Ground Water in the Cuyama Valley California

By J. E. Upson *and* G. F. Worts, Jr.

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By J. E. UPSON and G. F. WORTS, JR.

ABSTRACT

This is the fourth of a series of interpretive reports on the water resources of the major valleys of Santa Barbara County, Calif., prepared by the Geological Survey, United States Department of the Interior, in cooperation with Santa Barbara County. The first three reports described the other major valleys in the county: the south-coast basins, Goleta and Carpinteria, and the Santa Maria and Santa Ynez River valleys. This report deals with the Cuyama Valley in the northeastern part of the county and adjoining parts of San Luis Obispo, Kern, and Ventura Counties. It includes estimates of natural discharge, pumpage, and yield of ground water, and all data on water levels, well records, and water quality that were available up to June 1946.

The Cuyama Valley is a large semi-arid intermontane valley about 12 miles long east and west and 5 miles in maximum width, situated in midcourse of the Cuyama River. Agriculture is restricted mainly to a central alluvial plain. The development of ground water for irrigation has increased from essentially nothing in 1938 to about 40 wells that irrigated more than 5,000 acres in 1946.

Unconsolidated clay, silt, sand, and gravel, 3,000 to 4,000 feet in total thickness, compose the alluvium, terrace deposits, and older continental deposits of Recent, Pleistocene, and Pliocene age that supply nearly all the water to the irrigation wells. Some of the foothill areas and most of the bordering mountains are underlain by continental and marine sedimentary rocks ranging in age from Miocene to Cretaceous and by some igneous rocks of Jurassic(?) age. Of these older rocks the continental beds of Miocene age store and transmit some ground water, although they are tapped by only a few domestic and stock wells.

All the formations are deformed by folds and faults. The principal structures that affect ground-water circulation are two echelon faults in the middle of the plain. Along these faults are several large springs which had a total measured and estimated discharge of about 1,600 gallons a minute in March and April 1947. In addition, there are other small springs and seeps along a terrace face in the western part of the valley.

The ground water beneath the alluvial plain moves toward the center of the valley mainly from the south and southeast, and it moves westward out of the valley at the extreme end. The principal sources of recharge are the Cuyama River, streams from the Sierra Madre on the south, and infiltration of rain.

Ground water discharges naturally by upward leakage into the Cuyama River, through springs, by evapo-transpiration, and by subsurface escape from the valley. Total natural discharge has been crudely estimated to be on the order of 13,000 acre-feet a year. Estimated net discharge by pumping — net amounts after subtracting estimated return to ground water — was 1,200 acre-feet in 1939, and this increased to about 11,200 acre-feet in 1946. The total net discharge since 1940 averaged about 20,000 acre-feet a year.

Periodic measurements of water levels have been made in wells in the area of pumping since August 1941. These, together with miscellaneous measurements made in other wells, show that water levels declined not more than 3 or 4 feet to 1947. The small decline in water levels is thought to be the result of an unusual amount of recharge during the wet years from 1938 to 1944, which, in addition to maintaining the high water levels, probably supplied a substantial part of the water pumped for irrigation during the period.

The perennial yield of ground water in the Cuyama Valley is the maximum amount of water that can be practicably salvaged from natural discharge. It is thought that it might be possible to salvage 9,000 to 13,000 acre-feet each year, but this would require the judicious location of wells in the area of natural discharge.

In quality, the water is only fair, and the concentration of salts in areas of poor drainage is apparently injurious to some types of crops. In general, the water is hard and rather high in sulfate. In most samples, hardness ranges from 850 to 1,200 parts per million; calcium from 200 to 275 parts; magnesium from 50 to 120 parts; and sulfate from 750 to 1,500 parts. Chloride is relatively low, ranging in concentration from 7 to 50 parts. Except locally, other constituents are in small amounts.

INTRODUCTION

LOCATION OF THE AREA

The Cuyama Valley is largely in the extreme northeastern part of Santa Barbara County, Calif. It is traversed by the Cuyama River, which along much of its course forms the county boundary. The northern and northeastern parts of the valley are in San Luis Obispo, Kern, and Ventura Counties. The ground-water basin is between 119°25′ and 119°45′ west longitude and 34°45′ and 35° north latitude, and it is within the Santa Ynez and Mt. Pinos (abandoned) quadrangles of the United States Geological Survey. The location of the valley is shown on figure 9; other features are shown on plates 1 and 5.

DEVELOPMENT OF GROUND WATER

The development of ground water in the Cuyama Valley parallels the development of agriculture. Prior to 1941, when the United States Geological Survey first began the investigation of the area, most of the agriculture was dry farming, and grain was the principal crop. The greater part of the valley was, and still is, within one or two large ranches whose activities were mostly stock raising. In 1939 the only irrigated land was 400 acres of potatoes. By 1941, however, the total irrigated land had increased to about 3,000 acres, still planted chiefly to potatoes and watered from about 20 irrigation wells. In that year some acreage of potatoes was double-cropped, making the total area equivalent to 4,600 acres. The irrigated area was still only about 3,100 acres in 1944, doubtless owing to war conditions, but the variety of crops was larger and more wells were drilled. In 1945 and 1946 the irrigated land increased by nearly 1,000 acres each year, and by the spring of 1947 about 40 irrigation wells supplied water to more than 5,000 acres.

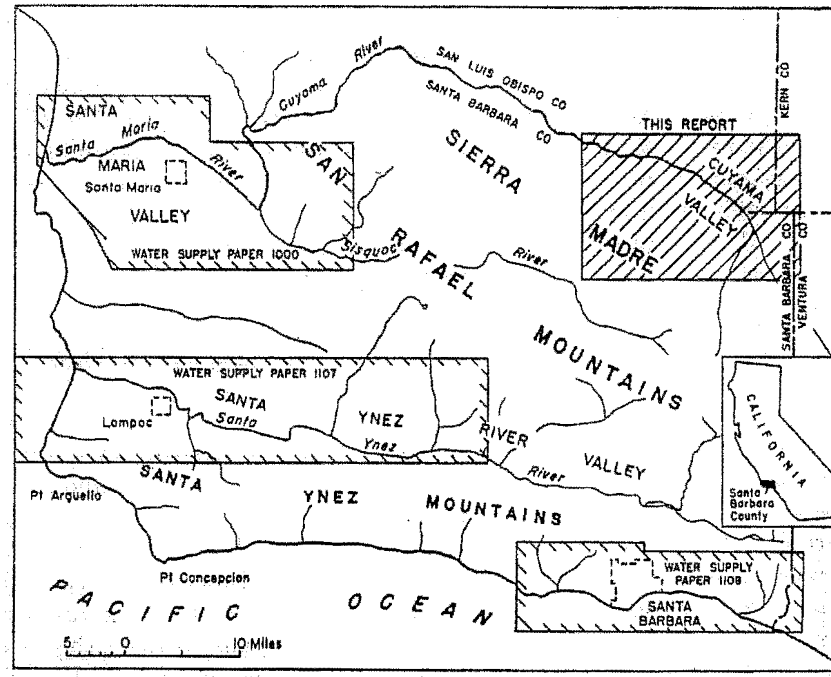


FIGURE 9. Index map of Santa Barbara County showing location of the Cuyama Valley, Calif. and area covered by plate 5 (shaded).

The population of the area has increased greatly, and a town site is being surveyed at the Cuyama post office. Electric power was made available to most of the valley by 1946, principally because of the demand for electrically operated pumping plants. The development of ground water is continuing as more land is cleared and new wells are drilled. The total amount of ground water pumped, which was less than 2,000 acre-feet in 1939, was nearly 17,000 acre-feet in 1946 and can be expected to increase.

PURPOSE AND SCOPE OF THE WORK

The investigation in the Cuyama Valley was undertaken by the Geological Survey in cooperation with Santa Barbara County for the purpose of evaluating the water resources of the principal agricultural districts of the county. This is the last of four reports; the others are on the Santa Ynez River valley (Upson, Thomasson, and others, 1951), the south-coast basins (Upson and Thomasson, 1951), and the Santa Maria Valley (Worts and Thomasson, 1951).

Inasmuch as the Cuyama Valley is in a relatively early stage of agricultural development, comparatively few wells have been drilled. Available records of rainfall, stream flow, and ground-water levels are few and cover periods of only a few years. Therefore, because data are not available on which to base a comprehensive and detailed study, the scope of the report must of necessity be narrow. The report is designed to summarize existing data on well records, water-level fluctuations, pumpage, quality of the water, and natural discharge as a basis for any more detailed investigations that may become desirable in the future. The report also gives a preliminary estimate of ground-water yield for the valley.

ACKNOWLEDGMENTS

The work and report were begun under the direction of the late O. E. Meinzer, geologist in charge of the Ground Water Division (now Branch), United States Geological Survey, and under the supervision of A. M. Piper, in charge of ground-water investigations in the Pacific Coast area. They have been completed under A. N. Sayre, present geologist in charge, Ground Water Branch, and J. F. Poland, district geologist for California. The work has been done in financial cooperation with the County of Santa Barbara, whose Board of Supervisors has been most helpful in carrying it forward. Considerable material aid or information also has been received from many individuals, companies, and agencies. Among these are the many ranchers and vegetable growers in the Cuyama Valley, the San Joaquin Power Division of the Pacific Gas and Electric Co., the United States Forest Service, the Richfield Oil Corp., and the Shell Oil Co.

WELL-NUMBERING SYSTEM

The well-numbering system used by the Geological Survey in the Cuyama Valley shows the locations of wells and springs according to the rectangular system for the subdivision of public land. For example, in the number 10/27–12J2, which was assigned to a well near the west end of the area, the part of the number preceding the bar indicates the township (T. 10 N.); the part between the bar and the hyphen shows the range (R. 27 W.); the digits between the hyphen and the letter indicate the section (sec. 12), and the letter indicates the 40-acre subdivision of the section as shown in the accompanying diagram. Within each 40-acre tract the wells are numbered serially, as indicated by the final digit of the

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

12

number. Thus, well 10/27-12J2 is the second well to be listed in the NE¼SE¼ sec. 12, T. 10 N., R. 27 W. As all of the Cuyama Valley covered by this report is in the northwest quadrant of the San Bernardino meridian and base line, the foregoing abbreviation of township and range is sufficient. The rectangular system of subdivision has been extended into areas that have never been public land.

