SW¼, sec. 36, T. 12 S., R. 5 E. Depth, 205 feet. Discharge, 250 gallons per minute. Acreage served, 10.
5043	36-12S-5E-c	333-4	P. Gospodnetich. Location corresponds to NW¼, sec. 36, T. 12 S., R. 5 E. Depth, 230 feet. Discharge, 100 gallons per minute. Acreage served, 20.
8079	36-12S-5E-d	33X-4	Jim Sugioka. NE¼, sec. 36, T. 12 S., R. 5 E. Depth, 353 feet. Static level, 90 feet; draws down to 138 feet. Discharge, 400 gallons per minute.
8439	36-12S-5E-e	345-5	Cecil Smith. E½, SE¼, sec. 36, T. 12 S., R. 5 E. Depth, 555 feet; perforated, 240 to 520 feet; 12-inch casing. Discharge, 200 gallons per minute. Static level, 113 feet; draws down to 200 feet. Sulfide odor; contains gas. Water is warm and comes out of blue sand.
8505	36-12S-5E-f	33X-3	Simunovich Bros. Domestic well. NE¼, NE¼, sec. 36, T. 12S., R. 5 E. Depth 185 feet; 10-inch casing. Windmill pump. Static level, 120 feet.
9152	36-12S-5E-g	334-5	J. Simunovich. New well. NE¼, NE¼, sec. 36, T. 12 S., R. 5 E. Depth, 400 feet; upper perforations, 260 feet; 12-inch casing. Discharge, 250 gallons per minute. Static level, 120 feet; draws down to 200 feet. Acreage served, 20.
6410	6-12S-6E	332-4	Fred Ames. Location corresponds to NW¼, sec. 6, T. 12 S., R. 6 E. Depth, 200 feet; 12-inch casing. Discharge, 310 gallons per minute. Draws down to 98 feet. Temperature, 61° F. Acreage served, 32.
4918	6-12S-6E-a	333-4	R. C. MacLachlan. Location corresponds to SW¼, sec. 6, T. 12 S., R. 6 E. Depth, 310 feet; 10-inch casing. Discharge, 250 gallons per minute. Acreage served, 25.
9040	6-12S-6E-b	343-3	Robert Grant. Location corresponds to NE¼, sec. 6, T. 12 S., R. 6 E. Depth, 190 feet; perforated, 120-165 feet; 12-inch casing. Discharge, 300 gallons per minute. Static level, 118 feet; draws down to 120 feet. Acreage served, 100.
12244			Resample. Static level, 55 feet; draws down to 58 feet.
5124	6-12S-6E-c	244-3	E. Robbs. Location corresponds to SW¼, sec. 6, T. 12 S., R. 6 E. Depth, 120 feet; upper perforations, 100 feet. Discharge, 300 gallons per minute. Acreage served, 22.
5122	7-12S-6E	212-4	Jeff Dooling. Location corresponds to SW¼, sec. 7, T. 12 S., R. 6 E. Depth, 333 feet. Discharge, 350 gallons per minute. Acreage served, 40.
5123	7-12S-6E-a	212-3	Ogden Bros. Location corresponds to SW¼, sec. 7, T. 12 S., R. 6 E. Depth, 120 feet. Discharge, 500 gallons per minute. Acreage served, 30.
6845	7-12S-6E-b	333-3	Ralph W. Jones. Location corresponds to NE¼, sec. 7, T. 12 S., R. 6 E. Depth, 160 feet; upper perforations, 90 feet; 12-inch casing. Discharge, 350 gallons per minute. Static level, 30 feet; draws down to 75 feet. Acreage served, 40.
9086	7-12S-6E-c	234-3	E. C. Oberholtzer. Location corresponds to NW¼, sec. 7, T. 12 S., R. 6 E. Depth, 172 feet; upper perforations, 158 feet; 12-inch casing. Discharge, 250 gallons per minute. Static level, 30 feet; draws down to 100 feet. No odor; gas present; off-color. Acreage served, 35.
6678	7-12S-6E-d	35X-5	Dan Regan. Location corresponds to NW¼, sec. 7, T. 12 S., R. 6 E. Depth, 460 feet; 13-inch casing. Discharge, 650 gallons per minute. Acreage served, 100.
10260	7-12S-6E-e	343-4	Elton L. Jones. Location corresponds to NE¼, sec. 7, T. 12 S., R. 6 E. Depth, 200 feet; upper perforations, 173 feet; 10-inch casing. Discharge, 200 gallons per minute. Static level 100 feet. Sulfide odor; no gas; clear. Domestic and irrigation. Acreage served, 10.
6286	10-12S-6E	212-S	W. P. Flint spring. Location corresponds to NW¼, sec. 10, T. 12 S., R. 6 E. Spring in mountain district. Discharge, 10 gallons per minute. In drainage basin of Dos Picachos Creek.
4919	18-12S-6E	364-3	M. E. Shippy. Location corresponds to SW¼, sec. 18, T. 12 S., R. 6 E. Depth, 155 feet; 13-inch casing. Discharge, 150 gallons per minute. Acreage served, 33.
6200	18-12S-6E-a	353-	P. Borovich. Location corresponds to SW¼, sec. 18, T. 12 S., R. 6 E. Acreage served, 9.
6283	18-12S-6E-b	212-2	Geo. A. Jarvis. Location corresponds to NE¼, sec. 18, T. 12 S., R. 6 E. Depth, 90 feet; upper perforations, 55 feet; 10-inch casing. Discharge, 50 gallons per minute. Static level, 45 to 50 feet. Temperature, 65° F. Acreage served, 20.
6284	18-12S-6E-c	212-3	A. M. Jarvis. Location corresponds to SE¼, sec. 18, T. 12 S., R. 6 E. Depth, 125 feet; upper perforations, 45 feet; 10-inch casing. Discharge, 25 gallons per minute. Static level, 45 to 50 feet. Acreage served, 20.

TABLE 11.—*Descriptions of wells sampled in Hollister area*—Continued

Laboratory No.	Location	Symbol	Description
9072	18-12S-6E-d	232-4	Antone Arnerich. Location corresponds to SW¼, sec. 18, T. 12 S., R. 6 E. Depth, 200 feet; upper perforations, 80 feet; 12-inch casing. Discharge, 300 gallons per minute. Static level, 52 feet; draws down to 86 feet. Domestic and irrigation. Acreage served, 10.
9941	18-12S-6E-e	25X-3	P. Gospodnetich. Well No. 2. Location corresponds to SW¼, sec. 18, T. 12 S., R. 6 E. 100 yards northwest of Well No. 1 (No. 9940). Depth, 130 feet; upper perforations, 50 feet; 13-inch casing. Discharge, 250 gallons per minute. Static level, 60 feet; draws down to 75 feet. Acreage served, 20.
9940	18-12S-6E-f	25X-3	P. Gospodnetich. Well No. 1. Location corresponds to SW¼, sec. 18, T. 12 S., R. 6 E. 100 yards southeast of Well No. 2 (No. 9941). Depth, 142 feet; upper perforations, 60 feet; draws down to 67 feet; 13-inch casing. Discharge, 300 gallons per minute. Static level, 55 feet. Sulfide odor; no gas; clear. Acreage served, 20.
9188	18-12S-6E-g	322-2	Frank Bozzo. Location corresponds to NW¼, sec. 18, T. 12 S., R. 6 E. Depth, 92 feet; upper perforations, 80 feet; 13-inch casing. Discharge, 250 gallons per minute. Static level, 43 feet; draws down to 56 feet. Acreage served, 22.
5044	19-12S-6E	232-4	George Stickler. Location corresponds to NE¼, sec. 19, T. 12 S., R. 6 E. Depth, 250 feet; perforated, 90 feet, 95 feet, 225 feet, 238 feet. Discharge, 400 gallons per minute. This sample taken after pump had been running about 5 minutes. Acreage served, 32.
6147			Resample. Sample taken after pump had been running for about 3 hours.
6195	19-12S-6E-a	35X-	J. L. Haller. E½, SE¼, sec. 19, T. 12 S., R. 6 E. This is an old well which is partly sanded up. Acreage served, 40.
6413	19-12S-6E-b	354-4	W. E. Dermody. Location corresponds to NW¼, sec. 19, T. 12 S., R. 6 E. Depth, 300 feet; upper perforations, 80 feet. Discharge, 400 gallons per minute. Temperature, 70° F. Acreage served, 30.
6414	19-12S-6E-c	232-3	J. E. Dermody. Location corresponds to NE¼, sec. 19, T. 12 S., R. 6 E. Depth, 150 feet; upper perforations, 80 feet. Discharge, 150 gallons per minute. Temperature, 68° F. Acreage served, 10.
8632			Resample. Sampled after well had been running 4 weeks. Draws down to 90 feet.
6415	19-12S-6E-d	222-3	Geo. Gadd. Location corresponds to NE¼, sec. 19, T. 12 S., R. 6 E. Depth, 113 feet; upper perforations, 60 feet. Discharge, 200 gallons per minute. Acreage served, 35.
9074			Resample. Described as follows: California Lands, Inc., E. E. Gadd well. Depth, 110 feet; upper perforations, 50 feet; 14-inch casing. Discharge, 200 gallons per minute. Static level, 50 feet; draws down to 85 feet. Domestic and irrigation. Acreage served, 23.
6675	19-12S-6E-e	354-5	F. Parker. E½, SE¼, sec. 19, T. 12 S., R. 6 E. Depth, 400 feet.
7269	19-12S-6E-f	454-3	Chas. Spadfore. SW¼,SW¼, sec. 19, T. 12 S., R. 6 E. Depth, 190 feet; upper perforations, 60 feet; 12-inch casing. Discharge, 200 gallons per minute. Static level, 90 feet; draws down to 120 feet. Slight sulfide odor; no gas. Temperature, 68° F. Acreage served, 100.
7545			Resample. Taken after 6 weeks of use.
7419	19-12S-6E-g	34X-	J. L. Haller. SE¼,SE¼, sec. 19, T. 12 S., R. 6 E. Depth, 60 feet. New well being drilled.
8070	19-12S-6E-h	34X-2	J. L. Haller. SE¼,SE¼, sec. 19, T. 12 S., R. 6 E. About 500 feet north of No. 7419. Dug well, about 65 feet deep; water from 59- to 65-foot level. Discharge, 60 gallons per minute.
8406	19-12S-6E-i	454-3	J. J. Cardoza. SW¼,SW¼, sec. 19, T. 12 S., R. 6 E. Sanded in to a depth of 143 feet; static level, 90 feet. Discharge, 10 gallons per minute. Abandoned except for a small pump that has been installed in place of the former large one.
8503	19-12S-6E-j	21X-3	Geo. Stickler. Location corresponds to NE¼, sec. 19, T. 12 S., R. 6 E. Depth, 120 feet; upper perforations, 60 feet; 10-inch casing. Discharge, 60 gallons per minute. Static level, 60 feet; draws down to 108 feet. Acreage served, 28.
8732	19-12S-6E-k	35X-3	Joe Marcella. Location corresponds to NW¼, sec. 19, T. 12 S., R. 6 E. Depth, 170 feet; upper perforations, 80 feet; 10-inch casing.
9767	19-12S-6E-l	353-3	Mrs. F. Maxwell. Domestic well. NW¼,SW¼, sec. 19, T. 12 S., R. 6 E. Depth, 100 feet; 13-inch casing. Discharge, 33 gallons per minute.
9808	19-12S-6E-m	353-5	H. L. Wilkinson. Location corresponds to NW¼, sec. 19, T. 12 S., R. 6 E. Depth, 500 feet; 14-inch casing. Static level, 65 feet. Some sulfide odor and gas. Acreage served, 20.
12195			Resample. Discharge, 150 gallons per minute.

TABLE 11.—*Descriptions of wells sampled in Hollister area*—Continued

Laboratory No.	Location	Symbol	Description
6668	30-12S-6E	453-5	C. H. Moran. Near center, SW¼, sec. 30, T. 12 S., R. 6 E. Depth, 400 feet; upper perforations, 246 feet; 12-inch casing. Discharge, 225 gallons per minute. Static level, 90 feet. Slight sulfide odor; no gas; no color. Water, warm. Acreage served, 50.
7270	30-12S-6E-a	454-3	Chas. Spadfore. NW¼,NW¼, sec. 30, T. 12 S., R. 6 E. Depth, 190 feet; upper perforations, 80 feet; 14-inch casing. Discharge, 35 gallons per minute. Static level, 100 feet. Temperature, 70° F. Domestic.
7307	30-12S-6E-b	454-4	Sam Matulich and Fred Paulus. NW¼,SW¼, sec. 30, T. 12 S., R. 6 E. Depth, 370 feet; upper perforations, 150 feet; 10-inch casing. Discharge, 300 gallons per minute. Static level, 124 feet. Acreage served, 65.
7410			Resample. Well cleaned out to 270 feet; static level, 100 feet; draws down to 200 feet.
8552	30-12S-6E-c	45X-4	John Guidinger. NE¼, SW¼, sec. 30, T. 12 S., R. 6 E. Depth, 210 feet; 10-inch casing. Discharge, 100 gallons per minute. Domestic.
8967	30-12S-6E-d	444-4	John Guidinger, Jr. NE¼, SW¼, sec. 30, T. 12 S., R. 6 E. Adjacent to No. 8552. Depth, 200 feet; 10-inch casing. Discharge, 12 gallons per minute. Static level, 100 feet. Domestic and irrigation. Acreage served, 15.
9249	30-12S-6E-e	445-4	Joe Lozaneo. SW¼,SW¼, sec. 30, T. 12 S., R. 6 E. Depth, 350 feet; upper perforations, 180 feet; 10-inch casing. Discharge, 50 gallons per minute. Static level, 135 feet; draws down to 170 feet. Irrigation and domestic. Acreage served, 15.
8564	30-12S-6E-f	44X-4	R. Farr. SW¼,SE¼, sec. 30, T. 12 S., R. 6 E. Depth, 370 feet; 10-inch casing. Discharge, 100 gallons per minute. Static level, 74 feet. Sulfide odor; no gas; clear. Well run 3 days before taking sample. Acreage served, 9.
4917	34-12S-6E	222-	Samarkand ranch. Location corresponds to NW¼, sec. 34, T. 12 S., R. 6 E. Acreage served, 132.
6279	34-12S-6E-a	222-3	Carl Sperber. Location corresponds to NW¼, sec. 34, T. 12 S., R. 6 E. Depth, 130 feet; 12-inch casing. Discharge, 300 gallons per minute. Static level, 30 feet; draws down to 75 feet. Temperature, 72° F.
10647	2-13S-4E	323-5	Ferry-Morse Seed Co. Location corresponds to NW¼, sec. 2, T. 13 S., R. 4 E. Depth, 450 feet; upper perforations, 90 feet; 14-inch casing. Discharge, 1,200 gallons per minute. Static level, 51 feet; draws down to 80 feet. Water muddy. Acreage served, 450. Run 48 hours before sampling.
10784	4-13S-4E	312-2	Mrs. Louis Pecatti. NE¼, sec. 4, T. 13 S., R. 4 E. Depth, 80 feet; 6-inch casing; 30-foot pit. Discharge, 100 gallons per minute. Domestic and irrigation. Acreage served, 5.
9085	1-13S-5E	343-4	Harry M. Daggett. Location corresponds to SW¼, sec. 1, T. 13 S., R. 5 E. Depth, 276 feet; 12-inch casing. Discharge, 200 gallons per minute. Static level, 120 feet; draws down to 180 feet. Water coming from 260-foot gravel.
4907	2-13S-5E	331-	F. L. Barnhisel. Location corresponds to SE¼, sec. 2, T. 13 S. R. 5 E. Acreage served, 43.
8504	2-13S-5E-a	332-3	F. L. Barnhisel. Location corresponds to SE¼, sec. 2, T. 13 S., R. 5 E. Depth, 125 feet; upper perforations, 51 feet; 13-inch casing. Discharge, 600 gallons per minute. Static level, 72 feet; draws down to 82 feet. Acreage served, 142.
8540	2-13S-5E-b	332-4	Carl L. Ladd. Location corresponds to SW¼, sec. 2, T. 13 S., R. 5 E. Depth, 254 feet; upper perforations, 85 feet; 12-inch casing. Discharge, 600 gallons per minute. Static level, 75 feet; draws down to 85 feet. Acreage served, 150.
5042	3-13S-5E	332-3	Otto Schultz. Location corresponds to SW¼, sec. 3, T. 13 S., R. 5 E. 135 feet of 13-inch casing; perforations all at bottom. Discharge, 600 gallons per minute.
10775	3-13S-5E-a	333-3	Luigi Pressenda. Location corresponds to SE¼, sec. 3, T. 13 S., R. 5 E. Depth, 120 feet. Discharge, 400 gallons per minute. Acreage served, 40.
10780	3-13S-5E-b	333-3	H. J. Schultz. Location corresponds to SW¼, sec. 3, T. 13 S., R. 5 E. Depth, 160 feet; 12-inch casing. Discharge, 500 gallons per minute. Static level, 70 feet. Acreage served, 100.
10779	10-13S-5E	333-3	Tranberg & Johnson. Location corresponds to NE¼, sec. 10, T. 13 S., R. 5 E. Depth, 150 feet; upper perforations, 100 feet; 14-inch casing. Discharge, 500 gallons per minute. Static level, 112 feet; draws down to 119 feet. Acreage served, 60.
4840	11-13S-5E-a	331-	W. O. Mathews. Location corresponds to SE¼, sec. 11, T. 13 S., R. 5 E. Domestic and irrigation. Acreage served, 18.
10777	11-13S-5E-b	333-4	Cowden Ranch Co. Location corresponds to SW¼, sec. 11, T. 13 S., R. 5 E. Depth, 200 feet; 14-inch casing. Discharge, 300 gallons per minute. Static level, 50 feet; no draw-down. Acreage served, 60. A water stratum at 150 feet.
10778	11-13S-5E-c	333-4	Mrs. Grace Kay. Location corresponds to SW¼, sec. 11, T. 13 S., R. 5 E. Depth, 225 feet; 12-inch casing. Discharge, 300 gallons per minute. Static level, 90 feet; very little draw-down. Sulfide odor; very little gas; clear. Acreage served, 90.