PHYSICAL FEATURES OF THE AREA

GEOMORPHOLOGY

The Cuyama Valley is a broad intermontane basin, largely structural in origin, situated about midway along the course of the Cuyama River. The river rises in a leaf-shaped headward drainage basin in the northern part of Ventura County, surrounded by the rugged San Emigdio and Pine Mountains, nearly all more than 6,000 feet in altitude and with peaks as high as 7,500 to 8,800 feet. Downstream beginning near the old settlement of Ozena, the river has a narrow, nearly straight north-northwesterly course for about 15 miles. In this reach the river valley is joined by three long and several short dry canyons on the east, and by many short, steep gulches on the west. The most northerly of the long dry canyons is Ballinger Canyon opposite whose mouth is the large Santa Barbara Canyon which heads in high mountains on the south. Off the mouths of Ballinger and Santa Barbara Canyons the Cuyama River course changes to a northwesterly trend and opens rather abruptly into a broad alluvial plain, which is about 12 miles long east to west and about 5 miles in maximum width. This alluvial plain, which is the main agricultural area along the drainage basin, is the Cuyama Valley of this report. Its general setting is shown on plate 1, and outstanding features are illustrated by the photographs, plates 2, 3, and 4. The river traverses the alluvial plain, first along a northwesterly course, then westerly, and finally leaves the plain in a relatively narrow valley. (See pl. 2, *A*.)

The alluvial plain is nearly level in its central part but laterally passes into gently sloping alluvial fans. These abut abruptly against the sharply dissected terraces bordering the dry Caliente Range on the north (pl. 2, *B*), but less abruptly against the foothills of the San Emigdio Mountain on the east and the Sierra Madre on the south. In its southwestern part the Cuyama Valley is bordered by long, continuous, gently sloping remnants of terraces, which extend northward from the Sierra Madre west of Salisbury Canyon. Westward, these remnants are progressively higher above the intervening stream grades, but east of Salisbury Canyon they pass beneath the alluvium of the plain.

Three minor features of the area are significant with respect to both the geology and the occurrence of ground water: (1) a pair of linear ridges somewhat west of the middle of the alluvial plain; (2) the location and amount of entrenchment of the Cuyama River channel; and (3) the variation in slope and continuity of the plain.

In about the middle of the western part of the alluvial plain, parallel to and 1 to 1½ miles north of State Highway No. 166, are two nearly continuous or alined ridges, en echelon and having a trend slightly north of west. (See pl. 5.) The southernmost and westernmost of the two is about 1 mile north of the highway in secs. 7, 8, 9, 15, and 16, T. 10 N., R. 26 W., south of the Cuyama River and south of the Cuyama Ranch headquarters. It is called the Turkey Trap Ridge. As shown on plate 5, it is partly discontinuous, extending for a little more than 3 miles. It is 200 to 400 feet wide, and in places it rises 5 to 15 feet above the level of the alluvial plain to the south. Between these high points it is nearly level with and appears to be continuous with the plain on the south. Near the west end are two gaps through which the alluvial plain slopes steeply from the south to the north sides of the ridge. However, the ridge summit is 25 to 35 feet above the alluvial plain on the north side, and the north flank is characterized by discontinuous benches as if terraced by the river. The west end slopes gently down and passes beneath the plain, but the east end is steepened and cut off somewhat abruptly by a spring-discharge channel. The higher parts of the ridge are capped locally by bodies of coarse gravel apparently stream-laid.

The northern of the two sets of ridges is north of the river, nearly all in secs. 11 and 13, T. 10 N., R. 26 W., and comprises two separate but alined ridges about half a mile apart, called the Graveyard Ridges. The western of the two is the larger and more prominent (pl. 3). It is about 300 feet wide at the base and half a mile long. Its summit is 20 feet above the plain to the south and 30 feet above the plain to the north. The smaller ridge is about 200 feet in maximum width and a quarter of a mile long, and rises only 10 to 15 feet above the plain. Its long axis is definitely alined with that of the larger ridge along a trend slightly north of west, and about parallel with the Turkey Trap Ridge. The larger of the Graveyard Ridges has remnants of a cap of coarse gravel, and the smaller has a few scattered pebbles on the highest part. Both parts of this ridge system have a steep north-facing scarp (pl. 3, *A* and *B*), a more gently sloping south side, and a suggestion of a slight southward slope of the top surface. The ends of both ridges slope gently down and appear to pass beneath the alluvium.

Both the Graveyard Ridges and the Turkey Trap Ridge probably are remnants of an older land surface nearly buried by alluvium and are probably composed of prealluvial deposits.

The second minor feature is the entrenchment of the Cuyama River channel. A short distance below the mouth of Santa Barbara Canyon, the river channel is about at the level of the plain — incised perhaps 1 to 2 feet. This entrenchment increases very slightly downstream, and amounts to

about 5 feet at the crossing of State Highway 166. From this point westward the entrenchment increases more rapidly to about 25 feet between the Graveyard and the Turkey Trap Ridges, and to 40 or 50 feet near the western end of the valley. (See pl. 4.) Another feature of entrenchment is the so called "New River," which is a broad-bottomed irregular trench 10 to 20 feet deep. Its floor is covered with dense vegetation, and it has standing or slowly moving water in the western part. Though irregular in detail, the trench has a generally straight alinement for several miles east of the Weir Spring (p. 40), but a curving course west of that spring (pl. 5).

The third minor feature is that the alluvial plain itself has some differences in continuity and slope. For example, the plain is several feet higher on the south side of both sets of ridges than on the north side. Also, at the east end of the Turkey Trap Ridge its slope steepens abruptly.

These features probably are related to the two faults immediately south of the ridges in midvalley, shown on plate 5. The ridges are considered to be in large part erosional remnants whose elongate form was determined by faults in the older continental deposits from which the ridges were carved. The relatively slight entrenchment of the Cuyama River in its eastern part may have been due to late slight movement on at least the southern fault such that the area south of the fault has been relatively dropped, thus causing the river to continue to aggrade its course. This may also explain the steepening of the slope at the east end of Turkey Trap Ridge. The present slight dissection is probably due to local climatic fluctuations. During at least the late stages of deposition of the alluvium, the river course probably has been between the two ridges as it is now. Accordingly, south of the Turkey Trap Ridge the alluvial plain has been built up higher than on the north side, because the ridge has dammed the tributary streams from that side. Similarly, the Graveyard Ridges formed an obstruction to the filling by the Cuyama River, causing the level of deposition to be higher south of the ridges than north of them, but having smooth, though slightly steeper slopes in the intervening areas. The straight-line trend of the "New River" and also its entrenchment may be due to movement on a third fault along the trench, but other evidence therefore is lacking. Additional evidence for the first two faults mentioned is discussed on pages 38 and 39.

CLIMATE

Although actually within the Coast Ranges, the Cuyama Valley has many of the climatic features of a typical desert basin. This is because it is at the landward side of the Coast Ranges near the southern end of the San Joaquin Valley and is surrounded by relatively high mountains. The valley has little rain, most of it in winter but some in summer in occasional thunder showers. Snow rarely falls on the valley floor but rather frequently in the adjoining mountains east and south. Winter temperatures are low;

there are many nights of below-freezing temperatures, but the days generally are comfortably warm unless the sun is obscured. Summer temperatures are high, frequently in the nineties and occasionally above 100°, but generally they are not so high as in the nearby San Joaquin Valley.

Rainfall has been measured at four stations in and near the valley. The longest record, dating back to 1903, is for Ozena near the head of the Cuyama Valley (pl. 1), and the shortest, since 1945, is at Cuyama in midvalley. A record has been kept since 1915 at Pattiway in the hilly area northeast of the valley, and since 1931 at the Cuyama Ranger Station southeast of the main cultivated area. Thus, the longest records are in the hilly area bordering the valley proper; very little is known concerning rainfall on the valley plain. The available records are given in table 1.

The records are inadequate, but they show the main features of the seasonal distribution and intensity of the rainfall. The bulk of the precipitation is in winter; considerably more rain falls in the higher areas, as at Ozena, than in the lower areas, as on the valley floor. The altitude at Pattiway is slightly greater than at Ozena, but the rainfall is appreciably less because Pattiway is remote from mountainous areas surrounding the valley. In general, rainfall is heavy on the higher parts of the Sierra Madre to the south, and evidently is heaviest on the San Emigdio and nearby peaks on the northeast drainage divide of the Cuyama River.

Only a few data are available on temperatures in the Cuyama Valley; records have been kept at Cuyama only during 1945 and 1946. For 1945, the annual mean temperature was 58.4° F., with a maximum of 104° on July 27 and a minimum of 15° on December 15. For 1946, the annual mean was 57.6°, with a maximum of 105° on August 3 and a minimum of 17° on February 11. The average of the two annual means is 58° F.

OCCURRENCE OF GROUND WATER

GEOLOGIC FORMATIONS

The geologic features of the Cuyama Valley were examined only briefly in connection with this investigation, and previous work in and near the area has been drawn upon rather heavily — notably the work of English (1916, pp. 191–215) and that of Dibblee as shown on an unpublished map of Cuyama Valley area made in 1946 and now in the files of the Richfield Oil Corp. A report by Eaton and others (1941) is of some value, but it does not deal directly with the area under consideration. The formations that are partially penetrated by and that yield water to wells have been distinguished. These are the youngest and the most permeable formations of the area and are three or four thousand feet in thickness. They rest on a variety of older formations, which also include in large part relatively permeable deposits. Although these deposits are not generally tapped by water wells, they contain and transmit considerable water.

TABLE 1. — *Monthly and yearly precipitation, in inches, at four stations in and near the Cuyama Valley, Calif.*

[Except as indicated, data are from publications of the United States Weather Bureau]

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Year
Ozena (altitude 3,700 feet)													
903–04	..	..	..	0.40	1.55	2.90	0.85	0.20	0	0	0.40	1.20	...
904–05	0	0	1.28	1.08	7.46	10.30	.05	1.61	0	0	0	.18	21.96
905–06	.23	.97	.52	1.13	1.69	6.16	.57	.44	0	.63	0	0	12.34
906–07	0	.37	4.22	11.59	.75	6.46	0	0	0	0	0	0	23.39
907–08	2.83	0	1.05	4.80	5.30	.10	.35	.20	0	.10	.25	1.94	16.92
908–09	.10	1.70	1.67	6.61	4.90	4.73	.10	0	.32	0	.67	0	20.80
909–10	.10	1.60	8.83	2.52	.60	2.25	.55	0	0	.25	0	4.50	21.20
910–11	.75	.45	1.00	10.63	5.75	7.25	.45	.28	.10	0	0	.50	27.16
911–12	0	.70	1.33	.51	.10	5.93	.65	.77	0	0	0	0	9.99
912–13	.15	.57	0	3.10	5.55	.12	0	0	.72	0	.32	0	10.53
913–14	0	2.24	.86	10.08	9.47	.57	.39	.53	0	0	0	0	24.14
914–15	.56	0	3.57	6.21	6.82	.76	1.20	1.01	0	0	0	.08	20.21
915–16	0	.44	1.72	8.38	.64	2.19	.52	0	0	0	0	.83	14.72
916–17	1.13	.12	3.05	2.88	1.63	.20	.52	.39	0	.26	0	0	10.18
917–18	0	0	.10	.73	9.97	6.69	0	Tr.[1]	0	.14	0	.94	18.57
918–19	0	1.86	1.50	.80	2.47	2.94	.09	2.19	0	0	0	.43	12.28
919–20	.11	.36	1.62	.20	2.49	4.89	.42	0	0	0	0	0	10.09
920–21	.32	.54	1.00	3.78	1.14	.52	.43	1.18	0	.08	0	.28	9.27
921–22	.52	.22	5.99	2.86	3.01	1.98	0	.15	0	0	0	0	14.73
922–23	.42	1.15	3.18	1.46	.33	0	1.51	0	.15	0	1.10	.25	9.55
923–24	.40	.10	.40	.47	.18	2.61	.79	0	0	0	0	0	4.95
924–25	.22	.30	.76	.61	.48	2.23	1.02	.97	1.10	.40	.94	0	9.03
925–26	.95	.97	1.35	1.50	2.69	.38	6.51	0	0	0	0	0	14.35
926–27	.19	2.62	1.31	.55	5.88	1.60	.65	.42	0	0	0	0	13.22
927–28	.70	.46	1.63	.10	3.26	.68	.48	.54	0	0	0	0	7.85
928–29	.09	1.16	1.34	1.20	.39	1.48	.82	.27	.06	0	.23	0	7.04
929–30	.13	0	0	1.65	.92	2.55	.36	.45	0	0	0	.08	6.14
930–31	.12	1.49	0	3.15	2.65	.09	1.46	.97	.17	.23	.84	.11	11.28
931–32	0	1.92	5.72	1.40	5.33	.03	.26	0	.10	0	0	1.04	15.80
932–33	0	.15	.57	5.92	.22	.06	.38	.38	0	0	0	0	7.68
933–34	.20	.12	2.96	.26	1.88	.25	0	.19	.15	0	0	0	6.01

[1]Trace means 0.005 inch or less of rain or melted snow.

TABLE 1. — *Monthly and yearly precipitation, in inches, at four stations in and near the Cuyama Valley, Calif.* — Continued.

[Except as indicated, data are from publications of the United States Weather Bureau]

Water Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Year
Ozena (altitude 3,700 feet) — Continued													
1934–35	2.38	1.54	2.16	3.82	0.39	2.15	1.16	0	0	0.06	0.58	0.13	14.37
1935–36	.44	.35	1.37	.48	5.47	.99	.54	.05	0	.06	.32	0	10.07
1936–37	2.70	.05	5.76	1.52	3.11	5.49	.12	.04	0	0	0	0	18.79
1937–38	.18	0	1.50	2.98	7.45	6.47	1.03	0	0	.53	.19	.06	20.39
1938–39	.21	.10	4.51	2.40	.68	2.28	.36	.72	0	0	. 4	2.44	13.74
1939–40	.09	.02	.65	2.44	3.63	1.43	.46	0	0	0	0	0	8.72
1940–41	.96	.37	7.27	3.47	6.28	9.12	3.28	1.76	.09	0	.03	0	32.63
1941–42	.77	.34	4.15	.83	.54	.66	2.41	0	0	0	.24	0	9.94
1942–43	.25	.12	.57	8.19	2.53	3.00	1.64	0	0	0	0	0	16.30
1943–44	.16	.06	4.27	1.30	6.50	1.10	.36	.13	0	0	0	0	13.88
1944–45	.10	3.05	.22	.50	2.61	2.48	.12	1.06	0	0	.13	0	10.27
1945–46	2.63	.23	4.06	.63	1.24	4.45	.09	.03	0	.71	0	.30	14.37
42-year average	0.50	0.69	2.26	2.97	3.20	2.75	0.76	0.40	0.07	0.08	0.14	0.34	14.16
Pattiway (altitude 3,790 feet)													
1915–16	[1]0	[1]0.31	2.10	3.21	0.49	2.16	0.53	Tr.	0	0	0.30	0.72	9.82
1916–17	1.07	0	2.92	2.39	Tr.	.36	.87	0.92	0	Tr.	.05	0	8.58
1917–18	.05	.74	.08	1.41	6.56	3.32	Tr.	Tr.	Tr.	Tr.	Tr.	1.08	13.24
1918–19	.50	2.27	2.06	Tr.	3.26	2.95	.52	1.77	0	Tr.	0	.26	13.59
1919–20	.10	.90	.85	.31	1.62	3.86	.35	0	Tr.	0	.10	0	8.09
1920–21	.30	Tr.	1.14	2.40	.96	.74	.66	2.08	.15	0	.15	0	8.58
1921–22	0	.60	2.51	4.00	1.76	2.89	.10	1.23	Tr.	.10	0	0	13.19
1922–23	.40	.81	1.53	1.03	.72	.05	1.69	0	Tr.	0	Tr.	Tr.	6.23
1923–24	.69	1.05	.64	.15	.74	1.90	1.58	0	0	0	0	Tr.	6.75
1924–25	.35	.62	1.44	1.01	.58	2.00	1.20	.50	.10	0	.15	0	7.95
1925–26	.58	.75	.95	1.65	2.34	.48	3.60	.06	0	0	Tr.	0	10.41
1926–27	.27	2.65	2.44	1.16	3.58	2.32	.46	.05	.65	0	0	0	13.58
1927–28	1.21	.73	.72	.81	2.11	.41	1.00	.78	0	0	0	0	7.77
1928–29	.10	1.59	1.14	.96	.66	1.73	.48	0	Tr.	0	0	0	6.66
1929–30	0	0	.02	1.57	1.61	.22	.31	.83	0	Tr.	Tr.	.08	4.64
1930–31	.08	1.12	Tr.	2.46	1.38	.39	.78	.22	.42	0	Tr.	Tr.	6.85
1931–32	.22	1.92	4.10	1.43	4.14	Tr.	.84	.12	0	0	0	.33	13.10
1932–33	.05	.11	1.24	4.16	Tr.	.08	.58	.60	1.00	0	Tr.	0	7.82
1933–34	.47	.13	.84	.07	1.26	.26	0	.15	0	0	0	Tr.	3.18
1934–35	1.63	1.78	1.42	2.84	1.72	1.94	.71	.16	0	0	.81	.72	13.73
1935–36	.55	.30	.81	.38	3.54	1.30	.20	.47	.42	0	.28	0	8.25
1936–37	2.11	.05	4.15	1.72	1.63	2.54	.50	.05	0	0	0	0	12.75
1937–38	.25	Tr.	1.78	2.74	2.65	5.75	1.37	Tr.	0	0	0	Tr.	14.54
1938–39	.17	.16	2.09	2.30	1.03	1.63	.99	.23	0	0	Tr.	1.26	9.86
39–40	0.39	0.14	0.66	1.87	2.33	0.44	1.77	0	0	0	0	Tr.	7.60
40–41	1.10	.59	2.53	2.06	4.09	5.35	3.22	.08	0	0	0	0	19.02
41–42	1.25	.30	4.27	.62	.05	.41	3.64	.15	0	0	.16	0	10.85
42–43	.70	.58	.69	5.28	1.95	1.67	2.21	.18	0	0	0	0	13.26
43–44	.55	.10	1.64	.59	5.29	1.36	1.01	.20	Tr.	0	0	0	10.74
44–45	Tr.	3.27	.57	.57	2.41	2.85	.22	.25	0	Tr.	Tr.	.62	10.76
45–46	.56	.43	2.04	.63	.92	2.21	.81	.24	0	0	0	0	7.84
1-year average	0.51	0.77	1.59	1.67	1.98	1.73	1.04	0.37	0.09	0	0.06	0.16	9.97
Cuyama Ranger Station (altitude 2,755 feet)[3]													
1–32	...	...	...	...	...	...	...	...	...	...	...	1.04	...
2–33	0	0.15	0.57	5.92	0.22	0.06	0.38	0.38	0	0	0	0	7.68
3–34	.20	.12	2.96	.26	1.88	.25	0	.19	.15	0	0	0	6.01
4–35	.95	...	...	...	...	...	...	...	...	...	.55	.22	...
5–36	.29	.19	1.19	.24	1.14	.56	.24	.23	.12	.07	.06	0	4.33
6–37	2.25	...	...	...	...	...	...	...	...	...	...	...	13.18
7–38	...	...	.06	.99	2.27	3.54	4.52	.90	...	...	...	...	...
8–39	...	...	...	2.00	.86	1.98	.60	.24	0	0	.01	2.39	...
9–40	.08	.01	.48	1.57	1.73	.55	1.68	0	0	0	0	.08	6.18
0–41	1.09	.19	3.97	1.98	4.04	3.60	3.47	0	0	0	.02	0	18.36
1–42	.74	.11	2.71	.99	.19	.61	4.25	.04	0	0	.10	0	9.74
2–43	.25	.22	.81	5.08	1.38	1.43	2.40	.08	0	0	0	0	11.65
3–44	.50	.06	2.67	.51	7.62	.58	1.19	.13	0	0	0	0	13.26
4–45	.01	2.86	.64	.04	1.97	2.05	.12	.78	0	0	0	.40	8.87
5–46	.04	.22	1.26	.50	.78	1.53	.78	.09	0	.05	0	0	5.25
1-year average	....	....	....	....	....	....	....	....	....	....	....	....	[4]9.50
Cuyama (altitude 2,260 feet)													
4–45	...	...	...	0.06	1.49	1.35	0.07	0.66	Tr.	0	0.01	0.59	...
5–46	0.13	0.13	1.42	.14	.73	1.41	.51	.02	0	0	0	Tr.	4.49

Trace means 0.005 inch or less of rain or melted snow.
Estimated as 71 percent of rainfall at Ozena.
Record 1931-1932 to 1937-38 from War Department, U. S. Engineer Office, Los Angeles.
Excluding 1931-32, 1934-35, and 1937-39.

PRINCIPAL FORMATIONS THAT YIELD WATER TO WELLS

The formations that yield water to wells are the alluvium — including river-channel deposits — terrace deposits, and older continental deposits. Their distribution is shown on plate 5.