TABLE 11.—*Descriptions of wells sampled in Hollister area*—Continued

Laboratory No.	Location	Symbol	Description
4906	13-13S-5E	332-3	Claude Sharp. Near center E½,SE¼, sec. 13, T. 13 S., R. 5 E Depth, probably 142 feet; casing perforated at strata below 72 feet. Discharge, 56 gallons per minute. Acreage served, 22
9561	27-13S-5E	332-1	Cassie Crow, ground water. Location corresponds to SW¼, sec. 27, T. 13 S., R. 5. E. At point where Bird Creek emerges from canyon and crosses road above Vineyard School. Depth, 8 feet. Water stands at depth of 3 to 10 feet, and this sample was taken from a dug hole in the ground.
9570	27-13S-5E-a	322-1	Cassie Crow, ground water. Location corresponds to SW¼, sec. 27, T. 13 S., R. 5 E. At a point where Bird Creek emerges from canyon and crosses road above Vineyard School. Depth, 30 feet; upper perforations, 25 to 30 feet; 12-inch casing. Static level, 4 feet; draws down to 16 feet. Domestic and emergency irrigation.
10414	5-13S-6E	554-S	Ladd spring, near Santa Ana Creek. NW¼, NW¼, sec. 5, T. 13 S., R. 6 E. Used for stock. Discharge, 5 gallons per minute.
7370	7-13S-6E	555-4	E. J. Anderson. NE¼, SW¼, sec. 7, T. 13 S., R. 6 E. Depth, 260 feet. Water becomes warm after a few minutes pumping. No longer used for irrigation.
10497	7-13S-6E-a	444-3	J. E. Annand well. N½,NE¼, sec. 7, T. 13 S., R. 6 E. Depth, 150 feet; 13-inch casing. Discharge, 50 gallons per minute. Static level, 75 feet. Irrigation and domestic.
5121	20-13S-6E	443-2	Julius Jessen. NE¼, sec. 20, T. 13 S., R. 6 E. Depth, 65 feet. Discharge, 150 gallons per minute. Acreage served, 10.
7774	21-13S-6E	332-3	W. E. Parker, Jr. SW¼, sec. 21, T. 13 S., R. 6 E. Depth, 160 feet. Discharge, 300 gallons per minute.
4835	11-14S-6E	332-2	Paicinesorchards. George Sykes, owner. Location corresponds to SE¼, sec. 11, T. 14 S., R. 6 E. Depth, 90 feet.
7368	12-14S-6E	332-4	Hotel orchard well. George Sykes, owner. SW¼, sec. 12, T. 14 S., R. 6 E. Depth, 375 feet; upper perforations, 37 feet; 20-inch casing. Discharge 1,450 gallons per minute. Static level, 37 feet; drawn down to 90 feet. Temperature, 57° F. Acreage served, 210.
7369	35-14S-6E	432-5	Cunaan orchard pump. Geo. Sykes, owner. NE¼, sec. 35, T. 14 S., R. 6 E. Depth, 553 feet; 20-inch casing. Discharge, 3,500 gallons per minute. Static level, 34 feet; draws down to 54 feet. Temperature, 46.5° F. Acreage served, 350.
7896	1-15S-7E	342-1	R. L. Matthews. Near center sec. 1, T. 15 S., R. 7 E. Dug well 35 feet deep.
4834	7-15S-9E	343-3	Antelope patrol station P. G. E. N. center sec. 7, T. 15 S., R. 9 E. Depth, 180 feet—dry hole 30 feet. Windmill pump.
12144	7-15S-9E	333-2	Earle C. Fancher ranch. NE¼, sec. 7, T. 15 S., R. 9 E. Depth, 85 feet; static level, 20 feet. Discharge, about 2 gallons per minute from windmill. Domestic, livestock, and small amount of irrigation.

DISCUSSION OF BORON CONCENTRATIONS

The occurrence of concentrations of boron in excess of 1.5 p. p. m. in the ground waters underlying the Hollister area is for the most part limited to a strip of land in the eastern portion of the valley. This band extends northward from the mouth of Santa Ana Creek for a distance of about 6 miles, ending near Ausaymas School, which is approximately midway between the mouth of Arroyo de Las Viboras and the right-hand bend in Pacheco Creek. This area in which especially high concentrations of boron have been found is of irregular shape, varying in width from a few hundred feet to a mile or more. The area can be followed in figure 2 on the basis of the middle figure of the water-quality trinomial, concentrations of boron in excess of 1.5 and 3 p. p. m. being designated by the numerals 4 and 5, respectively.

Four wells were sampled near the mouth of Arroyo Dos Picachos, east and north of Fairview School, which contained, like the creek itself, less than 0.25 p. p. m. of boron. Two wells produced waters with between 0.25 and 0.75 p. p. m.; otherwise all of the wells sampled east of the high-boron band produced waters with from 0.75 to 3.0

p. p. m. of boron. Immediately west of the high-boron band there are a few wells that contained between 1.50 and 3.0 p. p. m. of boron, but generally concentrations below 1.5 p. p. m. are represented.

Wells in the northeast portion of the area in the vicinity of Pacheco Creek, with three exceptions, produced waters with boron concentrations between 0.25 and 0.75 p. p. m.

South and westward from Hollister along the San Benito River, in the immediate vicinity of Hollister and northwestward toward and in the Bolsa, the ground waters, with very few exceptions, contained between 0.75 and 1.50 p. p. m. of boron, the former concentration being approached more frequently than the latter. This range of concentrations is represented by numeral 3 as the middle figure of the trinomial.

A well in the upper delta of San Juan Creek, like water from the creek itself, carried less than 0.25 p. p. m. of boron.

Ladd's spring, which discharges in the bed of Santa Ana Creek, contained 5.12 p. p. m. of boron in December 1935, and the creek itself during a period of storm run-off in February 1938 had 0.46 p. p. m. These waters were also relatively high in chloride.

A sample collected from a well at location 19–12S–6E after the well had operated for 5 minutes contained 0.96 p. p. m. of boron. Several months later when the well was resampled after 6 hours' pumping 15.9 p. p. m. of boron were found. This well was 250 feet in depth. A nearby well drilled to a depth of 120 feet on the bank of an arroyo, 19–12S–6E–j, contained 0.18 p. p. m. of boron. These and other observations have indicated that the water in the upper strata is extensively replenished by storm run-off. A further comparison of the quality of ground waters encountered at the successive depths in the Fairview School area during drilling is afforded by the samples collected from the well at location 13–12S–5E–1, where it was found that the upper strata yielded water with less boron than did the lower strata. Where the hydrostatic pressures existing in deep high-boron strata have exceeded those in overlying aquifers, an extensive movement of water from one to the other through casing perforations has sometimes been indicated.

Discussion of Chloride Concentrations

The ground waters adjacent to the San Benito River and those underlying the portion of the valley that extends northwestward from the river through Hollister were found to have chloride concentrations ranging from slightly more than 2 m. e. to less than 4. In fact, approximately one-half of all the waters sampled in the area as a whole fall in this range. Only rarely can significant chloride injury be expected to result from such waters when used on well-drained recent alluvial soils under rainfall conditions such as prevail in the Hollister area. Approximately one-quarter of all of the waters sampled contained less than 2 m. e. of chloride; 20 percent of the waters of the area contained from 4 to 10 m. e. of chloride; and 7 percent in excess of 10 m. e. Nearly all of the high-boron well waters along the east side of the valley were also high in chloride. Few wells with more than 2 p. p. m. of boron contained less than 4 m. e. of chloride. Some other wells in this locality that had little boron carried substantial concentrations of chloride. It is worthy of special mention that the

Figure 3

Located at end of

document.

wells in section 30, T. 12 S., R. 6 E., near the mouth of Santa Ana Creek, all contained between 5.74 and 15.30 m. e. of chloride, and high chloride concentrations were sometimes found in the two sections, 18 and 19, to the north. Santa Ana Creek as sampled during heavy run-off carried 0.90 m. e. of chloride, which is higher than the concentrations found in the other streams during flood periods. Ladd's spring on Santa Ana Creek contained 17.42 m. e. of chloride.

Several of the nine wells sampled in sections 6 and 7 between Dos Picachos and Las Viboras Creeks carried less than 1 m. e. of chloride and only one had more than 2.11 m. e. This latter was a deep well with 4.40 m. e. of chloride and 7.58 p. p. m. of boron.

There has been considerable conjecture as to the source of the boron and chloride in the waters of a group of wells in section 36, T. 11 S., R. 5 E., between Pacheco and Las Viboras Creeks. During the drilling of the well at location e in this section a sample with 0.94 p. p. m. of boron and 3.55 m. e. chloride was bailed when the depth was 180 feet; at 275 feet a pumped sample contained 3.32 p. p. m. of boron and 10.15 m. e. of chloride. The logs of this well and of the well d, about 100 feet away, were dissimilar, indicating abrupt changes in formation probably associated with earth movements. The waters from the wells at a and e are notably similar.

Discussion of Sulfate Concentrations

There is a marked diversity in the concentrations of sulfate in the ground waters in the various portions of the Hollister area. This fact is brought out by the analyses reported in table 10. The relations in this regard are graphically presented in figure 3 where it may be observed that many waters, particularly some of those along the east side of the valley, are notably low in sulfate. For the valley as a whole, 41 percent of the wells sampled showed sulfate concentrations below 1 m. e. per liter, 27 percent had between 1 and 4 m. e., 28 percent between 4 and 8 m. e., and 4 percent between 8 and 12 m. e. There were none with more than 12 m. e. It is clear from these findings that only exceptionally can sulfate be regarded as a dominant toxic constituent in the ground waters of the Hollister area. In this respect these coastal mountain ground waters are demarked from those on the opposite side of the Diablo Range in the San Joaquin Valley (*5*).

SOURCE OF GROUND WATERS AND ORIGIN OF BORON

Substantial evidence on the sources of the ground water in the several sections of the Hollister area is afforded by the chemical analyses. Most indicative in this regard are the sulfate concentrations taken in conjunction with the sum of the anions—carbonate, bicarbonate, sulfate, chloride, and nitrate. In figure 3 the sum of the anions and the sulfate concentrations, respectively, have been shown by the total height and height of shaded portions of columns at the locations of each of the wells for which complete analyses were made. The concentration of boron is designated by a numeral at the side of each of these columns, and on a similar 1 to 5 scale the depth of the well is designated by a numeral at the base of each column. The depth of a well has a greater significance as a limiting value than as an index to the depth of the most important aquifers which contribute to the discharge.

The ground waters adjacent to San Benito River, those in the vicinity of Hollister, and those northwestward through the floor of the valley possess similar chemical characteristics, and in conformity with geophysical evidence it seems certain that they have a common source. They are distinct from the waters entering the valley from the east but similar to waters of the San Benito River. The direction of movement of ground waters is customarily at right angles to the contour lines representing the elevation of the ground water. It is to be noted that the angle of decline of the water plane is greater from the San Benito River across Hollister and northwestward than it is along the present channel of the stream south and west of Lomerias Muertas (hills). The boron concentrations, total salinity, and the concentrations of constituents, such as chloride and sulfate, tend to be similarly related in the waters of San Benito River and the ground waters in this portion of the valley. The boron concentrations not only tend to confirm the preceding conclusion as to the source of the ground waters but they provide important evidence that the deep alluvial material in this section of the valley also originated in the San Benito-Tres Pinos watershed. Boron is extensively fixed by soil and fine-textured alluvial materials, and, because of the equilibrium effects, to be discussed in the section on the behavior of boron in soil (p. 45), important changes in the boron concentrations of slowly moving or stagnant ground waters take place only slowly.

The ground waters in the vicinity of Pacheco Creek and along the east side of the valley are variable as regards the sum of anions, but they are similar to one another and to the waters of Pacheco, Las Viboras, Dos Picachos, and Santa Ana Creeks in that the sulfate concentrations are generally, though not always, low. This fact as well as the elevation and slope of the water plane support the idea of origin and recharge from the streams mentioned. The boron concentrations in some of the wells near Pacheco Creek north of Ausaymas School and under the strip of land extending southeastward toward the mouth of Santa Ana Creek necessitate the view that these waters, if of the same origin as those on either side, have accumulated boron after entering the ground.

Lacustrine conditions have undoubtedly existed at various times during the building up of the valley floor, and there is evidence that the area has been occupied one or more times by an arm of the sea. The fine sediments now present on the surface of much of the northwest portion of the valley floor are an indication that San Felipe Lake at one time occupied much of the Bolsa. Should a body of water evaporate, perhaps after isolation as by changes in stream courses, salines would crystallize out. Some of the boron compounds, particularly the silicates, are only slightly soluble, and extensive fixation of boron by lake-bed sediments would occur. Under subsequent conditions of water movement through lake-bed materials, either while on the surface or after having been buried by later deposits, the more soluble salt constituents such as chloride and sulfate would be leached away. But boron fixed in forms of low solubility would remain much longer to gradually come into solution in the waters with which these materials were in contact. In many situations an explanation such as this probably accounts for the boron contamination of ground waters. Another explanation, to be discussed in the next section, for the occurrence of boron in the comparatively narrow and irregular strip of land across the east side of the valley seems more probable.

Chemical Evidence of an Uncharted Fault Zone

A number of characteristics of this high-boron area point to the existence of a previously uncharted fault zone (*11, 14*) extending in a northwesterly direction through the sharp bend in Santa Ana Creek near Ladd's spring, past Fairview School, and slightly east of Ausaymas School, to the eastern escarpment of the hills lying to the west of the little valley through which Pacheco Creek enters the Hollister Valley. On the basis of the chemical analyses of the ground waters this fault is probably not represented by a single line of fracture but rather by a zone cross-fractured at places for a mile or more in width.

The waters of hot springs, like the warm or hot waters obtained from wells, are in some cases brought into the upper horizons of the earth from great depths. More commonly, however, they are waters that are heated by hot gaseous emanations which find an outlet through the fissures resulting from earth movements. Volcanic vapors may contain steam, sulfur, ammonium salts, chloride, and fluorides as well as boron compounds. The waters of hot springs sometimes contain low concentrations of boron, but typically they are in excess of 1 p. p. m. and in some instances more than 100 p. p. m. have been found. There is similarly a tendency toward high concentrations of boron in hot or warm waters from wells, since the cause of such occurrence is not different from that in springs.

The association of high temperature with boron concentrations regarded as high from the standpoint of effects on plants is not an essential one. This is so since the activity that once caused the emissions from fumaroles or other deep-seated openings from the lower earth may have long since died away. By reason of large quantities of boron having been injected into and fixed by alluvial or other materials through which vapors or waters passed, conditions such as those outlined in the discussion of lacustrine deposits may have been created. Boron from any source that is fixed by alluvial material is subject to dissolution in the waters that later come in contact with it.

Ladd's spring, which is cold, produces a water containing 5.12 p. p. m. of boron, and in this locality or elsewhere along its course Santa Ana Creek picks up enough boron to produce higher concentrations (0.46 p. p. m.) than the others of the east-side streams during similar heavy run-off. A well on the former Luther property near Fairview School produced a warm water with sulfide odor, but this well, the water of which was observed to be deleterious to crops, was filled in before boron had been shown to be one of the causes of failure of irrigated lands in the Southwest. A later well drilled a few hundred yards away on the same property produced a cool water containing in one sample 18.2 p. p. m. of boron.

The fact that waters high in boron were found in a group of wells northeast of Ausaymas School near Pacheco Creek has heretofore been difficult to explain. These wells, however, are seen to lie (fig. 3) in the same northwest-southeast band as the high-boron wells to the south.

Evidence of a southeasterly extension of this fault is afforded by the finding that about 1 mile south of the bend in Santa Ana Creek there is a 150-foot well (7–13S–6E–a) which produces water containing 2.70 p. p. m. of boron. This well lies about 1,000 feet west of the center of the fault zone as projected. Farther to the south in the same section there is a 260-foot well on the Anderson property which produces hot water with 5.99 p. p. m. of boron. This latter well is about a half mile west of the fault. The several analyses of ground waters in Santa Ana Valley east of Ladd's spring have shown boron concentrations below 1 p. p. m.

The fault zone here projected on the basis of chemical analyses of ground waters parallels the Hayward fault, which crosses the valley just east of Hollister passing through the San Felipe Lake depression. The fact that irregularities occur in boron concentrations in the well waters through this faulted zone is to be expected rather than otherwise. Differences in proximity to a source of present or past activity, in the extent of the activity, in the communicating aquifers, and in water movement, as well as in the relative yield of water from high- and low-boron aquifers, are all involved. It has been previously noted (p. 38) that in this section water encountered in the upper water-bearing strata commonly contained less boron than that from deeper strata. The fact that the deep aquifers contain more boron than those near the surface might indicate either that the friable alluvial formations overlying vents of fissures impeded the upward movement of boron-carrying waters and gases or that the upper sediments have been deposited since the time of the earth movements. An obstacle to the latter conclusion is the fact that abrupt discontinuities were observed in the gravels and sediments in the logs of two adjacent wells in the high-boron area.

Lowering of water levels as a result of pumping to meet the demands of the recent irrigation development must result in an increased water movement. Whether there will be a tendency for the area of boron contamination to extend itself westward cannot be anticipated. It would seem, nevertheless, that such extension would probably be slow and that water movement might be most rapid in the upper strata which in some instances have proved to be low in boron.

A movement of the deeper high-boron waters upward through well casings and out into the upper aquifers has been demonstrated in one instance. The water in that well, 12–12S–6E, as sampled 180 feet below the surface, was noticeably warm and had a distinct sulfide odor and a boron content of 9.65 p. p. m. As sampled from a stratum at a higher elevation after blocking the casing below the perforations, the water was much cooler, but the boron content was changed but little.

Boron, Chloride, Conductance, Well Depth, and Other Correlations

There are presented in this section the results of examinations of the chemical analyses of ground waters for evidence of interrelations between certain water characteristics and the depths of wells. In presenting tables 12 and 13 it is desirable to point out that each table embraces all wells, irrespective of location, for which the two values correlated were available. Each correlation accordingly is a general one for the area as a whole without regard to the diverse or particular conditions that may have prevailed in one or more sections. More wells are sampled in some portions of the area than in others and the magnitudes of the values are influenced accordingly. The correlations are made on the basis of the ranges in concentrations, percentages, and depths presented in table 9 rather than on the basis of the actual values.

TABLE 12.—*Frequency table between well depths and water characteristics* [1]

Range of depth	Wells with water in boron classes [2] indicated—					
	1	2	3	4	5	Total
	Number	*Number*	*Number*	*Number*	*Number*	*Number*
1		2	1	1		4
2	2	1	3	4	3	13
3	6	9	27	6	11	59
4	1	1	37	12	15	66
5	1	1	6	1	8	17
Total	10	14	74	24	37	159
	Wells with water of conductance classes [2] indicated—					
1			3		1	4
2		3	7	2	1	13
3		19	34	5		58
4		8	44	13	2	67
5		1	13	3		17
Total		31	101	23	4	159
	Wells with water of percent sodium classes [2] indicated—					
1		3	1			4
2		5	5	1		11
3	2	25	18	8		53
4		17	28	13	2	60
5		3	8	2	2	15
Total	2	53	60	24	4	143

[1] Calculated correlation coefficients: Boron $r=0.20\pm0.051$; conductance $r=0.09\pm0.053$; percent sodium $r=0.39\pm0.070$.
[2] For class range, see table 9, p. 23.