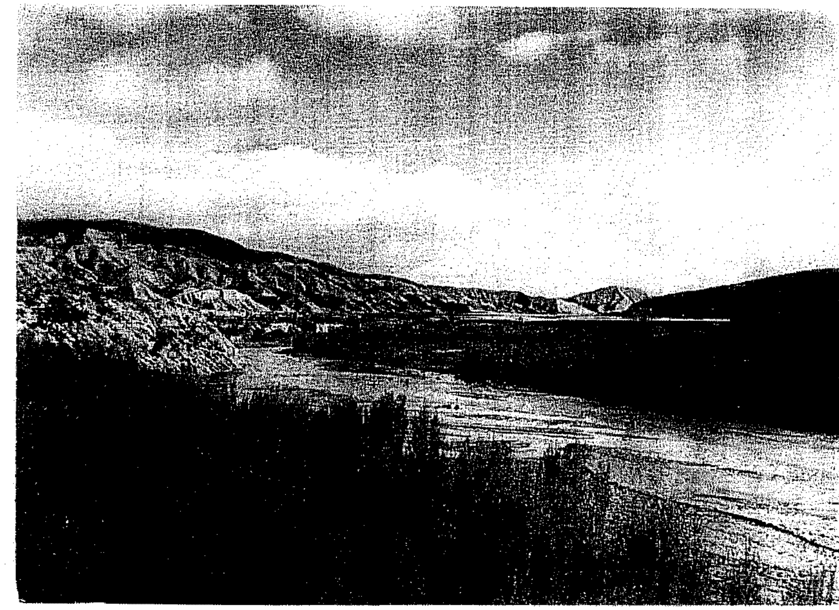
ALLUVIUM

The alluvium underlies and forms the alluvial plain of the Cuyama Valley and extends in tongues up the valleys of tributary streams. It includes the channel deposits of these streams and of the river. In general it rests with angular unconformity on the older continental deposits and locally on still older formations. It also overlies the terrace deposits, unconformably at least along the margins of the plain, but it may be conformable with them beneath the eastern part of the plain. As indicated beyond, the alluvium and terrace deposits are not readily distinguishable in well logs. The alluvium is considered to be of Recent age.

In the part of the valley west of Cuyama, the upper beds of the alluvium are exposed in steeply cut banks along the river (see pl. 4, *A*), but information concerning most of the formation is obtained from records of wells. As exposed, the upper 10 to 50 feet is mostly sand and silt in even beds, locally with thin clay seams. Most beds appear massive, but some are evenly stratified or slightly cross-bedded. Along the river in sec. 10, T. 10 N., R. 26 W., exposures show a rather persistent bed of compact bluish clay about 5 feet thick, about 15 feet below the top of the stream banks. This bed is traceable along the river for half a mile to a mile, but it may not be extensive laterally as it is not reported in the logs of wells 10/26-9R1 and 10/26-9R2. However, the bed may be sufficiently continuous along the river channel to support shallow water along that reach. The channel deposits are composed predominantly of coarse sand and gravel. Their thickness is not known.

As revealed by well logs the deposits are highly variable in composition. In the western part of the valley the alluvium consists of sand and gravel in beds several feet thick alternating with beds of clay from 1 to 36 feet thick. (See logs of wells 10/27-11C1, 12E1, and 12J1, table 10.) These wells, though not deep, have moderately large yields; hence it is inferred that the sand and gravel have fairly high permeability. In the south-central part of the valley, as reported in logs of wells in secs. 21, 22, and 23, T. 10 N., R. 26 W., the alluvium is generally finer-grained in that it has little gravel. The logs indicate a predominance of sand and silt (sandy clay) with some beds of gravel, and clay and gravel, and some beds of clay. No continuous layers of any material seem to exist.

In contrast, in the eastern part of the area, the alluvium seems to be considerably coarser-grained. Logs of wells northeast of the river in secs. 20 to 23 and 26, 27, and 35, T. 10 N., R. 25 W., are very much generalized, but they show predominantly coarse gravel and sand in the

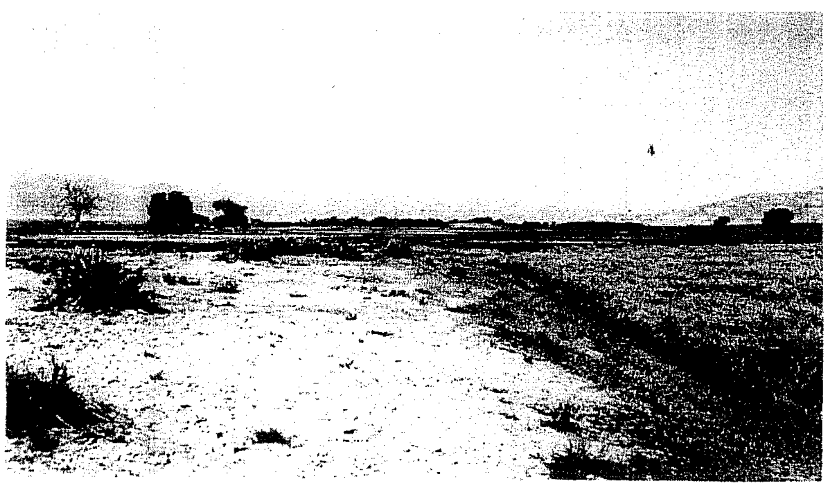


A. LOWER VALLEY OF CUYAMA RIVER.
View upstream from highway bridge below Cottonwood Creek. Photo, January 28, 1942.

B. PART OF CUYAMA VALLEY ALLUVIAL PLAIN.
View northward to Caliente Range from Graveyard Ridge. Tule swamp in foreground; then toward the rear a grass swamp (shown as a narrow dark band), sage-covered flats, terraces, and barren mountain slopes of the Caliente Range. Photo, April 24, 1947.

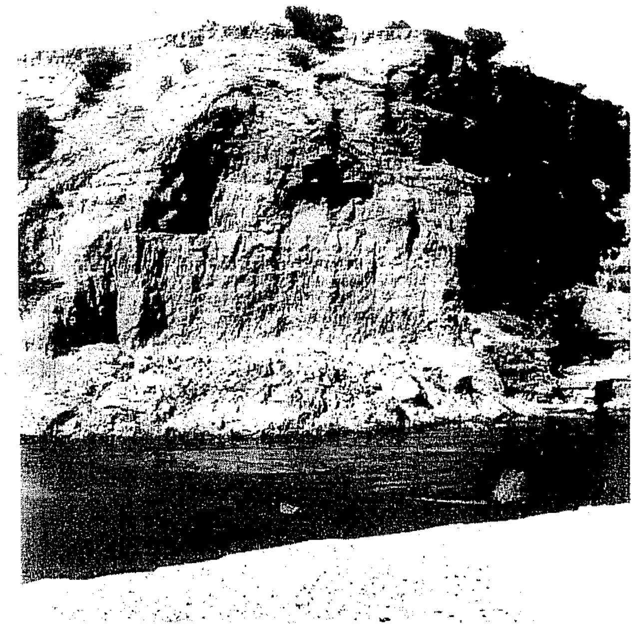
A. VIEW WESTWARD ALONG NORTH SIDE OF THE LARGER GRAVEYARD RIDGE

Shows straight alinement and rather steep slope; also, grassy swamp at base (right). Photo, April 24, 1947.



B. VIEW WESTWARD ALONG ALINEMENT FROM SMALLER TO LARGER OF GRAVEYARD RIDGES.

Tule swamp at right and grassy meadow between ridges. Photo, April 24, 1947.



A. RIVER BANK OF ALLUVIUM NEAR MISCELLANEOUS MEASURING SITE ON CUYAMA RIVER.

SE¼SW¼ sec. 1, T. 10 N., R. 27 W. View northward. Photo, April 24, 1947.

B. NORTHERN OF TWO MAIN ORIFICES OF GRAVEYARD SPRINGS (10/26-14C2).

Orifice is in fine-grained alluvium. View southeastward. Photo, April 24, 1947.

upper 100 to 200 feet. Also, logs of wells southwest of the river in secs. 30 to 33 show considerable sand and gravel.

The maximum thickness of the alluvium is tentatively inferred to be from 150 to 250 feet, as interpreted from well logs. The base can be recognized with fair certainty in the western part of the valley where the alluvium rests on thick clay beds of the older continental deposits 100 to 130 feet below the surface. The wells there are near the south side of the valley and probably do not penetrate the thickest section. In the south-central part of the plain the alluvium is distinguished from the underlying formations with difficulty, but is probably not less than 150 feet thick. In the eastern part of the area logs show an apparent change in the character of material penetrated at depths of about 200 to 250 feet, which may represent the position of the base. However, determination in this area is uncertain, and the lower deposits may be the equivalent of the terrace deposits along the margins of the plain.

The alluvium is not the principal water-bearing formation of the valley. Only in the western part is most of the water produced from it. In most other parts, the top of the saturated zone is either deep in the alluvium or below its base, and most well water is derived from the underlying deposits. In the central part of the valley south of the highway, most of the alluvium is saturated but is not very permeable; it is necessary to drill deep into the underlying older continental deposits to obtain any appreciable amount of water.

Nothing is known about the character of the alluvium in the part of the plain north and northwest of the Graveyard Ridges except for the upper 30 to 50 feet exposed along the river. These deposits are predominantly sand, as previously discussed. Only drilling in the area will reveal the character of the deposits in the swampy area north of the ridges.

The alluvium doubtless readily absorbs water nearly everywhere except in the west-central part of the valley, where the ground water is locally confined or the shallow deposits already saturated. In the central and marginal parts of the plain where the water table is a few feet or more below the land surface, water falling on or flowing over the area is readily absorbed. In particular, the alluvium readily absorbs the normal flow of the Cuyama River and major tributary streams in the entire area upstream about from the crossing of State Highway 166. Below that crossing the alluvium is capable of receiving and transmitting water, but the deposits are already saturated at least within a few inches or feet of river level. Also, in the vicinity of the east end of Turkey Trap Ridge, and to the south along State Highway 166, the non-pumping level and behavior of water levels in wells and springs suggest the presence of confining beds. Hence in this area the alluvium probably does not readily transmit water downward.

TERRACE DEPOSITS

The terrace deposits as here defined (pl. 5) consist of relatively thin bodies of sand and gravel that cap benches and slopes bordering the alluvial plain. They are considered to be of Pleistocene age. Somewhat thicker and more extensive bodies of alluvial deposits occur on old erosion surfaces in the hills to the northeast and east. Although somewhat older than the thin deposits here discussed, they also are probably of Pleistocene age. These older terrace deposits are mostly outside the area shown on plate 5, and generally are not tapped by wells.