TABLE 13.—*Frequency table between conductances and water characteristics* [1]

Range of conductance	Wells with water in boron classes [2] indicated—					
	1	2	3	4	5	Total
	Number	*Number*	*Number*	*Number*	*Number*	*Number*
1						
2	8	11	7	3	6	35
3	2	5	67	17	20	111
4			5	6	12	23
5		1	1		3	5
Total	10	17	80	26	41	174
	Wells with water of percent sodium classes [2] indicated—					
1						
2	2	22	4	3		31
3	2	30	52	11	2	97
4		5	5	11	1	22
5			1	2	1	4
Total	4	57	62	27	4	154
	Wells with water of percent chloride classes [2] indicated—					
1						
2	17	17				34
3	32	42	19			93
4	4	9	5	3		21
5			1	2		3
Total	53	68	25	5		151

[1] Calculated correlation coefficients. Boron $r=0.34\pm0.046$; percent sodium $r=0.45\pm0.043$; percent chloride $r=0.40\pm0.046$.
[2] For class range see table 9, p. 23.

For the area as a whole the coefficient of correlation between the concentration of boron and well depth is $+0.20 \pm .051$ (table 12). A coefficient as high as this is believed to result principally from the fact that the deeper waters in the faulted zone along the east side of the valley tended to be high in boron. There is little evidence of any such relationship in the south and central portions of the area where the waters and alluvium probably originated in the San Benito watershed.

The correlation between total salinity, as measured by conductance, and well depth $(+0.09 \pm .053)$ is positive but low and indicates only that the conditions in this regard for the valley as a whole are diverse.

Little has been said about percent sodium in this bulletin for the reason that few very high sodium percentages have been found, and in most of these cases the irrigation history of the land has been too brief for the development of notable effects on soil permeability. Here as in other areas there is evidence of higher sodium percentages with increasing well depths. The coefficient of correlation is $+0.39 \pm .070$ (table 12). Since there was little relation between depth and conductance it follows that the greater proportion of sodium in the deeper waters is consequent as often to loss of calcium and magnesium by precipitation as carbonate as to increments in the actual quantity of sodium ion.

Between percent sodium and conductance there is a substantial positive correlation of $+0.45 \pm .043$ (table 13). This finding is consequent to important principles of irrigation agriculture. After water is applied to land to support crops the salinity of the soil solution is increased as a result of the water losses by transpiration and evaporation. These more saline soil solutions return to the water plane in deep open alluvial soils, or, in soils with clay-pan or impervious strata, they accumulate in the root zone unless carried away by lateral movement. Chloride and sulfate concentrations are quite regularly found to be higher in soil solutions than in corresponding irrigation waters, but usually there have not been proportionate increases in the concentration of bicarbonate ion. Sometimes bicarbonate concentrations in soil solutions are substantially lower than in the water supply. This fact is attributable to an extensive precipitation of calcium and magnesium carbonates. The subsoil leachates, typically high in salinity as a result of precipitation of calcium and magnesium, have higher proportions of sodium than the water applied to the land. These subsoil leachates return to the water plane, and in all sections of the area, with few exceptions, the ground waters are both more saline and contain greater proportions of sodium than the streams from which the ground waters originate.

As shown by table 13 the chloride percentage, like the sodium percentage, increases with increasing conductance, $r = +0.40 \pm .046$. This finding is in line with the preceding discussions and is associated with the loss of bicarbonate ion from soil solutions. As has been shown in other publications (*6, 12*), increases in the actual and percentage concentrations of sodium and chloride are characteristic of rivers at successive downstream stages where diversions for irrigation and the return of drainage waters are involved.

The extensive precipitation of calcium and magnesium carbonates in irrigated lands is believed by the authors to be conducive to the formation of plow soles and to calcareous hardpan, and for this reason the phenomenon probably has an important bearing on the continued productivity if not the permanence of many irrigation developments.

BORON IN SOILS

Investigations of the behavior of boron in soils (*9*) have pointed to certain conclusions that have a bearing on the reactions of crop plants to boron added to soils by irrigation waters. Some of this work has been based on Hollister soils, and there are presented here additional data bearing directly on the Hollister problem.

One of the most salient findings has been that soils, in common with a number of finely ground materials, are capable of removing substantial quantities of boron from solutions. The removal of boron by soils suspended in boron solutions is never quantitative; but according to the character of the soil and the conditions of the test, fixation may proceed until upwards of 50 percent or more of the boron has been removed from solution. If a boron solution, with for example 1 p. p. m. of boron, is added to the surface of a column of soil, the first percolate to come through may contain less than 0.1 p. p. m. of boron. Upon continuing the percolations, the solutions coming out of the soil column will eventually carry 1 p. p. m. of boron. As many as 20 displacements of the solution held by the soil column may be required before this comes about. More boron is fixed if the percolating solution contains a higher concentration of boron. If after passing successive quantities of a boron solution through a soil the soil is leached with a boron-free solution, all or nearly all of the previously fixed boron will eventually be recovered in the leachate. In other words, boron under these conditions is not permanently fixed by the soil, but instead it is held in a form of low solubility.

It has not been possible to leach soils with distilled water to the point that there was no boron in the percolates. This is so because all soils apparently contain minerals in which boron in some quantity is a constituent, and these minerals yield at least very slowly to the process of dissolution. Under field conditions soils are alternately wetted and dried, and it has been found that drying increases the fixation of boron. Soils that have been treated with boron and then dried and subsequently allowed to stand moist for 30 days gave rise to solution concentrations substantially lower than those found in suspensions allowed to stand for 30 days without drying.

The alkalinity or acidity of a soil influences the solubility of its boron. Soils made slightly acid (pH 6) have been observed to yield from 40 to 100 percent more boron to the solutions in which they are suspended than similar soils made slightly alkaline (pH 8). By these results it is indicated that the addition of an acidifying agent, such as sulfur, to soils will increase boron solubility and thereby hasten reclamation when the lands are leached. Conversely the addition of an alkaline material, such as lime, to land results, temporarily at least, in an increased fixation of boron by the soil, giving rise to lower soil-solution concentration. The growth of a portion of a badly injured apricot orchard treated with lime was observed to be better than in untreated portions. The initial pH value of this soil was about 7. Treatment with lime offers a possible means of lessening field injury, but under low-boron conditions alkaline soils are usually not as productive as soils that are nearly neutral in their reaction.

Soils differ greatly in their boron-fixing power. A series of samples was collected (*9*) in the San Fernando Valley from 29 lemon groves in 1931, and the same groves were resampled at the original locations in 1936. All of these groves had been irrigated from the same water supply since 1916. The water over the period of observation contained an average of 0.65 p. p. m. of boron. The soil solution of some of these soils contained as little as 0.54 p. p. m. of boron, whereas others had as much as 1.80 p. p. m. During the 5-year period the average soil-solution concentration increased from 1.05 to 1.14 p. p. m. Only one soil contained as little boron in its soil solution as was found in the irrigation water of the corresponding year.

Coarse-textured soils, as a group, have lower boron-fixing capacities than fine-textured soils. It is found as a consequence that the onset of boron injury is more rapid on the lighter soils, but these, having fixed less boron, are most easily reclaimed when a better water supply is substituted.

Data are presented in table 14 on the concentrations of boron found in a series of soil samples collected at 10 locations in the Hollister area in 1934. The concentrations of boron in the corresponding irrigation waters and in the tissues of the apricots and prunes grown on the soils are given. When available, leaf samples were collected from walnut trees on the same properties, but in no instance were these trees immediately adjacent to the locations of the soil samples.

Soil 2, irrigated with a water containing 0.11 p. p. m. of boron, and soil 5a, which had never been irrigated, had soil solutions with substantial concentrations of boron. In the first, the concentrations in the successive horizons were 0.9, 1.0, and 2.1 p. p. m. and in the second 0.6, 0.5, and 0.6 p. p. m.

Soils 3, 5, and 9, irrigated with waters containing 0.65, 12.5, and 5.10 p. p. m. of boron, respectively, show substantially higher concentration of boron in the upper soil horizons. This finding probably signifies an active fixation of boron still in progress. With continued irrigation, a uniform concentration of boron will doubtless result throughout the root zone. The latter result has been observed in some citrus lands in Ventura County that have now been under irrigation for over 40 years.

Soil 4 had been irrigated for 17 years with a water supply which in 1931 contained 4.39 p. p. m. of boron. The soil solutions of the successive horizons to a depth of 6 feet contained 2.8, 2.5, and 2.6 p. p. m., respectively. This finding may be construed as indicating a limited fixation of boron by a relatively heavy soil and deep penetration of irrigation and rain waters, giving rise to soil-solution concentration intermediate between the two. This irrigation water is so high in chloride that without an abundant leaching of the root zone a chloride concentration incompatible with good growth would have developed. The trees are large, and they produce satisfactorily. The Yolo soil upon which the orchard is planted is a relatively permeable one.

The French prune orchard on soil 6 was markedly injured by boron. Several rows of Sugar prunes at one side of the orchard were in an advanced stage of decline, and beyond these there had been a planting of Imperial prunes which failed. During the winter previous to sampling, the orchard had been heavily irrigated with storm waters from Dos Picachos Creek, and no pump water was applied during the preceding summer. Although much boron was obviously removed from the upper 6 inches of soil by leaching, the results illustrate the fact that the reclamation of soils high in boron is customarily slow and difficult. Uncertainty is attached to the concentrations of boron in

TABLE 14.—*Boron in irrigation waters, soil solutions, and plants of 6 French prune and 3 apricot orchards in the Hollister area*

[Leaf samples, September 1933; soil samples, January 1934]

Soil	Soil survey classification	Saturation percentage in horizon—			Irrigation water				Boron in soil solution horizon—			Boron in plant material				Yield per acre of dried fruit, 1933	Evidence of boron injury	
												Prunes			Walnut leaves			
		0–6 inches	6–36 inches	36–72 inches	Boron	Chloride	Irrigated	Estimated total application	0–6 inches	6–36 inches	36–72 inches	Leaves	Bark	Wood			Prunes	Walnuts
					P. p. m.	*M. e.*	*Years*	*Acre-inches*	*P.p.m.*	*P.p.m.*	*P.p.m.*	*P.p.m.*	*P.p.m.*	*P.p.m.*	*P.p.m.*	*Pounds*		
1	Yolo silt loam				0.08	0.75	15	224				38	30	13	188	4,000	None	None.
2	Rincon loam	40	52	45	.11	.60	11	200	0.9	1.0	2.1	55	50	14	118	5,048	do	Do.
3	Yolo silt loam	47	46	28	.65	1.70	17	168	1.3	.9	.7	44	60	28	185	5,000	do	Do.
4	do	35	33	33	4.30	9.15	17	212	2.8	2.5	2.6	54	76	13	1,051	5,000	Present	Marked.
5	Rincon loam [1]	36	57	38	12.5			30	7.9	2.6	1.3	38	55	16			do	
5a	(Adjacent unirrigated)	40	39	38					.6	.5	.6							
6	Yolo sandy loam [2]	47	45	40	4 to 18	4.95			4.6	8.3	6.9	96	142	44	1,176	1,200	Marked	Severe.
												Apricots						
7	Yolo silty clay loam				.91	3.22						49	82	37			Present	
8	Rincon loam	43	48	38	1.35	2.45	5		1.0	1.0	.7	42	20	28			None	
9	do	49	52	51	5.10	9.14	3	30+	5.1	3.7	.9	33	32	55			Marked	

[1] Appears to be Montezuma clay adobe which is shown by Soil Survey map (4) to be scattered through area mostly classed as Rincon loam. Water has been used sparingly on this orchard and the trees are not large.

[2] This orchard was not irrigated from the well during the year preceding the sample, but winter floodwaters were used copiously to promote leaching.

the irrigation waters used on this orchard. The lower of the two values given is that of a bailed sample from an abandoned well and the other represents water from a new well used only for a short time. Intervening these waters, another well was used that produced a warm water. It was filled in prior to the investigations.

Field observations have pointed to notable differences in the intensity of the boron reactions of tree crops on different ones of the several soil series represented in the Hollister area. Limitations to general conclusions have been imposed, as the extensive use of pumped ground waters has developed only since about 1914, and within the area in which high-boron waters are most frequently encountered there is much diversity not only in the age of the plantings but also in the quantity and quality of water applied.

Among the heavier soils, the recent alluvial ones such as the Yolo and Dublin have been observed to be more tolerant to high-boron water than those of the old transported group of which the Montezuma or Rincon are important examples. These latter soils, which have well developed and characteristically somewhat impervious subsoils, occur extensively in the high-boron area, and on them are found many instances of failure of orchard plantings. The soils of the area illustrated by plate 2, *B*, are principally Rincon. This soil series is not only shallower, and for this reason less productive, than the Yolo and similar soils but high-boron waters can be used successfully on it for only a few years. The portion of the apricot orchard on Rincon loam represented by soil 9, table 14, declined to the point that it was removed in 1936. Another portion of the same orchard on Montezuma clay adobe, though not good, is still in production. This orchard irrigated with a water containing 5.10 p. p. m. of boron and 9.14 m. e. of chloride may be contrasted with the orchard on soil 4 (both apricot and prunes), which, irrigated with water containing 4.39 p. p. m. of boron and 9.15 m. e. of chloride, has been in production for 17 years.

The Conejo soils of the area are of the gravelly type, and probably because of their texture orchards on them have developed boron symptoms rather rapidly. The Conejo soil being well drained, it is possible to control the boron concentrations in the soil solutions to some extent by more abundant use of water. This soil responds quickly when good water is substituted.

Good apricot orchards have been maintained for many years on Yolo silt loam along the San Benito River where ground waters averaging about 0.80 p. p. m. of boron are used. There has been a suggestion that the Yolo soils in the vicinity of Pacheco Creek have a higher fixing capacity than those in the vicinity of San Benito River. This difference is probably related to the origin of the soil-forming materials. The former were brought in from a drainage area, which now yields water containing only about one-seventh as much boron as the latter.

BORON ACCUMULATION IN PLANTS AND ITS INJURIOUS EFFECTS

Basis of Injury

Symptoms of boron injury in the form of abnormal leaf or other characteristics are the result of an excessive concentration of boron in the affected part of the plant. Species differ markedly in the extent to which they accumulate boron, in the tissues or organs in

A, Apricots planted in 1921 and grown as a promising orchard without irrigation for 5 or 6 years. They were then irrigated 3 times with a water containing 15.9 p. p. m. of boron. Ill effects of this water were noted, and the orchard has not been irrigated since. Tomatoes interplanted in 1937 were markedly injured by boron still remaining in the soil. *B*, Rincon loam northeast of Hollister occupied until about 1934 by apricot and prune orchards. The ground waters underlying this immediate area were found to be too high in boron for the successful culture of other than boron-tolerant crops.

Persian walnut leaves showing (*A*) boron injury and (*B*) the type of injury customarily attributed to excess chloride. Not infrequently composites of these distinct types of necrosis are found in the field. Few other plants exhibit chloride injury such as is shown by the walnut.

which greatest accumulation occurs, and in the concentrations of accumulated boron that result in visible symptoms. Examinations by Webber (*16*) have shown that the histological bases of boron injury, though not always the same, have certain similarities in different tissues. In leaves, an excess of boron results in the conversion of chloroplasts into leucoplasts and, as accumulation progresses, the cell contents brown and finally shrink away from the cell walls; a transition is thus represented from a normal green condition, through yellowing, browning, and the appearance of necrotic areas, to the final death of the affected part or of the entire plant. In the bark of current season's stems of boron-affected prunes, peaches, and apricots, necrotic areas comparable to those of boron-injured leaves occur in the epidermis and subjacent cortical parenchyma. Cortical gum cavities and yet more conspicuous gum ducts of the xylem are formed by cell disintegration. These histological abnormalities are in general similar to those that may be brought about by other agents, but taken collectively and in conjunction with a knowledge of the loci of boron accumulation they become fairly specific indicators of boron toxicity. The enlarged nodes of some of the stone fruits (*5*) are due to the growth of normally dormant axillary and accessory buds and to the multiplication of the cells of the cortex of the nodes as well as those of the underlying woody elements.

SYMPTOMS OF WALNUTS, GRAPES, AND MANY ANNUAL CROPS

A large group of plants, which includes not only all of the annual crops that have been examined but also many trees, such as walnuts, citrus, sycamores, persimmons, and elms, and such plants as the grape (*5*), characteristically accumulate boron in their leaves, and from the leaves there is relatively little removement of boron to the bark, to the roots, or to the fruit. In these plants, illustrated by the walnut (table 15) and the grape (table 16) it is believed that boron is carried to the leaves by the transpiration stream and there laid down, probably in combination with sugarlike or other organic compounds, in forms that are not readily translocated. In these plants the leaves are the organs that exhibit symptoms of injury. The greatest accumulation of boron and the most marked evidence of injury occurs along the margins of the leaves and at points most removed from the veins. In these regions (pl. 3, *A*), yellowing first appears along the margins between the veins and, with the advance in age of the leaf, this yellowing is followed by the development of necrotic areas and by the death of the affected tissues.