The most extensive of the terrace deposits referred to here are on the benched and terraced slopes west of Salisbury Canyon. They appear in road and stream cuts as beds of coarse gravel 5 to 20 feet thick resting in sharp contact on the underlying reddish sand and silt of the older continental deposits. These deposits are fairly continuous on the northern parts of the benches along the river valley and on lower benches and terraces along Branch Canyon. On higher levels they become discontinuous and locally are represented by scattered boulders on hill and ridge summits. West of Branch Canyon the southern boundary of the deposits is generalized. To the east, between Salisbury Canyon and Tennison Canyon, the deposits are poorly exposed but appear to comprise thin masses of sand, silt, and some pebbly gravel. East of Tennison Canyon and along the Cuyama River bank below the mouth of Santa Barbara Canyon, the terrace deposits consist of coarse rounded boulders and cobble gravel in bodies 10 to 30 feet thick. Similar but finer-grained deposits apparently occur on the lower slopes of the hills bordering the east side of the valley both north and south of the mouth of Ballinger Canyon, but they are difficult to distinguish from underlying deposits and are not mapped. Also, bodies of coarse gravel and sand and scattered pebbles occur on the flattish crests of the Graveyard Ridges and on the east end of Turkey Trap Ridge. These bodies are considered to be remnants of formerly more extensive terrace deposits.

The terrace deposits are not appreciably deformed, but between Branch Canyon and Santa Barbara Canyon they slope northward more steeply than the alluvium and probably have been tilted slightly northward. Both along Branch Canyon and at the mouth of Santa Barbara Canyon the gravel on low benches can be traced downstream to points where it passes under the alluvium. The terrace deposits are not distinguishable from the alluvium in logs of wells situated on the plains near those localities. Near Branch Canyon the difference in slope of the alluvial and the terrace surfaces is very slight and the terrace deposits are probably thin. However, in the area northeast of Tennison Canyon the difference in slope is greater, and there, although clearly truncated by and unconformable beneath the alluvium in sec. 2, T. 9 N., R. 25 W., the terrace deposits may thicken northward and grade imperceptibly upward into the alluvium

beneath the plain. No attempt is made to distinguish terrace deposits in the logs in table 10.

Where exposed, the terrace deposits are too thin to contain appreciable quantities of water, and in most parts of the valley they are above the zone of saturation. However, along the south side of the valley where they pass beneath the alluvium they doubtless are saturated. The gravel and sand appear to be very permeable.

OLDER CONTINENTAL DEPOSITS

The older continental deposits include large and extensive bodies of poorly consolidated clay, silt, sand, and gravel, which rest unconformably on the more consolidated pre-Pliocene marine and continental deposits and in turn are overlain by the alluvium and by terrace deposits. These deposits include beds belonging to the Cuyama formation of English (1916, pp. 196, 204; pl. 19.) and the Morales formation and fanglomerate as mapped by Dibblee (see p. 28). Within the area of this report, the Morales formation of Dibblee includes the Cuyama formation of English, except west of Branch Canyon in the western part of the valley. There a considerable thickness of light-buff to pink sandy and silty clay and sand with lenticular beds of gravel, mapped by English with his Cuyama formation, is considered by Dibblee to be younger and is mapped by him as fanglomerate. The present writers are inclined to agree with English, and accordingly include the beds in the unit here defined. In the eastern part of the area, in the vicinity of Ballinger and Quatal Canyons, the Morales formation of Dibblee also includes a considerable thickness of continental deposits underlying the Cuyama formation as mapped by English.

Thus, the older continental deposits as here defined embrace parts of at least two previously defined formations but do not wholly correspond with either. Distinction between the Morales formation of Dibblee and the Cuyama formation of English is apparently to be found, at least in part, west of the area covered in plate 5, and such distinction is outside the scope of this report. Accordingly, rather than attempt to establish the validity of either formation on the basis of the probably insufficient evidence to be found within the area of plate 5, the writers prefer to use the general name "older continental deposits," and to leave the problem open.

In age, English considered his Cuyama formation as probably Pliocene; and Dibblee considers his Morales formation as Pliocene. The deposits, which total more than 3,000 feet in thickness, rest unconformably upon deposits of Miocene age. They have been somewhat tilted and folded and have been cut by faults. Near the faults along the southwest side of the valley, dips are steep (50°–90°), and the beds are locally overturned. Because they have been strongly deformed locally, and because they underlie the alluvium and terrace deposits of presumed Pleistocene age, these older continental deposits are considered to be of Pliocene age. However, inasmuch as deposits occupying a corresponding stratigraphic position in other parts of the county, such as the Santa Barbara formation (Upson, 1951, p. 21) and the Paso Robles formation (Upson and Thomasson, 1951, p. 34), are wholly or partly of lower Pleistocene age, the older continental deposits of the Cuyama Valley may also be in part of lower Pleistocene age.

As thus defined, the older continental deposits underlie the extensive terraces west of the alluvial plain and the terraces and adjoining foothills along the south side of the plain. They also underlie part of the much-dissected hills east of the alluvial plain in the vicinity of Ballinger and Quatal Canyons. Centrally, they pass beneath the terrace deposits and the alluvium, and thus underlie the alluvial plain at least as far north as the Turkey Trap Ridge. The deposits that compose the ridges are not exposed, but those of the Graveyard Ridge, were penetrated by an oil-prospect hole which passed through fine-grained deposits, apparently continental, to a depth of at least 1,500 feet. The upper part of these deposits is probably part of the older continental deposits, but the lower part may be older.

The older continental deposits vary considerably in texture, being relatively coarse-grained in the eastern and southeastern parts of the area and relatively fine-grained in the western and southern parts. Thus, at the east side of the mouth of Santa Barbara Canyon outcrops have considerable gravel interbedded with sand and silt; on the west side, about 2 miles south from the mouth, is a body of coarse gravel and sand at least 150 feet thick with its base about 200 feet above the bottom of the formation. This body contains lenses of coarse cleanly washed gravel with rounded boulders as much as 2 feet in diameter. In the vicinity of Ballinger Canyon the beds are composed of poorly sorted lenticular sand and gravel with minor amounts of finer material. Lenses of gravel contain rounded boulders and cobbles as much as 1½ feet in diameter. Logs of water wells within the eastern part of the alluvial plain are generalized, but the considerable gravel and sand in the lower parts of the logs are probably part of the older continental deposits. These coarse-grained deposits yield water readily and copiously to wells. (See p. 49.)

In the western and southern parts of the valley the older continental deposits consist mainly of loose to slightly compact clayey or silty sand, coarse to fine in texture. This sand is also interbedded with strata of silt, some clay seams, and occasional lenses of gravel, which at places is moderately coarse but ordinarily not cleanly washed. In the sides of canyons such as Branch Canyon, the beds are somewhat finer-grained, more compact, and clayey northward; as seen in exposures farther west and near the river, they contain a high proportion of clay beds, which, however, are interbedded with gravel. The wells in secs. 11 and 12, T. 10 N., R. 27 W., penetrate chiefly clay for several hundred feet below the base of the alluvium. Logs of wells in the south-central part of the valley show that the deposits consist of sandy clay and clay with very little sand or gravel.

Thus, the older continental deposits in the central and western parts of the valley are predominantly fine-grained. As will be brought out (p. 49), wells that penetrate these deposits in the south-central part of the alluvial plain have comparatively poor yields.

NON-WATER-BEARING FORMATIONS AND WATER-BEARING FORMATIONS NOT TAPPED BY WELLS

Formations that do not carry water or that carry water but are essentially untapped by wells are those indicated on plate 5 as pre-Pliocene marine and continental deposits, undifferentiated. They comprise more or less consolidated deposits of Miocene, Oligocene, Eocene, and Cretaceous age. As shown, they also include discontinuous bodies of terrace deposits and older alluvial fans outside the area of ground-water development. The distribution of these rocks are shown on the unpublished map by Dibblee (see p. 35); the ensuing discussion of their age and lithology is largely based in part on that map and in part on reconnaissance field examination.

The marine beds of Miocene age on the north and west sides of the Cuyama Valley consist of considerable shale, in part siliceous, and rather compact. On the south side of the Cuyama Valley the beds contain much loose sand. These beds interfinger eastward with continental beds which consist of clay, silt, sand, and gravel. Most of these beds are fairly coarse-grained, but the upper part is composed of rather compact gypsiferous clay shale. The deposits of Oligocene age that underlie the Miocene deposits are continental in origin and contain considerable sand and gravel, but they are largely consolidated. The Eocene beds are of compact marine sandstone and shale. The Cretaceous beds are predominantly of compact shale, sandstone, and conglomerate.

Thus, most of the formations that are older than the older continental deposits of this report probably are not water bearing. Some of these may store appreciable quantities of water in cracks and joints, but they do not transmit it. On the other hand, the loose marine sands and the continental deposits of Miocene age and the terrace deposits and older alluvial fans doubtless do transmit ground water fairly readily. However, they underlie land most of which is topographically unsuited to agriculture. Hence, even the water-bearing formations are not tapped by wells, except for a few scattered stock and domestic wells in valley bottoms. These more permeable beds occur largely east and southeast of the valley plain where, together with the older continental deposits, they underlie an area of about 150 square miles. Much of this area is in higher country on which rainfall is comparatively heavy and thus it constitutes a great catchment area for recharge. Although the deposits are not generally tapped by wells, they nevertheless are capable of transmitting to the valley plain water thus absorbed. Furthermore, the attitude of the beds, as indicated by their structure is favorable to the transmission of water to the alluvial plain.

GEOLOGIC STRUCTURE

The Cuyama Valley is essentially a structural depression modified by erosion and deposition. The Caliente Range, which borders the valley on the north, is a large overthrust mass, and it seems likely that most of the south front of that range is a fault scarp. Also, the Sierra Madre on the south is an overthrust mass. Thus, the intervening Cuyama Valley is a structural depression, and the formations of that area also have been considerably distorted. The San Andreas fault forms the limit of the area on the northeast.

The older formations have been the more intensely deformed, but the younger water-bearing formations also have been deformed. As has been discussed, the older continental deposits south of the alluvial plain are somewhat distorted, dipping generally northward. Also, the overlying terrace deposits, at least from Branch Canyon east, apparently have been slightly tilted northward so that they pass beneath the alluvium. In the hills between Ballinger and Quatal Canyons, the older continental deposits and underlying formations have been folded into a large downwarp, or syncline, whose trend is northwest toward the valley plain. (See pl. 5.) Thus, it seems likely that the valley is on the site of a large syncline whose axis is roughly parallel with the elongation of the valley. The north limb of this fold is cut off against the faults in the central part of the plain. (See below.) The syncline has no pronounced effect on the occurrence of ground water, but it has folded the composing formations so that the slope of the beds is favorable to the transmission of water from the east and south toward the valley.

Deformation of the area is expressed largely by faulting. Aside from the major faults, which control the outer limits of the area, and those in the foothills, the only faults known to affect the movement of ground water are two in the middle of the valley, and associated with the Graveyard and Turkey Trap Ridges previously described (p. 26 and pl. 5). The plotted locations of the faults are based in part on hydrologic evidence, as they seem to be closely related to the large springs in the middle of the valley. This evidence for mapping the two faults is discussed in the next section of this report.

Other evidence is principally the alinement of the ridges, and their arrangement en echelon. These suggest that the ridges are either tilted blocks or pressure ridges in fault zones. The hydrologic evidence discussed beyond (p. 45) suggests that there is a fault along the south side of each

ridge, whereas physiographic features suggest that a fault also lies along the north side of each ridge. For example, the north slopes of the Graveyard Ridges are steep and nearly straight (pl. 3), and from an endwise view their tops seem to slope slightly southward. Also, the alluvial fill on the north side of both the Graveyard and Turkey Trap Ridges is 5 to 25 feet lower than on the south side. However, the steep north-facing slopes could be erosional and their alinement is not perfect; moreover, the difference in elevation of the alluvial plain is probably due to differences in the amount of alluvium deposited locally.

Accordingly, the interpretation of two faults en echelon, as shown on plate 5, probably is the most reliable judged on the basis of existing knowledge. These faults, as drawn, are considered to cut the alluvium and the older continental deposits, and possibly deeper unconsolidated or semiconsolidated beds. They probably do not represent the true trace of faults in the underlying consolidated rocks but rather are the shallow expression of a single zone having a more nearly easterly trend. This fault zone may be the eastward continuation of one of the major thrusts in the Caliente Range to the northwest.

There is little existing evidence for continuing the faults farther east than shown. However, the straight alinement of the "New River" suggests that it may be on a fault zone. Also, old residents report that about 1900, after an earthquake, there was a dislocation of the ground in the area southwest of the highway intersection in sec. 23, T. 10 N., R. 25 W. This location is on a possible extension of either of the echelon faults. (See pl. 5). Thus, such evidence as there is would allow the eastward extension of the fault zone either into the extreme eastern tip of the alluvial plain in secs. 19 and 20, T. 10 N., R. 24 W., or farther south into sec. 23. Inasmuch as there seems to be no evidence for faulting in the hills still farther east in sec. 24, it is more likely that the zone takes the more northerly course.

Slightly permeable materials are inferred to have been uplifted on the north side of each of the two faults. These materials restrain the movement of ground water percolating through younger permeable deposits from the south and southeast (p. 46), thus forcing it upward to the land surface. This movement probably is mainly along the fault zones, thus accounting for the location and alinement of the springs.

ORIGIN OF THE PRINCIPAL SPRINGS

GENERAL FEATURES

Discharging ground water has created several springs or spring zones in the Cuyama Valley. Pertinent data on the principal defined orifices are summarized in table 2, and the locations are shown on plate 5. The largest springs are north of the river in the central part of the alluvial plain and are known as Graveyard and Weir Springs. (See pl. 5.) Sometimes both are referred to collectively as "The Giant Springs." These springs supply water to the meadows and to irrigated fields nearby. South of the river, several springs are on or along the south side of Turkey Trap Ridge. One of these, called the Headquarters Spring, supplies water to the Cuyama Ranch headquarters. Most are unnamed, but one near the east end of the ridge is called Turkey Trap Spring and in this discussion it lends its name to the whole group as well as to the ridge itself. In addition, a rather prominent line of springs and seeps occurs in the terrace front along the highway in secs. 3, 10, 11, and 12, T. 10 N., R. 27 W. These make a nearly continuous zone of seepage for more than a mile, and serve mainly to support a rather dense growth of grass for grazing stock. One spring orifice, 10/27-12E2, has been dug out, boxed, and piped to a watering trough for stock. Another, 10/27-3L1, is boxed and the water pumped for use at the California State Highway maintenance station. Also, along the river bottom and banks from the vicinity of sec. 10, T. 10 N., R. 26 W., downstream, are zones of seepage and occasional definite spring orifices. Finally, there are several small springs near the headwaters of tributary streams and locally in the mountains.

The origin of most of these springs has a definite bearing on the source, disposal, and, ultimately, the use of the ground water in the Cuyama Valley. Because certain groups of springs have different origins, they are discussed at some length beyond under separate headings. The origins of springs in the mountains remote from the alluvial plain are not discussed.

GRAVEYARD AND WEIR SPRINGS

Graveyard Springs consists of three circular orifices in the alluvial plain. Two of these orifices (10/26-14C2 and 3) are about 50 yards apart and about 100 yards south of the western part of the Graveyard Ridges. Each contains a pool of milky water fringed by a growth of tules (pl. 4, *B*). The discharge level in each is about 5 feet below the plain. About 100 yards northeast of 14C2 is a third orifice, (10/26-14C1) which is smaller and in which the water is clear and discharges at about the level of the plain. A small amount of water from the springs seeps southward to the river channel, but most of the discharge from all three orifices is carried in ditches to a reservoir from which it is diverted to various cultivated fields or allowed to flow into the Cuyama River. The discharge measured in a ditch below the reservoir on April 23, 1947, was 1.92 second-feet, and included discharge from all three orifices.

The Weir Spring, 10/25-18K1, is a small area of concentrated seepage about 2½ miles east-southeast of Graveyard Springs and in the bottom of the so-called "New River" trench. Water flows westward along the trench for about a mile to a dam, by which the flow is diverted into a ditch which carries the water south and west. Nearly all the water seeps from the ditch

TABLE 2. — *Principal springs discharging from the ground-water body of the Cuyama Valley, Calif.*

Number	Name	Owner	Occurrence	Altitude of water surface (feet)	Temperature (°F.)	Estimated discharge (gpm)	Date	Remarks
10/25-18K1	Weir Spring	Cuyama Ranch	Open pool on floor of meander in "New River."	2,255	62	[1]620	Apr. 23, 1947	Measured at weir about 1 mile west. Chemical analysis in table 8.
10/26-10P1	....	...do.....	Seeps along river channel.	2,115	....	....	......do......	River flow increases about 0.5 cfs. across this zone.
10/26-13G1	....	...do.....	Pool in tule clump on alluvial plain.	2,225	64	....	......do......	Faint "sulfur" odor.
10/26-14C1	Graveyard Springs	...do.....	Open pool in alluvial plain.	2,190	57	[2]860	......do......	
10/26-14C2		...do.....	......do......	2,180	64		......do......	Water level about 5 feet below plain.
10/26-14C3		...do.....	......do......	2,180	62		......do......	Water level about 4 feet below plain. Chemical analyses in tables 8 and 9.
10/26-15G1	Turkey Trap Spring	...do.....	General seepage in swale south of ridge.	2,180	63	80	Apr. 24, 1947	Chemical analysis in table 8.
10/26-15G2	....	...do.....	Pool in tule clump on alluvial slope.	2,180	....	30	......do......	
10/26-16A1	....	...do.....	Three circular pools on crest of ridge.	2,160	62	5	Mar. 20, 1947	
10/26-16B1	....	...do.....	Circular pool near crest of ridge.	2,155	64.5	5	......do......	Light-gray clay overlain by dark soil impregnated with deposits of white salts.
10/26-16C1	Headquarters Spring	...do.....	Circular swale on crest of ridge.	2,155	64.5	5	......do......	Chemical analysis in table 9.
10/27-3L1	....	State of California	Concentrated seeps along terrace front.	1,990	70	10	Mar. 19, 1947	Chemical analyses in tables 8 and 9.
10/27-12E2	....	....	East end of line of seeps in terrace front.	2,000	65	....	....	Chemical analysis in table 8.

into the saturated meadows in sec. 13, T. 10 N., R. 26 W., but possibly a small amount joins the Graveyard Springs discharge. The discharge of the Weir Spring measured just below the dam on April 23, 1947, was 1.38 second-feet.

Several features of these springs seem to be pertinent to their origin. First, the Graveyard Springs themselves occur in the alluvium, but the water level is about 12 feet above the adjacent bed of the Cuyama River, which, when visited, had a flow of not more than about 100 gallons a minute, nearly all apparently originating upstream. Thus, the spring discharge is localized and is not a part of general upward leakage of ground water. This leakage would occur in the stream bed, the lowest point in the vicinity. Secondly, the Graveyard and Weir Springs are alined on an essentially straight line slightly south of and parallel to the alinement of the Graveyard Ridges. This line also passes through a small spring orifice, 10/26-13G1, and, projected westward, through a zone of considerable spring seepage and rather abrupt increase in river flow in the Cuyama River channel at 10/26-10P1 (pl. 5). Immediately below this zone is a sump from which the Cuyama Ranch pumps water; it is reported that the river has never been completely dry at that place.

The alinement of all these springs, the water-level altitude of the Graveyard Springs, and the parallelism between the alinement and that of the Graveyard Ridges probably show that the Graveyard and Weir Springs are on the line of a fault, as shown on the map. Movement along this fault has uplifted older impermeable deposits on the north side which obstruct the lateral movement of ground water in the truncated permeable deposits. Late movements, following erosion of the older continental deposits and deposition of the alluvium, have created local channelways in the alluvium, allowing upward movement of the water and also localizing the upward movement at Graveyard and Weir Springs, as well as at the minor orifice, 10/26-13G1, and the zone of seepage at 10/26-10P1. Probably impermeable clay in either the alluvium or the older continental deposits beneath the river channel south of the Graveyard Springs prevents discharge of water directly upward into the channel over a broader area.

The temperature of the spring water is not high, hence the water does not rise from appreciable depth (table 2). Furthermore, its quality is essentially the same as that of well waters in the area, particularly the water from wells that tap the older continental deposits. Therefore, the spring water probably rises not more than a few hundred feet at most from water-bearing beds in those deposits that have been truncated by the fault.