TABLE 15.—*Accumulation of boron in various tissues of field-grown apricots and walnuts*

[Expressed as parts per million based on the dry weight of the material]

Apricots			Walnuts	
Plant part	Uninjured	Injured	Plant part	Injured
	P. p. m.	*P. p. m.*		
Leaves	49	118	Leaves:	*P. p. m.*
Bark, twigs	22	63	Dead margins	2,717
Wood, twigs	5	27	Green portion	660
Fruit:			Midveins	118
Flesh	41	441	Entire	1,302
Shells	3	52	Petioles	27
Kernels	T	85	Bark, twigs	40
			Wood, twigs	30
			Nuts:	
			Husks	123
			Shells	33
			Kernels	14

TABLE 16.—*Accumulation and distribution of boron in tissues of plants grown in sand culture*

[Expressed as parts per million based on the dry weight of the material]

Variety and boron in culture solution	Leaves			Bark, earliest cycle			Wood, earliest cycle			Fruit, entire	
	1932	1933	1934	1932	1933	1934	1932	1933	1934	1933	1934
	P. p. m.	*P. p. m.*	*P. p. m.*	*P. p. m.*	*P. p. m.*	*P. p. m.*	*P. p. m.*	*P. p. m.*	*P. p. m.*	*P. p. m.*	*P. p. m.*
Peach, Sims cling:											
3 p. p. m	95	114			106			33			
6 p. p. m	120	184			187			36			
Peach, Champion:											
3 p. p. m	68	90			132			50			
6 p. p. m	109	182			245			92			
Plum, Kelsey:											
3 p. p. m	38	79	67		121	119		11	24		
6 p. p. m	54	89	102		198			104			
Apricot, Royal:											
3 p. p. m	48	125	207		66	91		3	67		501
6 p. p. m	78	123	189		94	185		20	81		628
Pear, Bartlett:											
3 p. p. m	73	76	84		42	99		50	41		
6 p. p. m	84	165	113		76	179		35	59		
Grape, Sultanina:											
3 p. p. m	320	462	655		28			11		79	59
6 p. p. m	501	693	1,008		42			28		89	89

SYMPTOMS OF STONE-FRUIT TREES

A second group of plants of which the stone-fruit trees are the only known examples reacts somewhat differently. Much higher concentrations of boron are found to accumulate in the bark and in the fruit of these plants (tables 15 and 16) than in the former. Marginally yellowed or burned leaves have rarely been observed, but injury to petioles and midribs together with thickening of leaves results (pl. 4). Presuming that boron is first carried to the leaves with the transpiration stream, the evidence indicates that it is readily translocated in these trees to other tissues. Whether the boron is moved in the form of organic compounds or as simple inorganic radicals is not known. In further contrast with plants of the previous group, young shoots of the stone fruits are injured and frequently die back as the bark is killed. Injury is likewise manifested by spots or longitudinal strips of brown corky-appearing tissue along the petioles and midribs; these represent the sloughing off of scales as a result of the death of

Twigs of prune (*A*) and apricot (*B*) severely injured by boron. Note sloughing of bark, gumming, death of tips, necrotic patches in bark, on petioles, and leaf veins and enlargement of some of the nodes.

Old Blenheim apricot trees on recent alluvial soils, photographed in January 1939 before pruning. The productive orchard on the left has been irrigated with water containing about 0.8 p. p. m. of boron and the now unprofitable orchard on the right with water containing 6.58 p. p. m. of boron. The difference in the growth of the current season's branches can be observed.

underlying tissue and the development of cork parenchyma. Thickening of the bark of the trunk and twigs of apricots is sometimes noted, and shortening of the internodes may occur. Twigs of injured trees are characteristically stiffened, and when bent they break transversely more easily than do unaffected twigs. The leaves of affected apricot and prune trees become thickened and lack toughness.

In apricots the first symptom that appears on new growth is the dying back of tips of shoots, which follows the break-down of the bark in the terminal region. Enlargement of nodes of first- and second-year twigs is a common symptom, but it is not always observed. Gumming at the nodes is likewise variable. The flowering and retention of fruit by apricot trees with well-marked symptoms of boron injury are not directly affected, and some orchards have been observed through a number of successive seasons to bear fruit of normal size, color, and flavor. The new growth of such trees is restricted, and this limits the size of crops and retards their development (pl. 5). For this reason satisfactory orchard production is not attained. The fruit of severely injured trees is often undersized, and necrotic areas may appear in the epidermis and in the underlying flesh. In yet more severe cases the flesh of the fruit is often discolored and shrunken either in spots or over the whole of one side. In one instance the flesh of badly injured apricot fruit was found to contain 732 p. p. m. of boron on the basis of dry weight. The authors' observations have not been sufficiently extensive to permit of differentiations in the sensitivity of different varieties of apricots to boron.

The Imperial prune is more sensitive to boron than the Sugar variety, and neither of these is as tolerant as the apricot. The French prune on the basis of tree growth is more tolerant than the apricot. Although the symptoms of injury of the three prunes, as well as of the apricot, and in some measure the peach, all belong in the same group, there are differences in emphasis. The Imperial prune exhibits a break-down of the bark and death of the tips of new shoots very much as the apricot does, and the enlargement of nodes, shortening of internodes, and tendency toward the production of many branches are conspicuous features. The break-down of the bark of the Sugar prune usually starts immediately above the nodes, resembling the peach in this respect. The set of fruit by injured trees of the Imperial and Sugar varieties is below that of the apricot but clearly superior to the French prune. The latter prune flowers profusely, but few fruits are set. It is probably for this reason that the French prune makes a better vegetative growth than those other varieties, since without fruit its photosynthetic product goes into new growth. Thickening of leaves, corkiness along the midribs and petioles, as well as enlarged nodes, death of shoot tips, and gumming are all characteristic symptoms of the French prune when severely injured, but, except for lack of fruitfulness, injury may often pass unnoticed even though water supplies unsuitably high in boron have been in use for a number of years.

The diagnosis of boron injury of peaches, of which few are grown in the Hollister area, is more difficult than in the case of apricots and prunes. The most conspicuous feature of peach injury is the break-down of cortex tissues in young twigs. This break-down is usually but not always initiated just above the axils of leaves, from where it extends and commonly encircles the twig, causing death of the tips. Gumming occurs to a limited extent, but the enlargement of nodes has not been observed. A poor setting of fruit by injured peaches is characteristic of the injury, but between varieties there is a noteworthy variability. The fruit from badly injured trees tends to be insipid, often poorly developed, and, as in badly injured apricots, the flesh may develop poorly either in large or small areas and in advanced instances may become discolored. The abnormality known as split pit is a feature of boron-injured peaches, but it is not specific as it is a common symptom of peaches produced by trees weakened by other causes.

Toxicity

Stone-fruit trees have been grown at Riverside, Calif., in a series of sand cultures supplied with nutrient solutions containing a trace, 1, 3, 6, and 9 p. p. m. of boron, respectively. The results of these experiments showed that peaches, apricots, prunes, and plums withstand 3 p. p. m. of boron in nutrient solutions under Riverside climatic conditions with little or no injury. Substantial injury results in nearly all instances with 6 p. p. m. The apricots, one of the two peach varieties, the French prune, and the Kelsey plum survived through the three seasons in the 9 p. p. m. culture, but their growth during the final year was negligible and the symptoms of injury were severe. Pear trees in these cultures showed a higher tolerance than did any of the stone fruits. The growth of two Sultanina grapevines in the 6 p. p. m. culture was about one-third as great as in the 1 p. p. m. culture. In other experiments, the growth of walnuts has been sharply depressed by 5 p. p. m. of boron. Culture-solution concentrations in these experiments are to be compared with the concentrations in soil solutions rather than with concentrations in irrigation waters. It was shown by table 14 that the soil solutions of land that has been irrigated for only a few years customarily contains less boron than the irrigation water, but as time goes on the concentrations in the soil solutions come to exceed those in the water.

Pears and apples have been grown in sand-culture tests and the condition of several orchards irrigated with water containing several parts per million of boron has been observed. Although neither of these fruit trees do well when the irrigation water is high in boron, they do not develop symptoms of diagnostic significance. On the basis of field observations it has appeared that apple and pear trees irrigated with high-boron waters were apt to be chlorotic, but this symptom is not a general one and in sand-culture experiments chlorosis has not followed the use of solutions high in boron. Neither the apple nor the pear accumulate high concentrations of boron in their leaves; in this respect their reactions resemble the stone fruits. The pear accumulates relatively more boron in its bark and fruit than do trees like the lemon and walnut, but this feature is not as marked as it is in apricots and prunes, and bark symptoms have never been observed. A pear orchard on the previously mentioned Luther property (p. 47)[6] in the Hollister area was chlorotic and grew poorly; when cut back the branches died back farther. Two sets of pear samples collected by C. J. Hansen, of the University of California, were submitted to the United States Department of Agriculture for boron determination. One set was from an orchard at Martinez, Calif.,

[6] Soil 6.

where boron injury was suspected because of the reactions of other plants and the stunted character of the trees. The leaves, bark, wood and fruit of these trees contained 58, 58, 33, and 48 p. p. m. of boron, respectively. The other set was from Davis, Calif., where trees such as walnuts show mild late-season boron symptoms, and contained in the same tissues 60, 43, 33, and 62 p. p. m. of boron, respectively. In sand-culture experiments the boron content of leaves of pears has sometimes exceeded and sometimes been below that of the bark (table 16).

Rootstocks

It has been found in the instance of a few plants (*8*) that the kind of rootstock upon which a plant is grafted may markedly influence the extent of boron accumulation in the scion and the degree to which it is injured. Such relations may exist among the stone-fruit rootstocks, but direct experiments have not been conducted nor has it been possible to draw conclusions on the basis of field observations. Myrobalan rootstock is used almost universally for prunes, and in the Hollister area it is generally used for apricots, particularly on the heavy soils to which it is best adapted. Heavy soils predominate in the portions of the Hollister area where waters high in boron are most common.

Shoots from myrobalan roots of apricot trees have been observed to show little boron injury even though the apricot scion was badly affected. Rather than to conclude that there are marked differences in the tolerances of myrobalan plum and the apricot, it seems more reasonable to believe that other factors are involved. The boron analyses that have been made of root tissues have nearly always shown relatively low concentrations, and it seems accordingly that the boron concentration in a shoot growing from the root below the graft would be much lower than that in one from the upper portions of the tree, where the bark normally carries relatively high concentrations under conditions of injury.

Effect of Fruit on Accumulation of Boron in Apricot Trees

The observation that the boron concentration in apricot fruit is higher than in leaf or stem tissues and the further one that the productivity of injured trees tends to be about the same as that of uninjured trees of like size raises a number of questions of physiological interest. For the purpose of determining whether the boron concentrations in the leaf and stem tissues are increased by removal of fruit at an early stage and whether the evidence of boron injury is thereby increased, an experiment was conducted at Hollister during the summer of 1937. Two adjacent and entirely similar trees were selected in an injured orchard of Blenheim apricots. This orchard was irrigated with water from a well that contained 2.96 p. p. m. of boron in 1931 and 4.36 p. p. m. in 1937. One of the trees was defruited during the first week in May, leaving only about 25 fruits for sampling purposes. The concentrations of boron found in the several tissues of the two trees on July 12 and October 18 are reported in table 17. The flesh of the fruit of the partly defruited tree was found to contain only a little more boron than that of the control tree, but the concentrations in leaves, bark, and wood were almost double. When the same trees were resampled 3 months later on October 18, it was found that the boron concentrations in the control tree had tended to increase and those of the defruited tree to decrease. The concentrations of boron in all tissues but the leaves remained higher in the defruited than in the control tree. The quantity of boron removed from the control tree with the fruit crop was not estimated, but it was obviously substantial. As measured in July when the fruit was ripe the length of the new shoot growth on the defruited tree averaged 20 percent greater than that of the control tree.

TABLE 17.—*Comparison of boron accumulations in leaves, bark, and wood of apricot trees with and without fruit*

[Expressed in parts per million on dry-weight basis]

Date of collection and portion of plant	Boron accumulations in—		Date of collection and portion of plant	Boron accumulations in—	
	Check tree	Defruited tree		Check tree	Defruited tree
July 12, 1937:	*P. p. m.*	*P. p. m.*	Oct. 18, 1937:	*P. p. m.*	*P. p. m.*
Leaves	62	122	Leaves	72	60
1937 growth, bark	45	115	1937 growth, bark	74	116
1937 growth, wood	25	101	1937 growth, wood	44	55
Old twigs, bark	65	161	Old twigs, bark	68	96
Old twigs, wood	25	59	Old twigs, wood	28	42
Fruit from foregoing twigs, flesh only	384	[1] 396			

[1] A few apricots left on tree to provide samples for analyses.

As observed the following summer there were more leaves on the defruited tree, then bearing a crop, than on the control tree. Little difference was observed in the growth of the trees or in the severity of boron symptoms on the latter date. This was perhaps to have been expected, since on the one hand removal of fruit stimulated vegetative growth, which is characteristic, but on the other the high-boron concentrations in the tissues tended to restrict it. In these reactions the defruited apricot tree was similar to boron-injured French prunes, which it will be recalled do not set a normal crop of fruit under high-boron conditions and do make a creditable vegetative growth.

COMPARATIVE TOLERANCES OF ORCHARD, FIELD, AND TRUCK CROPS TO BORON

A wide variability exists in the concentrations of boron that different crop plants withstand. There are likewise differences between plants in the concentrations of boron that are most suitable for rapid growth. An irrigation water relatively high in boron may sometimes be used profitably for the culture of boron-tolerant crops and be entirely unsuited for sensitive ones. In fact, farmers using waters high in boron have in some instances found, by trial and error and without a knowledge of the cause of their difficulties, that certain crops were more suitable to their particular conditions than others.

The relative tolerances of various cultivated plants have been determined by means of large out-of-doors sand cultures in which the concentrations of boron were closely controlled. By the use of these methods many of the experimental difficulties were avoided that under field conditions are associated with boron fixation by soils and variations in concentrations not only from place to place in field plots but also in the successive soil horizons. These results, which have previously been published (*5*) in conjunction with data on boron accumulation in the plants, are repeated, with minor changes based on later observations, in table 18 for the benefit of those interested particularly in the Hollister area. In this table plants are grouped according to their sensitivity to boron. The plants that withstand only relatively low concentrations have been designated in this table as sensitive, an intermediate group as semitolerant, and a final group as tolerant. This division of plants into three groups serves the purpose of convenience in classification, but between groups there are no sharp lines of demarcation.

TABLE 18.—*Tolerance of various cultivated plants to boron*

[In each group the plants first named are considered as being more sensitive and the last named more tolerant]

Sensitive	Semitolerant	Tolerant	Sensitive	Semitolerant	Tolerant
Lemon	Lima bean	Carrot.	Grape	Ragged Robin rose.	Asparagus.
Grapefruit	Sweetpotato	Lettuce.	Apple	Radish	Athel (*Tamarix aphylla*).
Avocado	Bell pepper	Cabbage.	Pear	Sweet pea	
Orange	Tomato	Turnip.	American elm	Pima cotton	
Thornless blackberry.	Pumpkin	Onion.	Navy bean	Acala cotton	
Apricot	Zinnia	Broad bean.	Persian (English) walnut.	Sunflower (native).	
Plum	Oat	Gladiolus.	Black walnut	Canadian field pea.	
Prune	Milo	Alfalfa.	Pecan		
Peach	Corn	Garden beet.			
Cherry	Wheat	Mangel.			
Persimmon	Barley	Sugar beet.			
Kadota fig	Olive	Palms.			

Within the groups the aim has been to name the more sensitive plants first. In some cases the differences between successive plants have been quite sharp, whereas in other cases the differences were too small or the data insufficient for clear differentiation.

Climatic conditions are believed to have an important bearing on the concentrations of boron that a plant will withstand. Plants grown in some summers showed substantially higher tolerances than in others, and a number of the garden vegetables showed differences in tolerance between winter and summer plantings. It appears on the basis of limited evidence that most plants withstand high boron concentrations better in cool and humid weather than under conditions that produce high transpiration rates.

AMELIORATION OF BORON INJURY

Boron injury resulting from the use of high-boron waters is consequent upon the development of unfavorable concentrations of boron in soil solutions. The soil-solution concentrations that develop from the use of a particular water supply are conditioned by such diverse factors as, (1) boron-fixing capacity of soils, (2) period over which the water has been in use, (3) quantities used, (4) quantity of rain in relation to quantity of irrigation water, (5) changes in pH value of soils as discussed in the section on soils, and (6) extent to which water is applied in excess of crop use for root-zone leaching.

Other than by the often undesirable procedure of making soils more alkaline, practical chemical treatments that will reduce boron concentrations in soil solutions are not known. Farmers accordingly may give consideration (1) to the substitution of crops of higher boron tolerance, (2) to the substitution of better water supplies, and (3) to reducing boron concentrations in their soils by more copious use of the water to more nearly bring soil-solution concentrations into line with the concentration of boron in the irrigation supply. This latter practice naturally involves some loss of soil nutrients. In one instance a Hollister prune grower with a badly injured orchard discontinued the use of a high-boron well and relied entirely on heavy winter irrigation and leaching with good storm waters. The water-holding capacity of that particular soil was relatively high and the condition of the trees improved, but profitable yields have not as yet resulted.

It has been found by greenhouse tests with citrus seedlings that boron injury in cultures amply supplied with nitrogen was less than that of seedlings supplied with solutions with concentrations of nitrogen insufficient for rapid growth of control plants. In the Hollister area it has been shown that the growth of boron-injured apricot trees could be stimulated by the application of nitrate fertilizers. The soil supporting the test trees was apparently poor in nitrogen, as the growth of boron-tolerant winter weeds was strikingly improved by the nitrogen application. This orchard would undoubtedly have responded to the applications of ammonium sulfate even though boron had not been a factor. It is believed, nevertheless, in keeping with the laboratory findings, that the boron injury and curtailed growth were accentuated by the low nitrogen conditions. In such a situation the profit from the applications of nitrogen is doubtless greater than it would be if boron had not been a factor. There is no evidence as yet that would show that boron injury would be materially lessened by the addition of excess nitrogen to already fertile soils.

BORON DEFICIENCY

The work of many investigators has pointed to the conclusion that some boron is essential to the growth of all plants. The boron requirements of different species, like their boron tolerances, are highly variable. Some plants are injured by concentrations of boron insufficient for the best growth of others. In many localities it has been found that the production of particular crops is increased by the addition of boron as a fertilizer, but because of the injury that results from an excess of boron much care must be employed in arriving at decisions as to the quantities that can be safely and most beneficially applied. The instances of beneficial use of boron demonstrated up to this time have tended to be in regions of plentiful rainfall, where soil leaching by rain is normally substantial and where the use of irrigation water, if any, is only occasionally necessary. Several partial exceptions to this general rule are found in the Northwestern States, but in these cases the boron content of the irrigation waters is notably low. The addition of boron to soil in quantities sufficient to meet the requirements of crop plants with high boron requirements may prove disadvantageous to other more sensitive crops grown on the land in subsequent years.

It is not improbable that occasional soils will be found here and there in the arid Southwest that are sufficiently poor in boron to admit of increased yields by boron applications, but present information on the quality of irrigation waters would suggest that such areas might be unusual.

The symptoms of boron deficiency are often striking, and usually they are fairly specific. They can nevertheless be confused with abnormalities resulting from other causes or only partly due to boron deficiency. It is unwise for this reason to draw conclusions on the basis of symptoms alone. Aid in diagnosis is afforded by chemical analyses of plant material. Such analyses, however, even in conjunction with symptoms, may not provide a conclusive guide to boron deficiencies. As an example, an excellent concordance was found, in collaboration with other investigators, between the boron content of walnut leaves and the severity of what were regarded as boron-deficiency symptoms. Relatively heavy applications of boron to affected trees did not correct the abnormality.