TURKEY TRAP SPRING GROUP

The Turkey Trap Spring group comprises the orifices 10/26-15G1, 10/26-15G2, 10/26-16A1, 10/26-16B1, and 10/26-16C1, on and at the south side of the long, low Turkey Trap Ridge south of the Cuyama River. Turkey Trap Spring itself (10/26-15G1) is south of the ridge in a shallow swale and discharges eastward around the end of the ridge. Considerable seepage occurs along the discharge course. Farther west the spring orifices are in circular depressions about on the ridge crest. The water stands a few feet below the level of the ridge crest, and it discharges through channels that trend northward across the ridge and are incised a few feet into its top and north face.

The Turkey Trap Springs occur on the south side of the ridge, as do the Graveyard Springs. The alinement of the ridge and the springs is about parallel and en echelon to the alinement of the Graveyard Ridges and associated springs. Thus, it is inferred that these springs too occur along a fault which trends about N. 75° W. and lies south of the ridge, and which has cut the alluvium so as to create vertical channelways for localized ground-water discharge. The altitude of the water surfaces in the springs seems to be slightly higher than the probable ground-water level to the south as indicated by the water-level contours (pl. 5). The water has a low temperature and a quality similar to that of the other springs and wells. Therefore the springs are inferred to be discharge of the ground-water body localized by faults.

OTHER SPRINGS

The origin of the nearly continuous zone of springs and seeps in the stream-cut terrace front along the highway in secs. 3, 10, 11, and 12, T. 10 N., R. 27 W., is uncertain. The springs are apparently along a nearly horizontal line which, westward, rises slightly above the surface of the alluvial plain; they appear merely to be contact springs discharging at the upper edge of an impermeable bed in the older continental deposits. Thus rain infiltrating from the terrace surfaces above and to the south would discharge at the spring line. At places, however, the springs are somewhat above the floors of gulches that trench the terrace front and they apparently do not occur on the floors of the gulches south of the terrace front. They may represent concentrations of water in depressions in an underlying impermeable bed; on the other hand, they may have an origin similar to that of the larger springs previously described, and may indicate the presence of another fault situated at or immediately south of the terrace front. However, a water sample from spring 10/27-12E2 (table 8) has a much higher chloride concentration (87 ppm) than do most other waters of the area, and has about double the hardness, thus suggesting that the water is not coming from the main water body to the east. Accordingly, these springs are considered to be of the contact type.

Except for the zone of seeps at 10/26-10P1, the numerous springs and seeps along the river course in the western part of the valley (not shown on pl. 5) probably result from the fact that the river has trenched its course a few feet below the water table, thus causing the ground water to discharge into the river.

THE GROUND-WATER BODY

The ground water in the Cuyama Valley occurs in all the relatively permeable deposits described in the foregoing pages, but it is most readily accessible to wells within the area of the alluvial plain, where it stands at comparatively shallow depths. The variation in depth to water from place to place in the plain and, more especially, the discontinuities of slope of the water table at certain places (pl. 5) suggest that there may be more than one water body, hydraulically separate at least locally. For example, there is a marked discontinuity in the body along the terrace front in the western part of the area, as the water beneath the terrace seems to be perched on the impermeable clay in the older continental deposits. However, the perched water is probably continuous eastward with the remainder of the body as the terraces pass under the alluvium east of Salisbury Canyon.

In addition, there are two large discontinuities along the faults in the central part of the plain. The water level in well 10/26-9R2 is about 25 feet below the land surface, whereas the level in the springs about a quarter of a mile to the south is about 25 feet above the land surface at the well, a difference in altitude of about 50 feet. It is inferred that the spring level reflects the head of water in permeable beds at some depth below the surface moving upward along the fault that parallels the south side of Turkey Trap Ridge. Similarly, along the Graveyard Ridges, the water level in the spring pool 10/26-14C3 is about 12 feet above the nearby river bed to the south, as explained on page 42.

Except for these discontinuities, and allowing for some increase of head with depth, the ground water tentatively is considered to be a single body practically continuous hydraulically. This concept is supported by the general similarity of quality throughout. If this is true, then the springs and swamps represent areas of discharge from the body.

The depth to water varies widely in different parts of the area, in general being close to or slightly above the land surface in the central part of the plain and several hundred feet below the land surface in the southern and eastern parts. For example, in wells near the river in the western part of the plain, water stands 15 to 25 feet below the surface. The discharge level at the main orifices of the Graveyard Springs is about 5 feet below the level of the plain. Except at well 10/26-22A1, the water level is progressively deeper from Turkey Trap Ridge southward. It is at or nearly at the land surface in secs. 15 and 16, T. 10 N., R. 26 W. It is about

30 feet below land surface at well 10/26-22D1; and it is about 98 feet deep at well 10/26-21Q1. Southeastward from the Weir Spring, water levels are progressively deeper for about 8 miles because the land surface rises more rapidly than the water table. For example, the water level is about 93 feet deep at well 10/25-22H1, about 155 feet at well 10/25-26E1, and nearly 200 feet at well 10/25-35C1. It is about 250 feet at well 9/25-6K1, about 333 feet at well 9/25-1L1, about 324 feet at well 9/25-7B1 in Ballinger Canyon, and about 286 feet at well 9/25-2P1 across the Cuyama River from Ballinger Canyon. Farther up the river valley to the southeast the water is shallower. For example, at well 9/24-19Q1 it is about 30 feet below the surface.

On the north side of the valley only three measurements are available. The depth to water is about 155 feet at well 10/25-14Q1, 32 feet at well 10/25-8P1, and 28 feet at well 10/26-4G1. From the last-mentioned two wells southward, the water probably is progressively shallower and is at land surface or slightly above it north of the Graveyard Ridges and for a mile or more to the east-southeast.

Beneath the alluvial plain the head of water may increase somewhat with depth. For example, the level of discharge of the Turkey Trap group of springs is a few feet higher than the land immediately south, where it is reported that standing water is encountered in any hole dug a few inches to a foot below the land surface. However, the vegetation there is short grass, as in other areas where the water table is several feet deep; possibly the water is not so shallow in this area as reported. If, as is inferred, the spring discharge is water from some depth moving up along a fault, then the head of water increases somewhat with depth. However, there are no tightly cased adjacent shallow and deep wells to check the inference. The condition is a normal one in dipping layers of imperfectly interconnected permeable beds such as those of the older continental deposits and does not necessarily demonstrate the existence of a separate deep water body. Rather, it indicates simply a loss of head of progressively shallower water through physical restraint to vertical movement.

As far as is now known the ground water is relatively unconfined except in small areas in the south-central part of the valley. Well 10/26-22A1 has flowed in very recent years, and the water level in the casing at times stands 1 to 2 feet above the land surface. Further, the water level declines promptly in response to pumping in other wells as far away as a mile or more, thus indicating that confining conditions extend for some distance from this well. The logs of this well and others nearby, however, do not indicate the presence of thick, continuous confining beds; hence the condition probably is local. The discharge level of the main orifices of the Graveyard Springs is about 12 feet above the river channel, and the water may be confined by the clay stratum exposed along the river in sec. 10, T. 10 N., R. 25 W., previously discussed, or by other impermeable beds.

Possibly the degree of interconnection between all parts of the body actually is slight at places, and real hydraulic discontinuities will appear with further draft on the deeper ground water. For example, it may ultimately appear (1) that there is a shallow body in parts of the area, most likely south of Turkey Trap Ridge and north of the Graveyard Ridges, which may become semiperched on relatively impermeable beds if the head of deeper water is lowered by pumping, and (2) that at present the interconnection between shallow and deep water is apparent only because the head of the deeper water is sufficient to cause upward leakage through relatively impermeable deposits.

SOURCE, RECHARGE, AND MOVEMENT OF GROUND WATER

The movement of ground water in an area is best illustrated by contours drawn on the water table or pressure surface of the ground-water body. Ground water moves from points of high head to points of lower head; hence contours, or lines connecting points of equal head on the water body, show the directions of movement of water, and thus may indicate the sources of recharge and also the areas of discharge.

Plate 5 shows water-level contours for the ground-water body in the Cuyama Valley. Available records indicate that within the area of heavy withdrawals for irrigation, water levels in most wells have not changed more than a few feet during the years 1942–46. Consequently, available non-pumping measurements made during this period were used to control the contours.

As discussed on pages 44–45, the water level at the Graveyard and Weir Springs and at the Turkey Trap Springs, shown by spot elevations entered on plate 5, stands somewhat higher than in areas either to the north or to the south. Contours are not drawn through these points for two reasons. First, because the water levels are determined by the altitude of the overflow lips and not by the static head of the water body. There are no wells near these springs to give controlled points. Hence, the true head is not known, although the levels may represent it fairly closely. Secondly, because in the vicinity of the Graveyard and Turkey Trap Springs there may be more than one water body — a deep body whose head is represented by the springs, and a shallow body in the surrounding alluvial deposits, having a lower head.

The map shows that the ground water moves northwestward beneath the Cuyama River channel and bordering plain, westward in the area north of Ballinger Canyon, northward from the Sierra Madre, and in very small amount southward from the Caliente Range. Thus, the water originates in the Cuyama River Valley southeast of the main part of the alluvial plain, and in the foothill areas that border the plain on the north, east, and south. It is inferred more specifically that the principal sources of ground-water recharge are by seepage loss from the Cuyama River and

from minor streams on the south side of the valley. Doubtless some recharge is from infiltration of rain through unconsolidated deposits in areas where rainfall is sufficient.

Seepage from the Cuyama River is believed to be the principal source of ground-water recharge. The area of seepage loss extends from above Ozena to slightly below the bridge on State Highway 166 near the town of Cuyama — a distance of about 25 miles (pl. 1). At Ozena there is a small perennial flow of several second-feet that keeps the channel deposits saturated to land surface for several miles downstream, but below this point the channel is dry throughout the greater part of the year. Downstream, the water table drops progressively farther beneath the channel until near well 9/25-2P1 it reaches a maximum depth of about 250 feet. From this point the water table again gradually approaches the channel surface, and about half a mile below the bridge ground-water seepage into the channel first occurs. Thus, within this 25-mile reach there is a vast volume of unsaturated deposits which could contain water, but evidently river recharge has been insufficient to fill them.

The bulk of the recharge is supplied during a few storms each year. In general, recharge is roughly proportional to the rainfall; that is, during years of high rainfall it is large and during years of low rainfall it is small. Most of the time the Cuyama River flows for only a short distance below Ozena, but during the infrequent winter storms and after rare summer cloudbursts it flows for some distance across the area of seepage loss. Only during rare floods does the river flow the whole length of its course. Thus, only during and after storms is there appreciable recharge.