The subject of boron deficiency is discussed in this bulletin, not because it is believed that beneficial results would follow the application of boron to any of the soils of the Hollister area, but rather because questions on the possibility of boron deficiency have been raised in this area and elsewhere in the coastal section in connection with the significance of irrigation waters containing only a few hundredths of a part per million of this element.

Experiments conducted in potted soils may provide valuable indications of the possibility of boron deficiency. In pots, however, the mass of soil available to a plant is customarily far more limited than in the field.

In any area the final conclusion as regards adequacy of the boron-supplying power of soils must rest on information afforded by trial application in the field.

SUMMARY

The Hollister area is an irrigated valley in west-central California, located 20 miles inland from Monterey Bay. The valley is best known for its production of apricots, prunes, and flower and vegetable seeds.

This bulletin constitutes a report on the following: (1) The quality of the surface and ground waters of the Hollister area, including analyses of waters of the contiguous coastal section between the south end of San Francisco Bay and Santa Ynez River in Santa Barbara County (complete analyses are presented, but the data are discussed with particular reference to the occurrence of boron); (2) the accumulation of boron in Hollister soils; and (3) the accumulation and toxicity of boron in plants, particularly apricots and prunes.

The higher concentrations of boron found in the ground waters of the Hollister area are limited principally to those underlying a strip of land extending across the east side of the valley. On the basis of chemical evidence it is believed that much of the boron in the ground waters underlying this strip of land was brought into upper strata by magmatic emanations rising through the fissures of a previously uncharted fault zone. Substantial quantities of boron originating in the rock and alluvial material of the drainage basin are annually carried into the valley with stream waters.

The correlation coefficient between concentrations of boron in ground waters and depths of wells was $0.20 \pm .051$, between electrical conductance and well depth $0.09 \pm .053$, between percent sodium and well depth $0.39 \pm .070$, between boron and electrical conductance 0.34

±.045, between percent sodium and electrical conductance 0.45±.043, and between percent chloride and electrical conductance 0.40±.046.

The concentrations of boron found in the soil solution of irrigated lands are dependent not only on the concentrations of boron in the irrigation water and the length and abundance of use but also on the origin, age, and texture of the irrigated soils.

The apricot and prune like other stone fruits tend to accumulate more boron in the bark and fruit than in the leaves, differing in this regard from other agricultural plants that have been studied. The fact that boron in the stone-fruit trees is moved out of the leaves after having been brought into the plant with the transpiration stream implies differences between these and other plants in the mobility of the organic compounds with which boron is believed to become linked. Trees bearing a heavy crop of fruit had less boron in the bark than adjacent trees from which the fruit had been removed.

The symptoms of boron injury of apricots and prunes are differentiated from those of plants that accumulate boron in their leaves on the basis of the tissues affected, but the histological characteristics of boron injury are similar. The vegetative growth of boron-injured apricot trees is curtailed, but relative to their size they set and mature many fruits. Injured prunes on the other hand make a creditable vegetative growth and flower profusely but set a light crop.

The comparative tolerances to boron of a series of 53 agricultural and ornamental plants to boron are reported.

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TB 746 (1941) USDA TECHNICAL BULLETINS UPDATA
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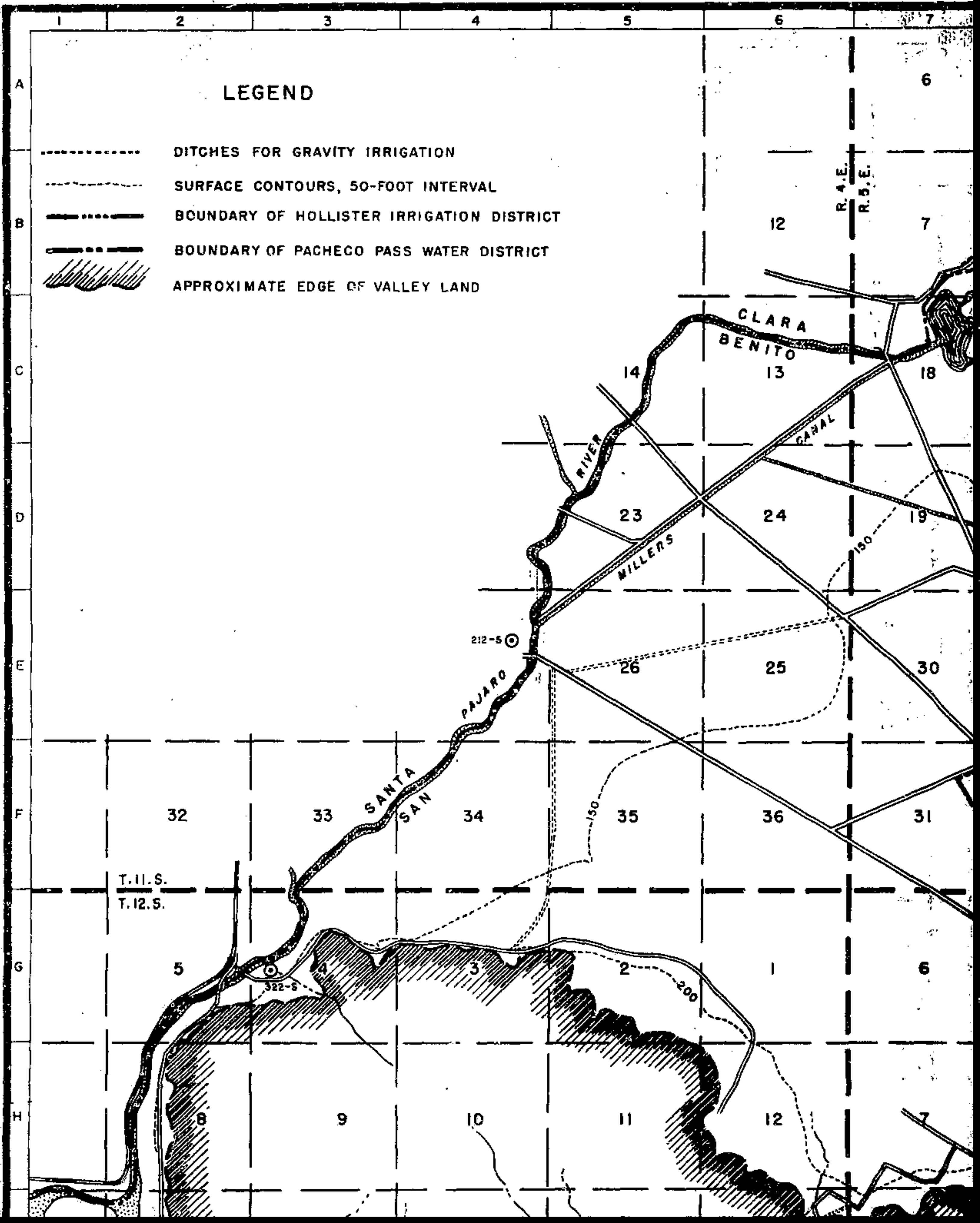
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SURFACE CONTOURS, 50-FOOT INTERVAL
BOUNDARY OF HOLLISTER IRRIGATION DISTRICT
BOUNDARY OF PACHECO PASS WATER DISTRICT
APPROXIMATE EDGE OF VALLEY LAND
SANTA CLARA RIVER
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SAN BENITO
MILLERS CANAL
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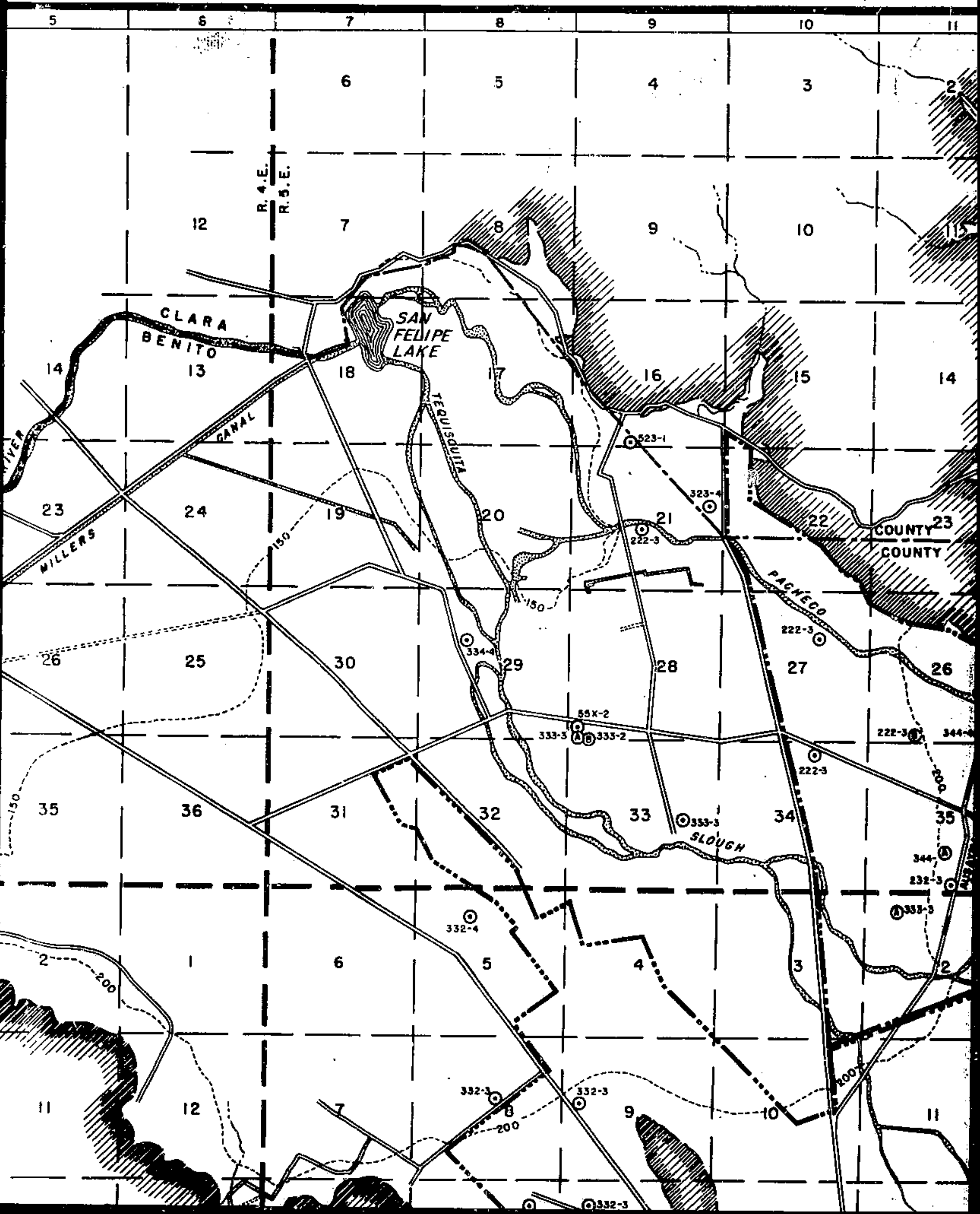

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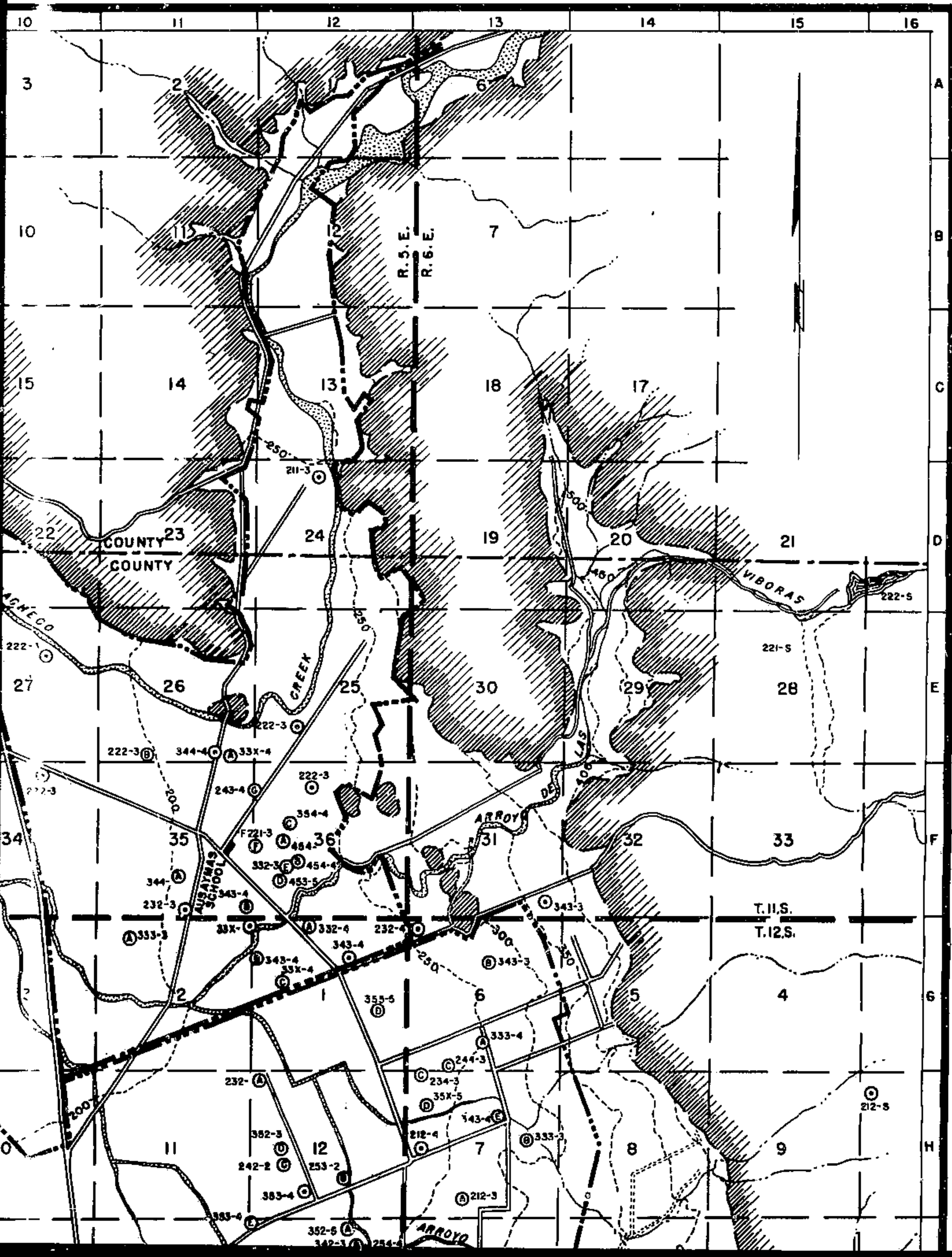
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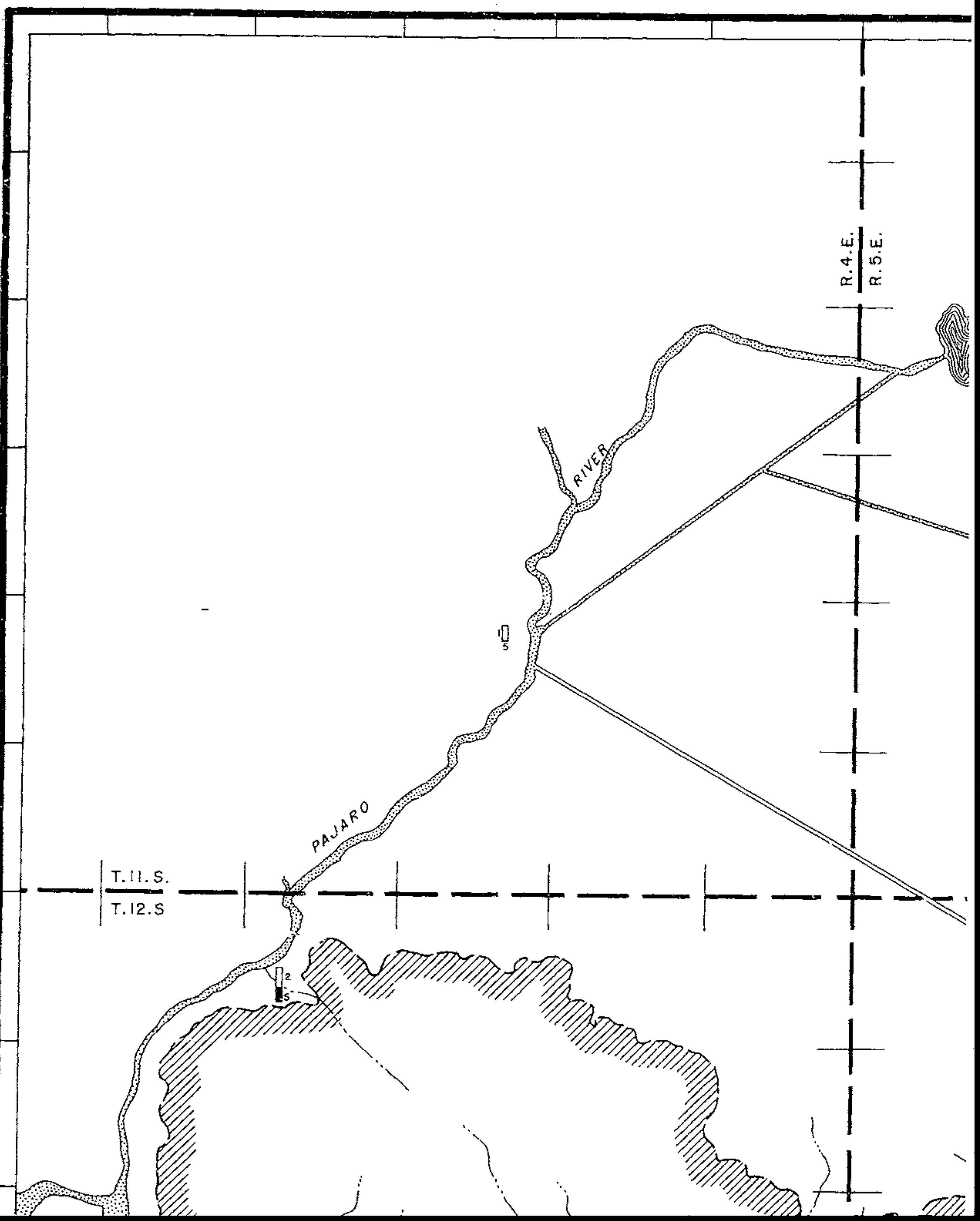
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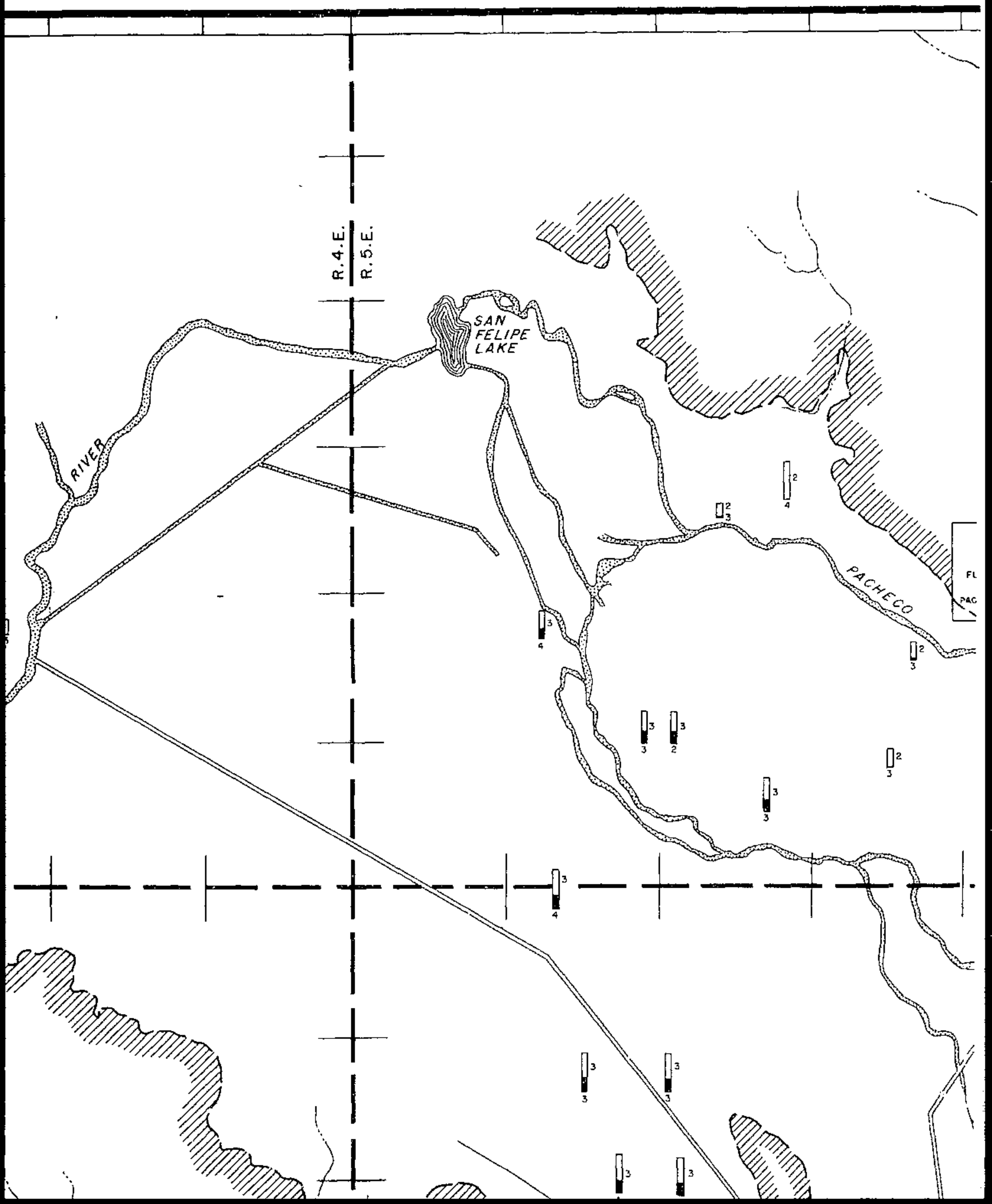
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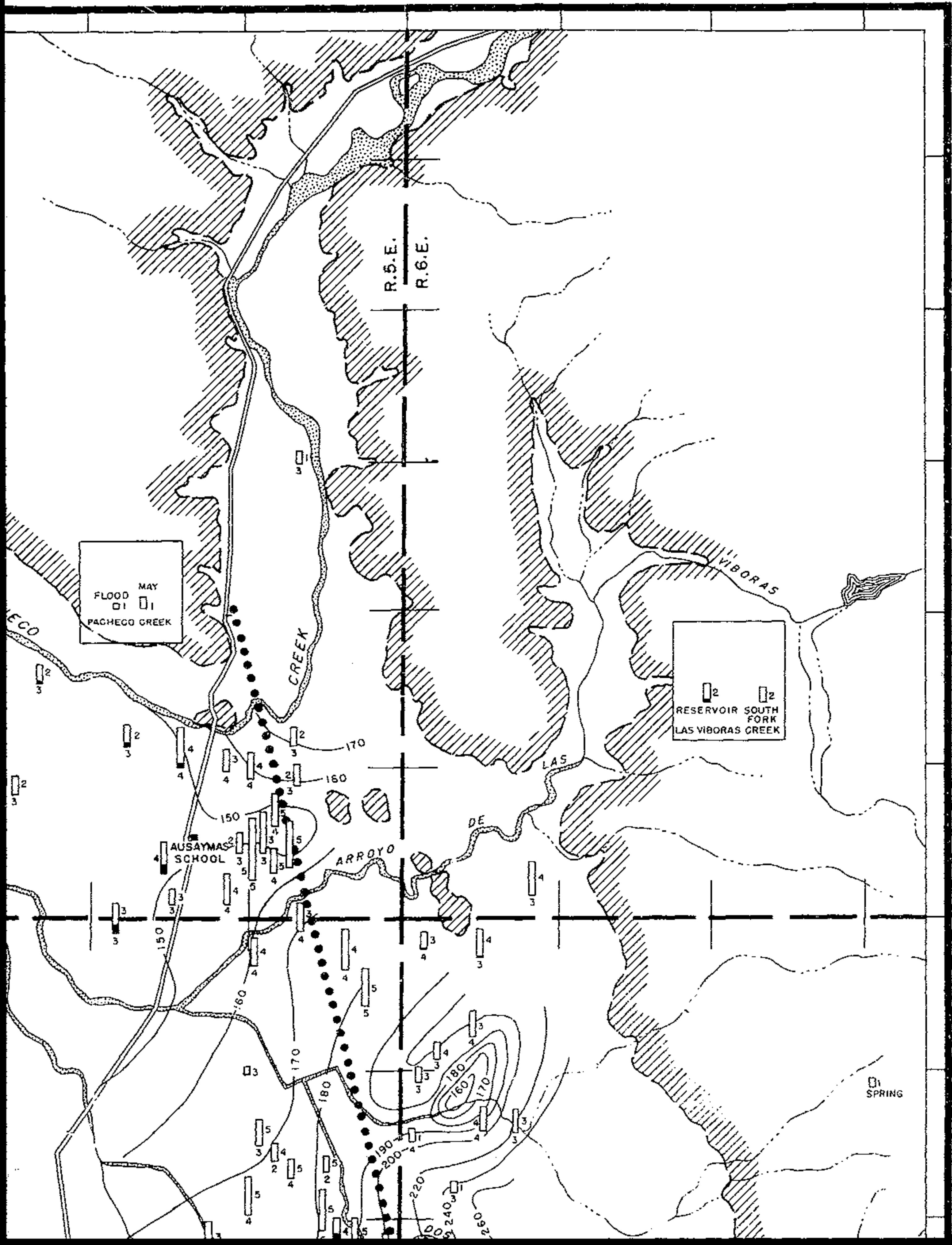

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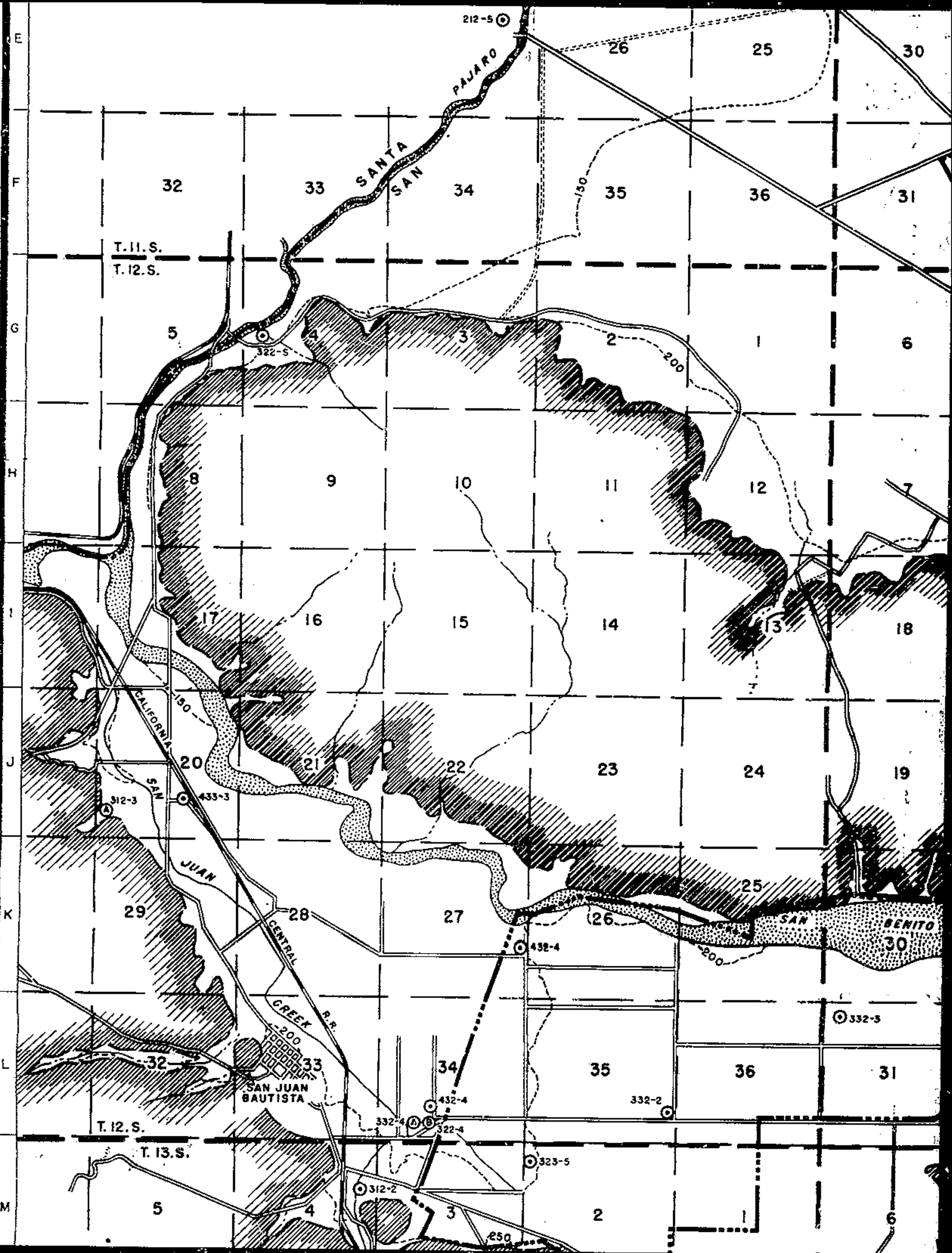

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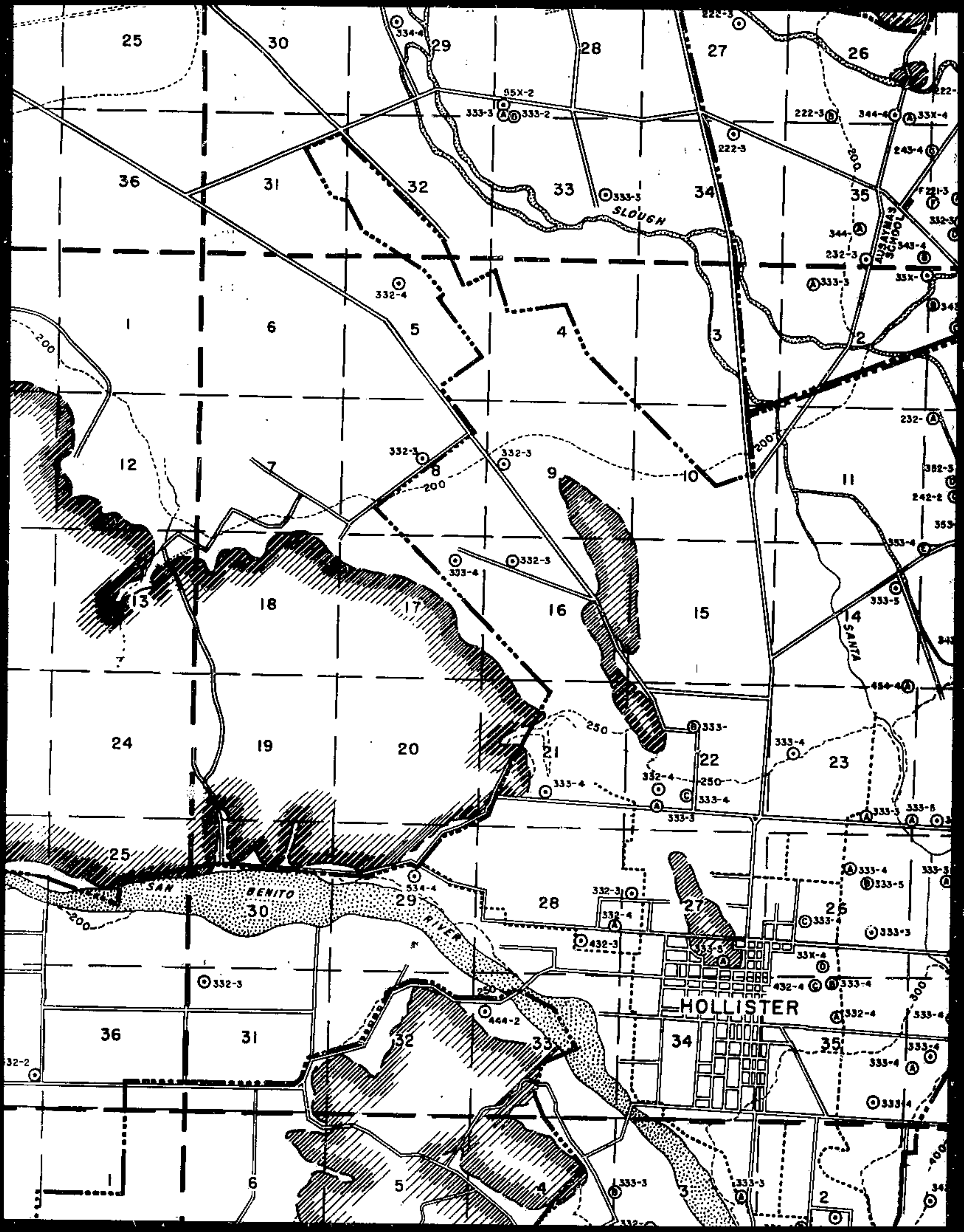

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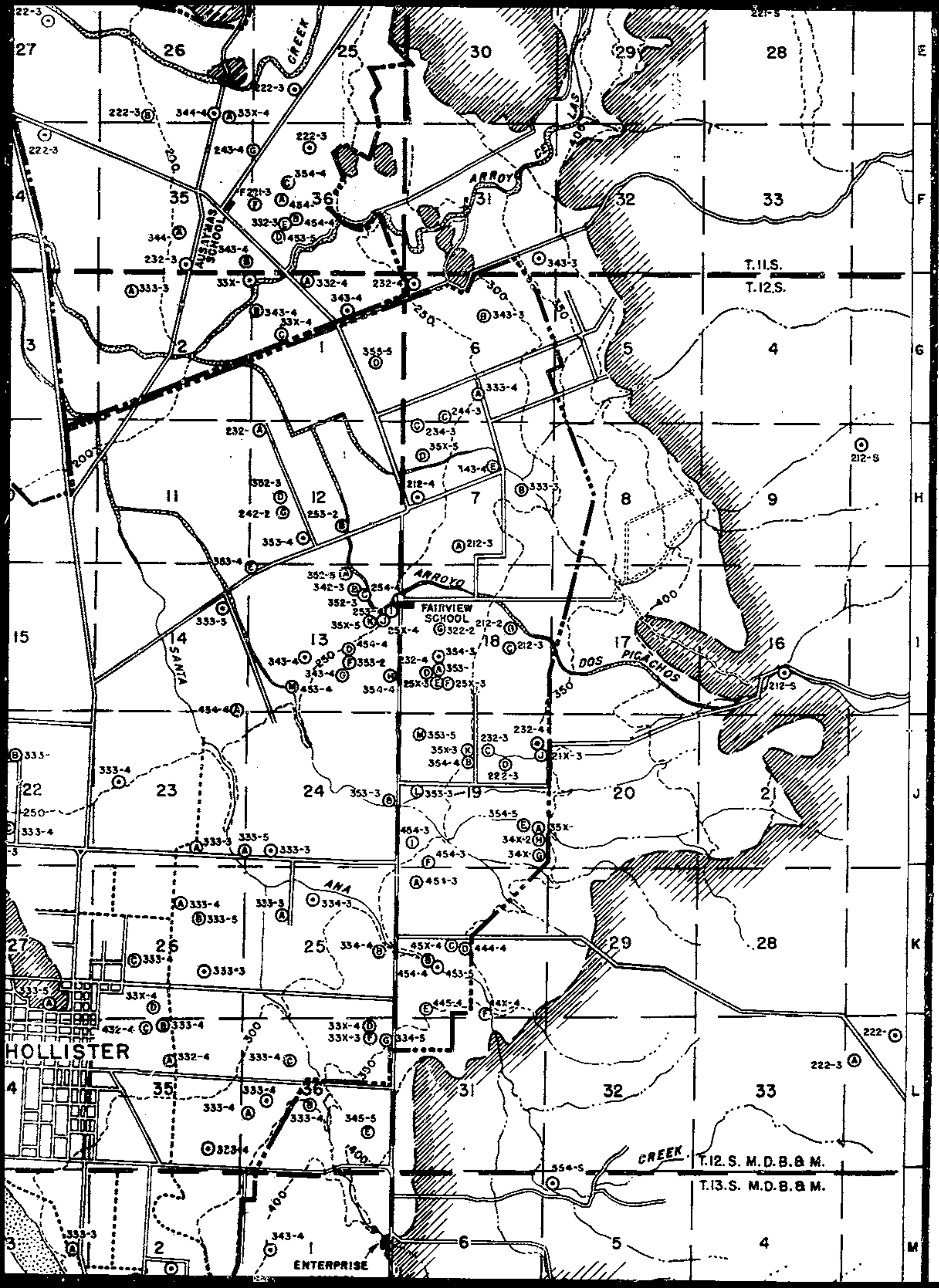

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ARROYO
FAIRVIEW SCHOOL
DOS PICACHOS
SANTA
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HOLLISTER
CREEK
T.12. S. M. D. B. & M.
T.13. S. M. D. B. & M.
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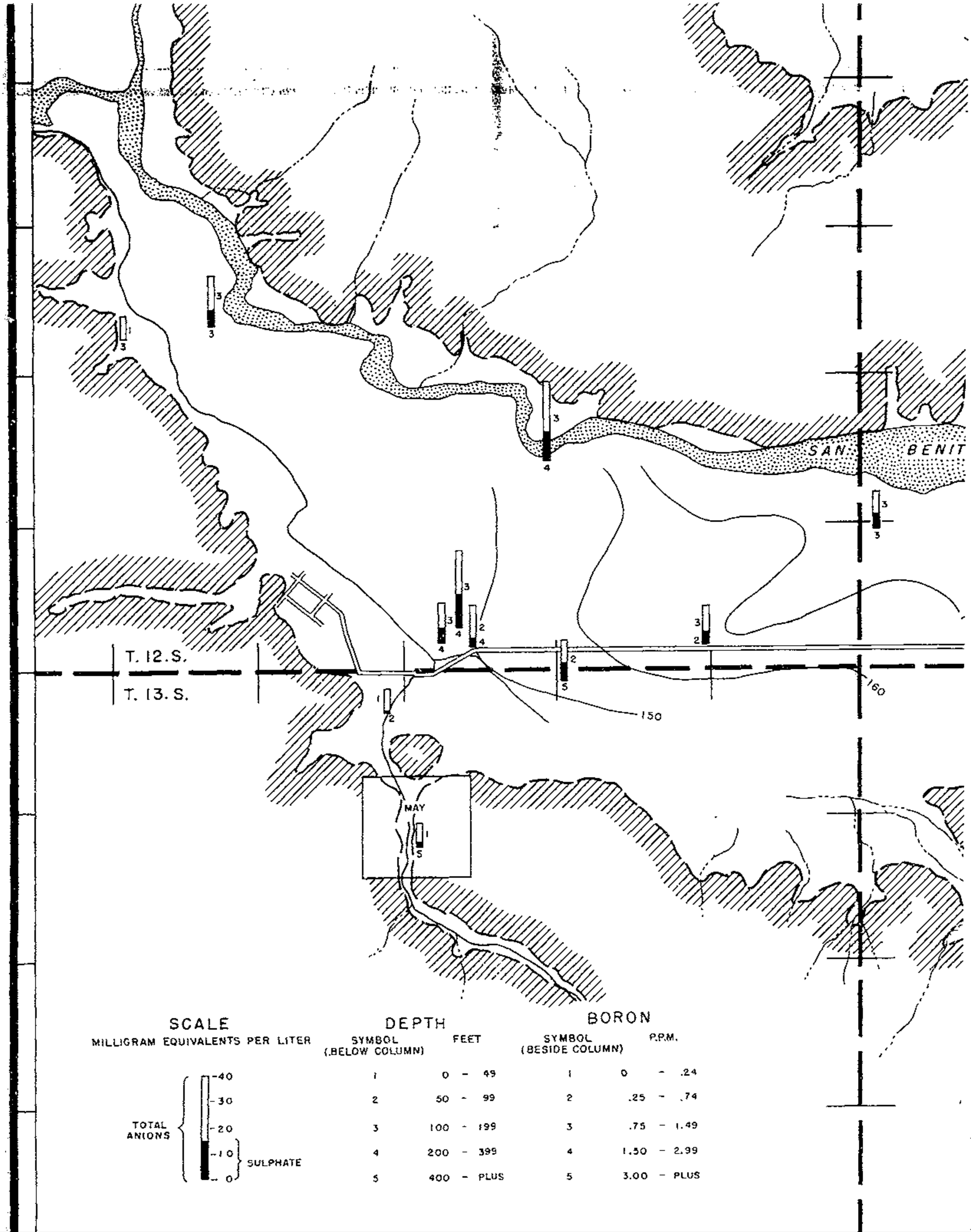

SAN BENIT
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T. 13 S.
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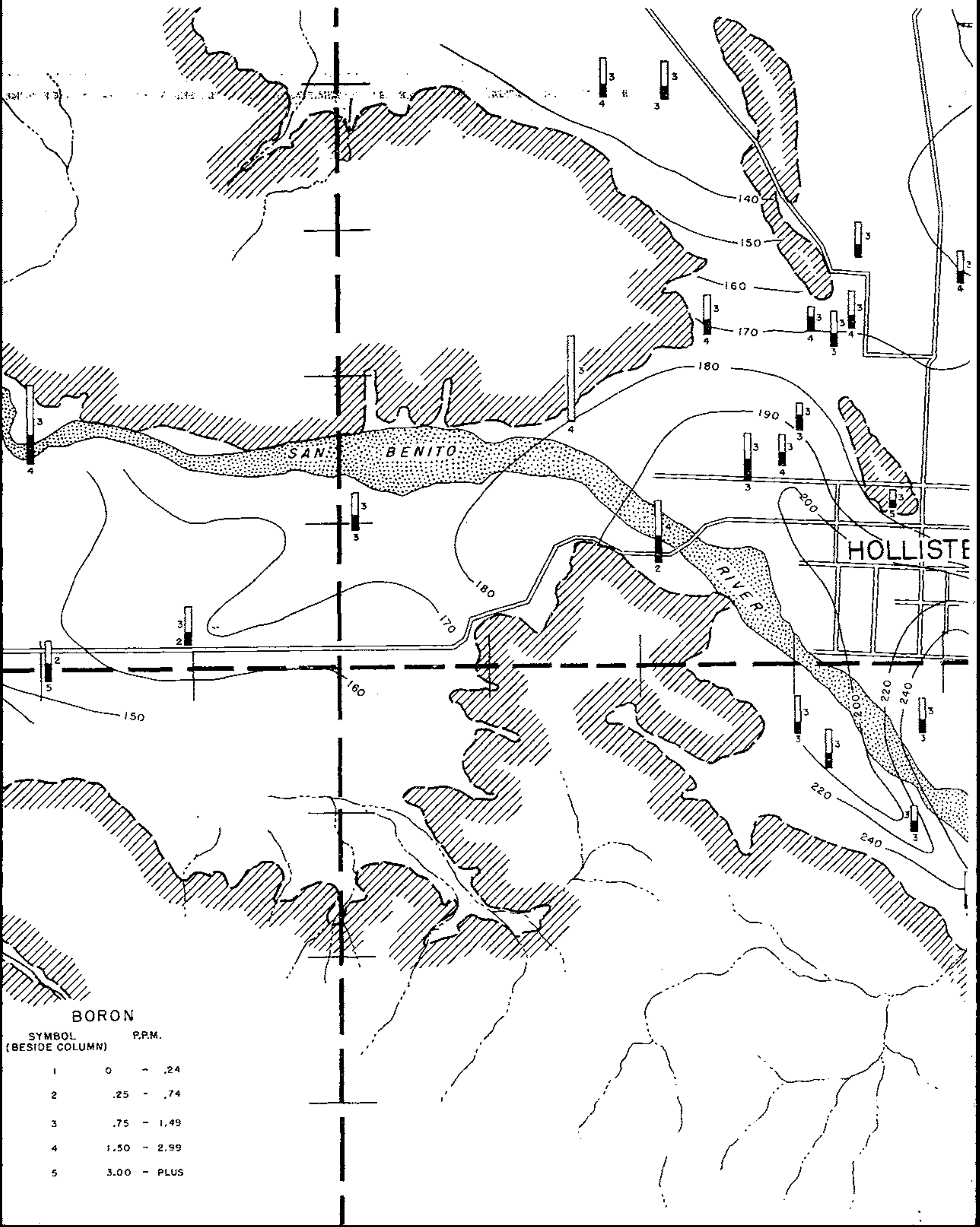
SCALE
MILLIGRAM EQUIVALENTS PER LITER
TOTAL ANIONS
SULPHATE
-40
-30
-20
-10
0
DEPTH
SYMBOL (BELOW COLUMN)
FEET
1 0 - 49
2 50 - 99
3 100 - 199
4 200 - 399
5 400 - PLUS
BORON
SYMBOL (BESIDE COLUMN)
P.P.M.
1 0 - .24
2 .25 - .74
3 .75 - 1.49
4 1.50 - 2.99
5 3.00 - PLUS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BORON
SYMBOL (BESIDE COLUMN)
P.P.M.
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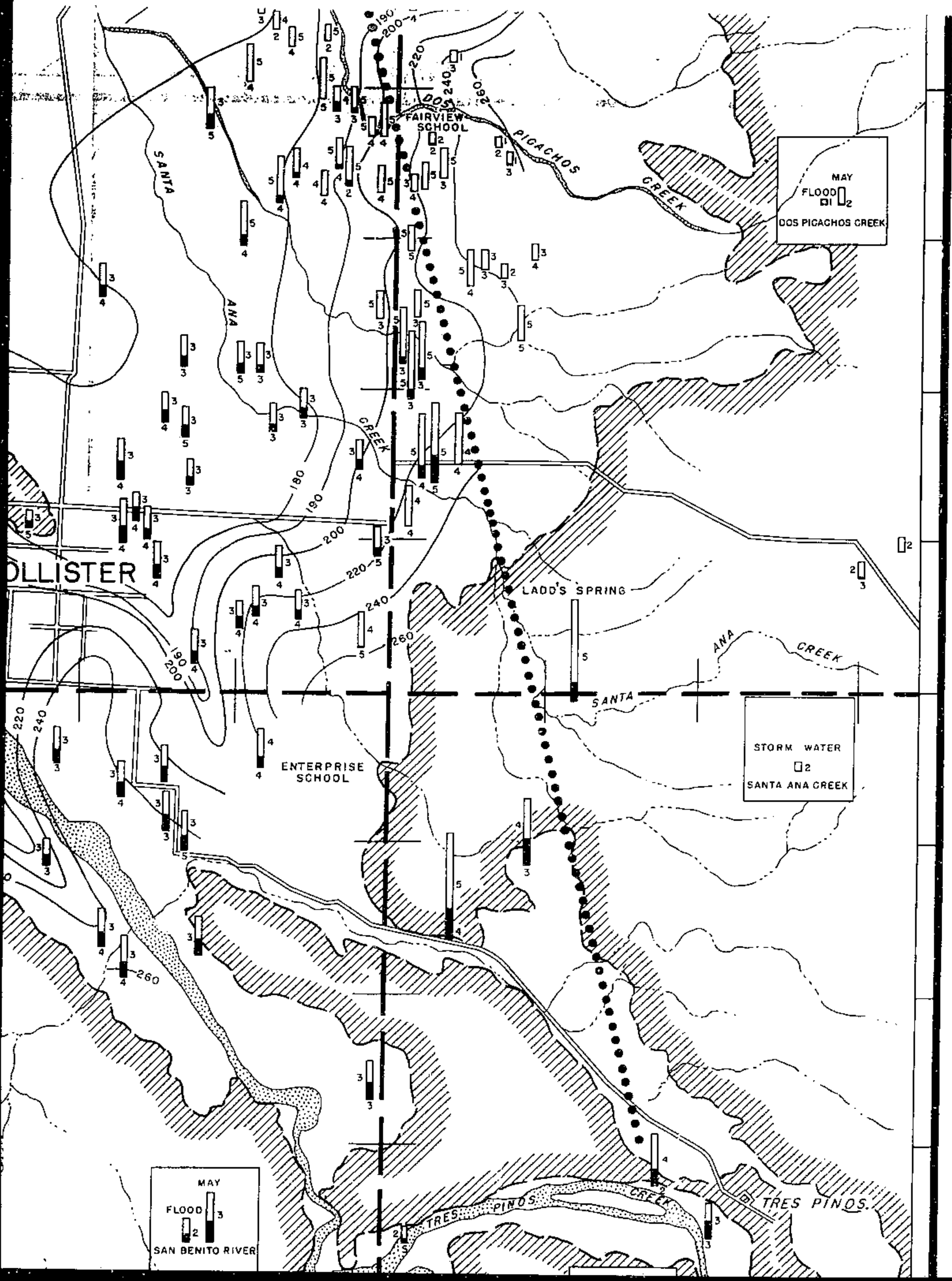
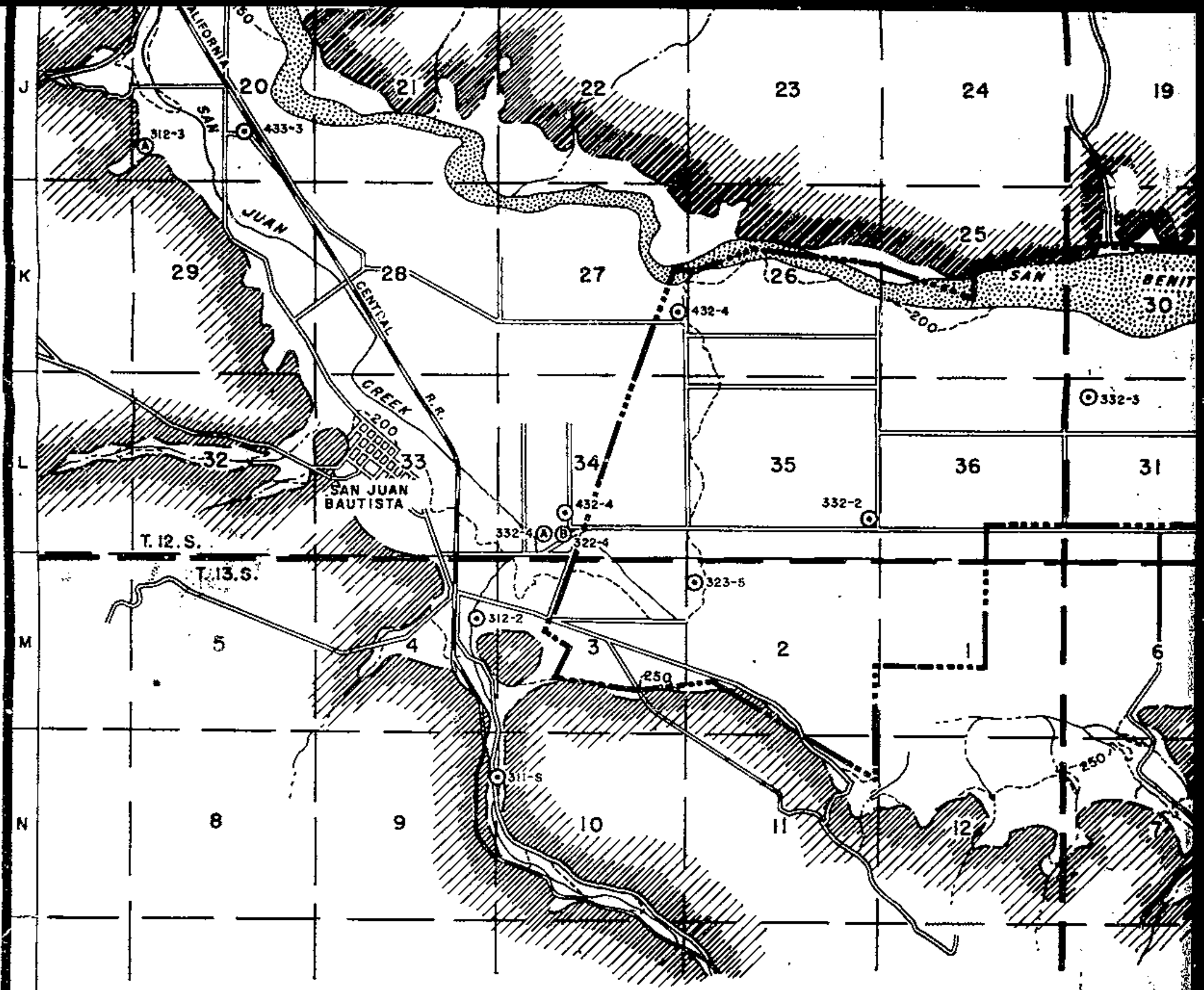


HOLLISTER
FAIRVIEW SCHOOL
DOS PICACHOS CREEK
SANTA ANA CREEK
LADD'S SPRING
ENTERPRISE SCHOOL
TRES PINOS CREEK
TRES PINOS
MAY
FLOOD
DOS PICACHOS CREEK
STORM WATER
SANTA ANA CREEK
MAY
FLOOD
SAN BENITO RIVER



INDEX TO WATER QUALITY CLASSIFICATION AND WELL DEPTH

THE FIRST FIGURE OF EACH NUMERICAL SYMBOL REPRESENTS CONDUCTANCE; THE SECOND, BORON; THE THIRD, PERCENT SODIUM; AND THE FOURTH, AFTER THE DASH, DEPTH OF THE WELL.

CLASS	CONDUCTANCE $K \times 10^5$ @ 25°C	BORON P.P.M.	PERCENT SODIUM	DEPTH FEET
1	0 – 24.0	0 – .24	0 – 19	0 – 49
2	25 – 74.9	.25 – .74	20 – 39	50 – 99
3	75 – 149.0	.75 – 1.49	40 – 59	100 – 199
4	150 – 299.0	1.50 – 2.99	60 – 79	200 – 399
5	300 – PLUS	3.00 – PLUS	80 – 100	400 – PLUS

(Face p. 22)

FIGURE 2.

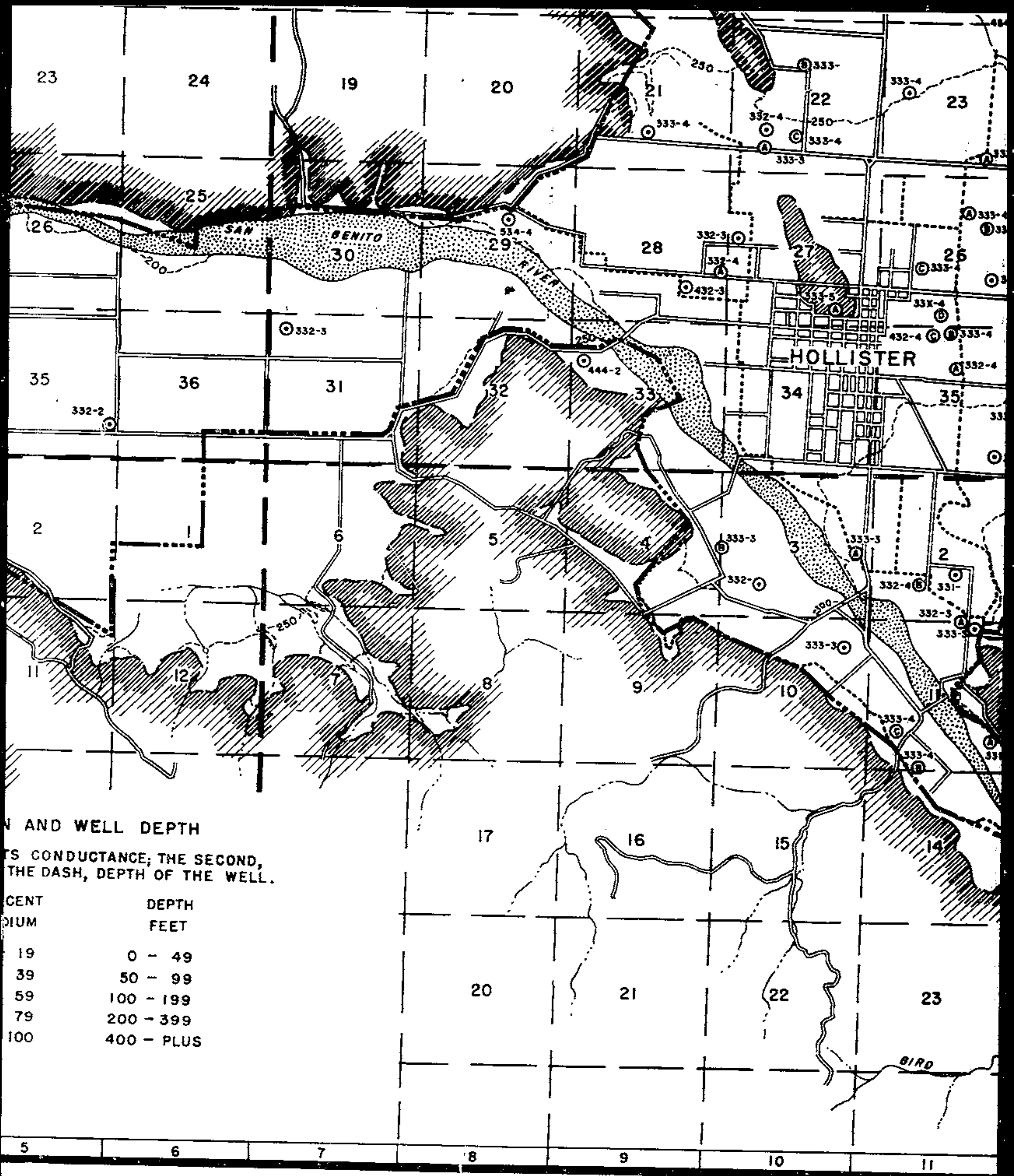
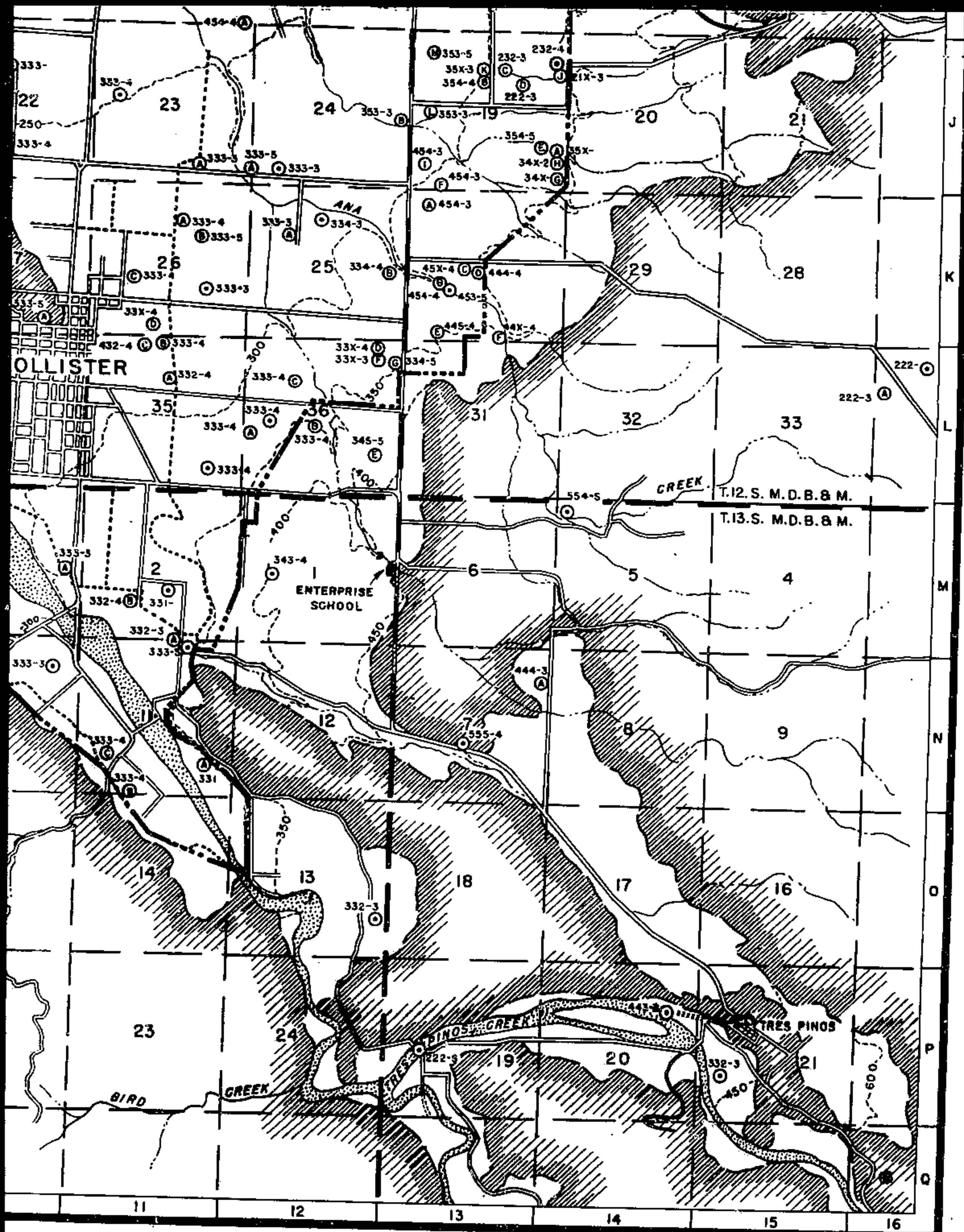


FIGURE 2.—Map of the Hollister area showing locations of wells sampled, with symbols indicating water quality and depth of well.



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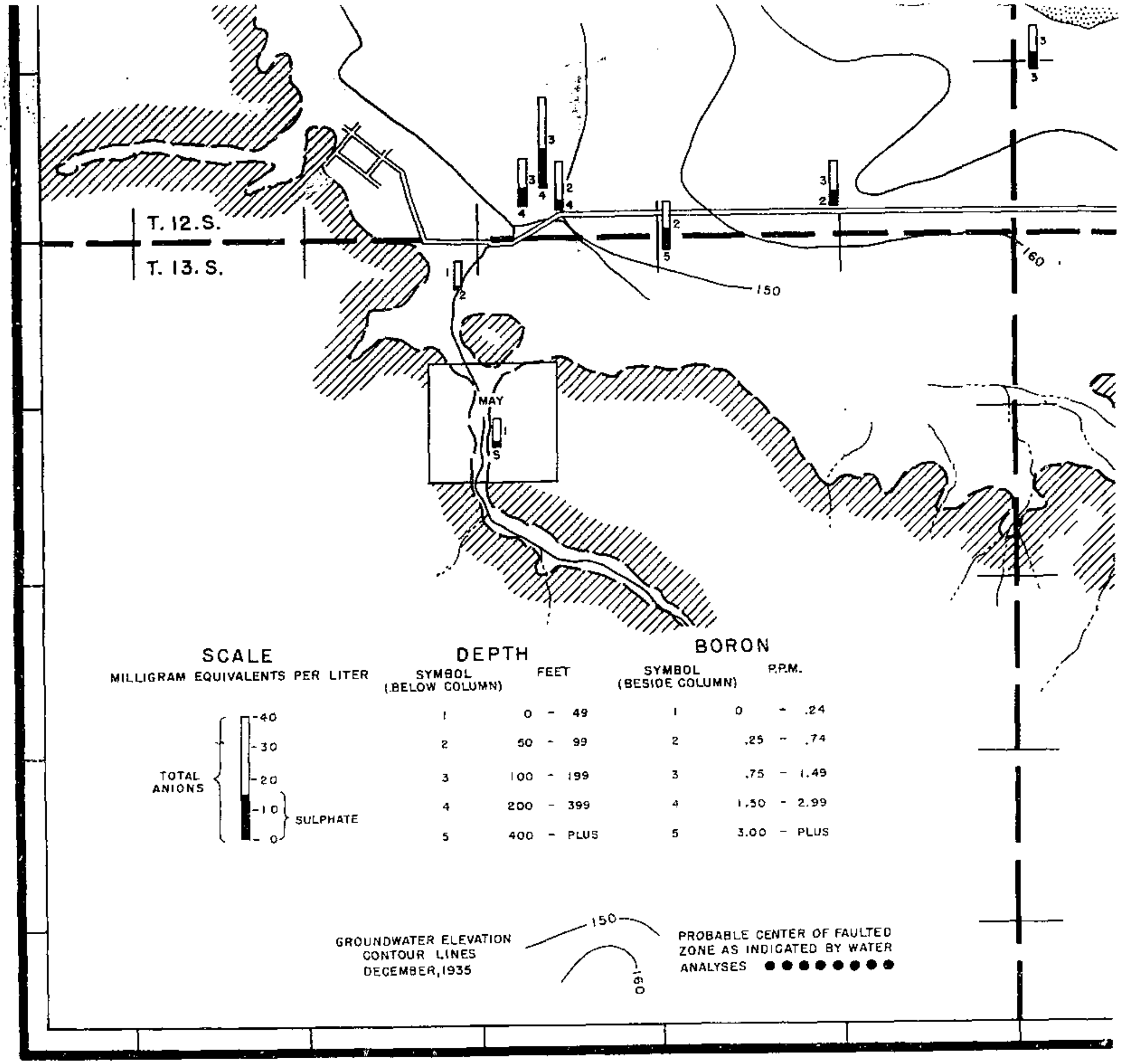
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SCALE
MILLIGRAM EQUIVALENTS PER LITER
TOTAL ANIONS
SULPHATE
40
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FEET
1 0 - 49
2 50 - 99
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BORON
SYMBOL (BESIDE COLUMN)
P.P.M.
1 0 - .24
2 .25 - .74
3 .75 - 1.49
4 1.50 - 2.99
5 3.00 - PLUS
GROUNDWATER ELEVATION CONTOUR LINES DECEMBER, 1935
PROBABLE CENTER OF FAULTED ZONE AS INDICATED BY WATER ANALYSES

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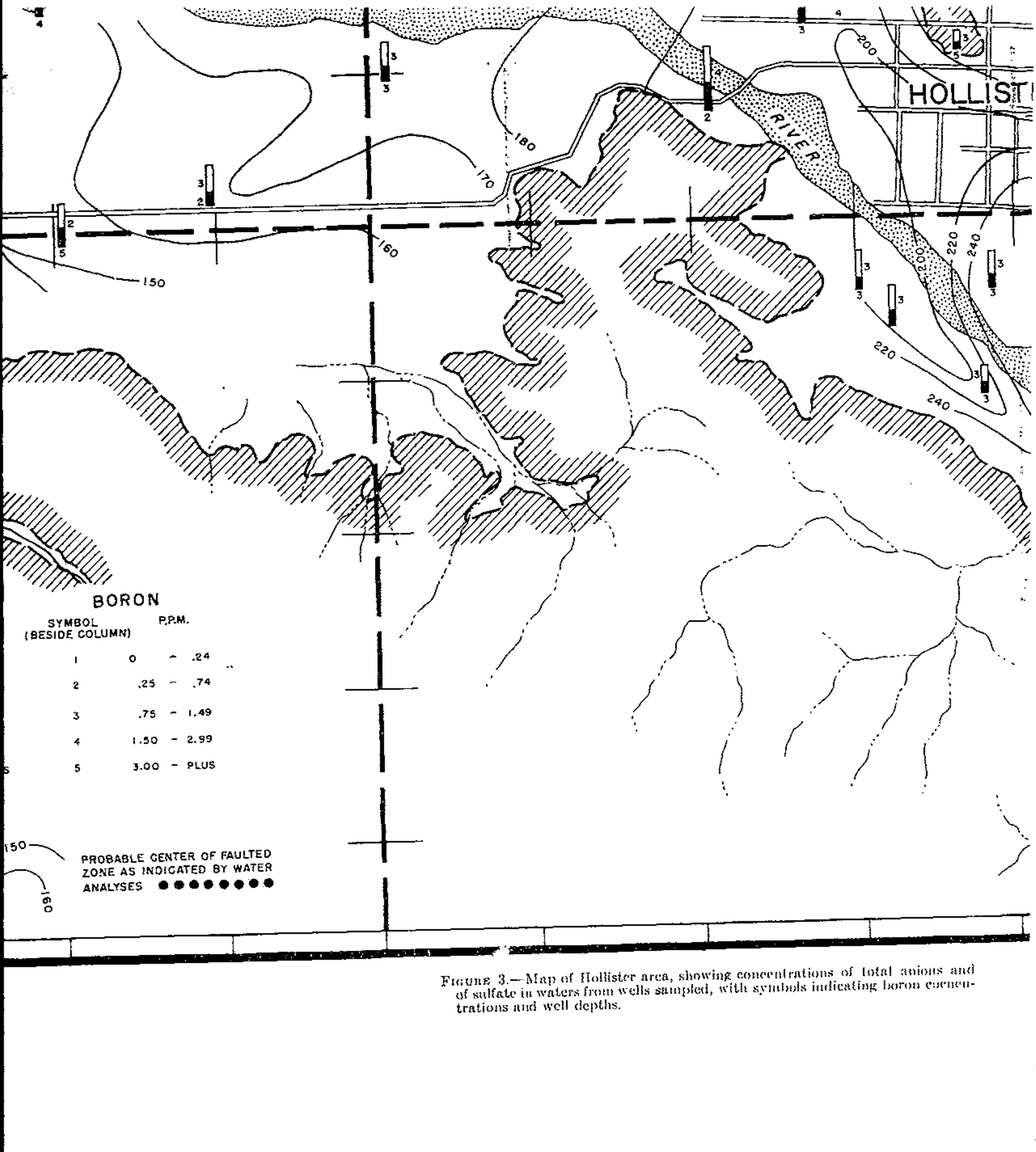
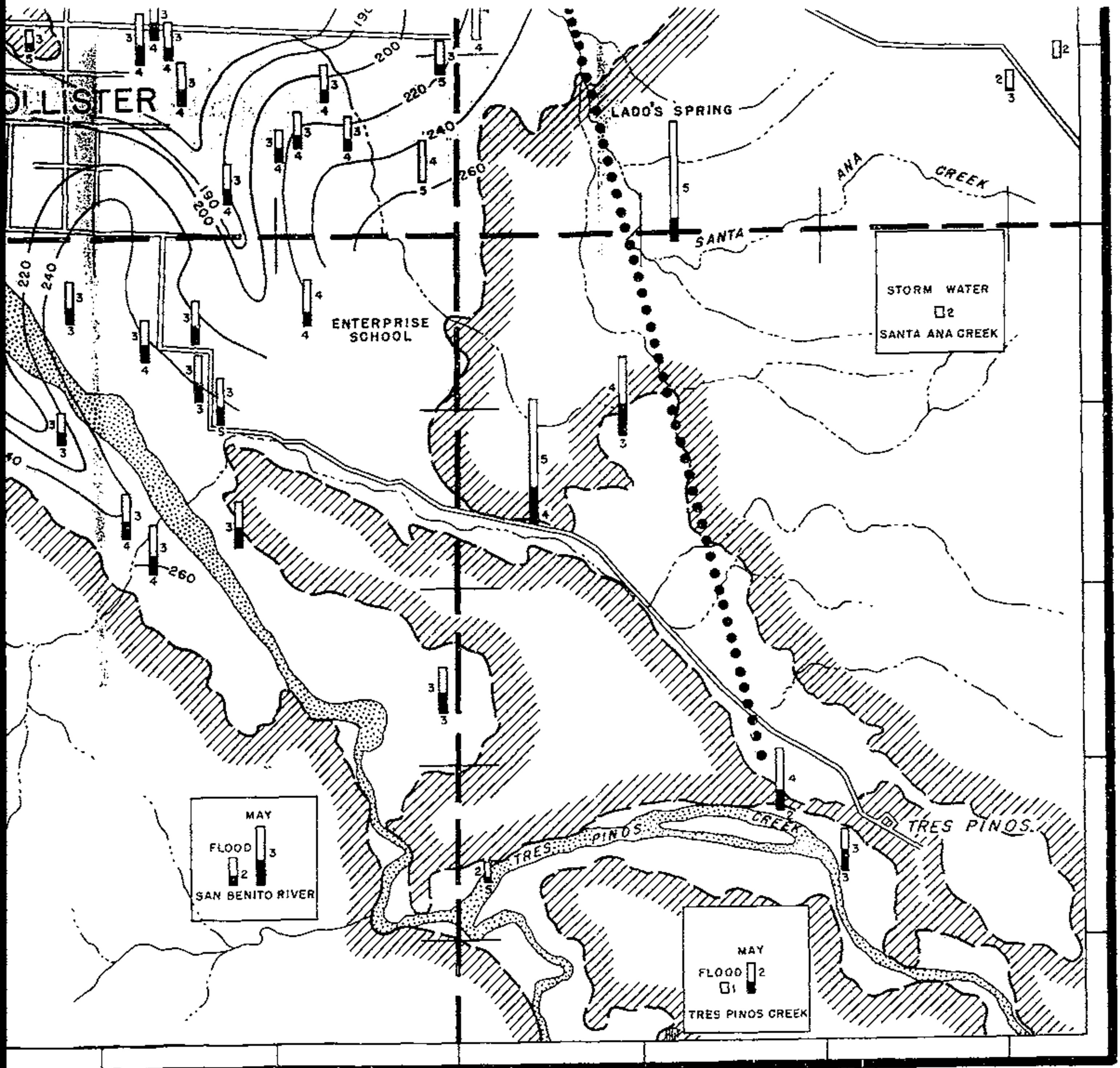


FIGURE 3.—Map of Hollister area, showing concentrations of total anions and of sulfate in waters from wells sampled, with symbols indicating boron concentrations and well depths.



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