Recharge by infiltration of rain doubtless occurs in areas of relatively high rainfall where underlain by unconsolidated deposits. The most likely catchment areas are the northern slopes of the Sierra Madre and the western slope of San Emigdio Mountain. Water infiltrating below the land surface in these areas, mainly in the area of outcrop of the older continental deposits and the Miocene continental deposits, moves toward the alluvial plain. Only during years of excessively high rainfall, such as 1940–41, has appreciable infiltration occurred on the valley floor. Ordinarily, rainfall amounts to only a few inches a year, and all of it probably is evaporated or consumed by vegetation.

Estimates of the amount of recharge by seepage loss from streams and by infiltration of rain have been made by Olmstead and Bradshaw in 1935 in a private report on irrigation possibilities, which was submitted to the Cuyama Ranch, and by the United States Bureau of Reclamation (1946). Olmstead and Bradshaw estimate average yearly recharge to be about 12,000 acre-feet, and the United States Bureau of Reclamation estimates it to be not more than 8,300 acre-feet. Because of lack of records showing amount and distribution of rain, and because of short records of runoff of the Cuyama River, and lack of data as to other factors affecting the amount of infiltration, such as type of vegetation, soil-moisture content, and storm intensity and frequency, no direct estimate of total recharge is here attempted. However, a rough estimate probably can be made indirectly from the natural discharge. (See p. 51).

Plate 5 shows several features of the movement of ground water, as follows: In the alluvial tongue beneath the Cuyama River, the hydraulic gradient increases from slightly more than 50 feet per mile above well 9/24-30H1 to nearly 150 feet per mile off the mouth of Santa Barbara Canyon. On the other hand, below wells 9/25-1L1 and 9/25-2P1 the gradient flattens abruptly to about 25 feet per mile. The reason for the steepening and flattening of gradient is not definitely known. It cannot be due to pumping for irrigation, because water-level records indicate that the features existed before pumping began.

It is inferred that the steepening of the contours is developed in part by the decrease in permeable cross section of the river deposits between the side-encroaching less-permeable fans of Santa Barbara and Ballinger Canyons, and that the flattening downstream results from a nearly proportionate increase in area of permeable saturated cross section, and perhaps in part from an increase in the permeability of the water-bearing deposits. A similar flattening of gradient occurs north of United States Highway 399, just east of the junction with State Route 166, and is inferred to be due to a proportionate increase in the area of saturated cross section.

In T. 10 N., R. 27 W., the contours indicate a fairly strong northward component of movement through the alluvium to the river where some discharge takes place. This direction of movement is due (1) to the spring discharge, which maintains the high head along the south edge of the alluvium, (2) to the effluent nature of the river, and (3) to the northwestward passage of water between the west end of Turkey Trap Ridge and the relatively impermeable beds in the older continental deposits that crop out in the terrace front.

Finally, the ground water in the western part of the alluvial plain moves westward down the course of the Cuyama River and out of the area. The contours show that the water thus moving traverses a progressively narrowing cross section. As a result, water is forced upward and discharges into the Cuyama River channel. This ground-water discharge plus the spring discharge to the south and east sustains the low flow of the Cuyama River and causes a general increase in flow downstream at least as far as Green Canyon. (See pl. 1.)

DISCHARGE OF GROUND WATER

PUMPING FOR IRRIGATION

Pumping for irrigation in the Cuyama Valley began in 1939 when 400 acres of potatoes was raised successfully with irrigation from wells.

Since that time the number of wells and the acreage irrigated have increased rapidly until in 1946 there were 43 wells supplying water for more than 5,000 acres of diversified crops. Even at this writing, additional wells are being drilled, and more land is being cleared and leveled. Table 3 shows, by years, the acreage of crops irrigated in the period 1939–46.

TABLE 3. — *Acreage of crops irrigated in the Cuyama Valley, 1939–46*[1]

Type of crop	Acreage of crops for indicated years							
	1939	1940	1941	1942	1943	1944	1945	1946
Potatoes	400	1,200	3,650	1,922	2,136	1,444	2,169	3,200
Lettuce	....	....	340	150	10	1	....	20
Peas	....	....	....	....	92	....	....	15
Popcorn	....	....	....	....	....	....	265	....
Spinach	....	....	450	250	110	155	190	66
Onions	....	....	16	107	132	19	....	14
Watermelons	....	....	....	....	....	....	10	105
Sugar beets	....	....	....	240	....	....	....	....
Seeds	....	....	....	....	25	280	31	12
Beans	....	....	....	....	....	....	....	75
Grain	....	....	....	[2]800	[2]1,000	[2]1,200	[2]1,400	[2]1,500
Tomatoes	....	....	20	270	....	....	....	....
Alfalfa	....	....	....	....	....	....	10	[2]60
Carrots	....	....	120	4	....	....	....	....
Celery	....	....	....	50	30	....	....	....
Total	400	1,200	4,596	3,793	3,535	3,099	4,075	5,067

[1] Figures supplied by Santa Barbara County Agricultural Commissioner.
[2] Acreage reported by owners or ranch foremen.

The table shows not only the rapid increase in irrigated acreage, but also that potatoes are the principal crop. The especially large acreage of potatoes in 1941 was due to double cropping in that year.

The wells used to irrigate these crops are widely spaced and range in depth from 131 to 990 feet (table 10). The yield of individual pumping plants varies considerably from one part of the area to another. Most wells in T. 10 N., R. 25 W., have exceedingly high yields, more than 2,000 gallons a minute; most wells in T. 10 N., R. 26 W., have relatively low yields, less than 600 gallons a minute; and wells in T. 10 N., R. 27 W., have fairly good yields, approximately 1,000 gallons a minute. (See table 10.) The average pumping rate for all wells is about 1,100 gallons a minute. The most productive well in the valley is 10/25-20H1, which has a yield of 4,400 gallons a minute with a drawdown of only 13.9 feet. The specific capacity thus is about 315 gallons a minute per foot of drawdown.

Prior to 1946 there was no electric power in the Cuyama Valley. All pumps were driven by Diesel and gas engines, which used either fuel oil or butane. No accurate records were kept of the amount of fuel used for pumping. Consequently, estimates of pumpage could not be based on the number of kilowatt-hours of electric energy or the amount of fuel expended for irrigation for the period 1939–46. The method selected for estimating pumpage is based on the irrigation depth or "duty of water" applied to each type of crop. During the course of the investigation each owner or ranch foreman was visited, and from the data collected the amount of water used for each type of crop was derived. For example, one owner stated that he had 450 acres of potatoes under irrigation and that the crop required the continuous operation of six wells for 90 days before harvesting. The combined yield of these six wells was about 5,000 gallons a minute, as determined from pumping tests by the Geological Survey and the San Joaquin Power Division of the Pacific Gas and Electric Co. Calculating the gallons required for 90 days, converting to acre-feet, and dividing by the acreage gives about 4.5 feet as the duty of water applied to this particular crop.

In this manner the duty of water was derived for each type of crop raised on every ranch in the valley. The duties thus obtained were averaged. It was found that from one ranch to another for any one type of crop the computed duties of water agreed rather closely. However, as would be expected, the duty of water varied widely for the different crops irrigated. Table 4 shows the results obtained from this field canvass.

TABLE 4. — *Estimated duty of water applied to irrigated crops in the Cuyama Valley*

Type of crop irrigated	Duty of water (feet)	Type of crop irrigated	Duty of water (feet)	Type of crop irrigated	Duty of water (feet)
Potatoes	4.5	Onions	2.5	Grain	1.0
Lettuce	2.5	Watermelons	2.0	Tomatoes	1.5
Peas	1.5	Sugar beets	3.5	Alfalfa	6.0
Popcorn	2.0	Seed crops	4.0	Carrots	2.5
Spinach	2.2	Beans	0.8	Celery	3.0

Estimates of total yearly pumpage are derived by totaling the products of the acreage of each type of crop irrigated and the respective duty of water of the crop (tables 3 and 4). The total pumpage thus determined is shown in table 5. However, the total pumpage does not represent the amount permanently removed from storage each year. A part of the water applied to crops and a part of that allowed to waste at the ends of the rows seeps downward to the water body. The amount of water thus returning to storage varies widely from one part of the valley to another. Where the soil is sandy and the water table relatively far below the surface, possibly as much as 50 percent of the water applied returns; but where the soil is clayey, where the water table is near or at the land surface, or locally where there is semiconfined water, probably little returns. Nearly all the irrigation is practiced in those parts of the valley where the soil is sandy, mostly in areas of fairly deep unconfined water; hence deep percolation is possible. Irrigation runs are in comparatively long ditches. Hence, of each year's total pumpage probably as much as one-third returns to storage; the remaining two-thirds is consumed by

crops or is lost through evaporation, runoff, and transpiration from native vegetation. The amount so consumed or lost is designated the net pumpage for irrigation. Table 5 shows, by years, estimated total and net pumpage for irrigation.

TABLE 5. — *Estimated total yearly pumpage and total yearly net pumpage for irrigation in the Cuyama Valley, 1939–46*

Year	Total pumpage (acre-feet)	Net pumpage (acre-feet)	Year	Total pumpage (acre-feet)	Net pumpage (acre-feet)
1939	1,800	1,200	1943	11,500	7,700
1940	5,400	3,600	1944	9,200	6,100
1941	18,600	12,400	1945	12,300	8,200
1942	12,000	8,000	1946	16,800	11,200
Total				87,600	58,400
8-year average				11,000	7,300

The table shows that pumpage has increased nearly tenfold from 1939 through 1946. The unusually large pumpage in 1941, which is the largest of record, is due to double cropping of potatoes in that year.

Pumpage for domestic and stock use is negligible when compared to that for irrigation. It is probably well within the limits of error involved in the estimates of pumpage for irrigation, and therefore no attempt has been made to estimate the pumpage for these minor uses. Thus, the yearly quantities given in table 5 may be considered to be a rough estimate of the total pumpage for all uses.

NATURAL DISCHARGE

Discharge of ground water by natural processes is accomplished in four ways: (1) evaporation and transpiration by native vegetation in areas of high water table, and evaporation from the river channel itself, (2) spring discharge, (3) river flow and (4) ground-water underflow.

The principal area of discharge by transpiration, evaporation, springs, and the river is along the Cuyama River and adjacent plains extending downstream from secs. 18 and 19, T. 10 N., R. 25 W., through sects. 6 and 7, T. 10 N., R. 26 W. The extent of this area is roughly 3,500 acres. Of this, about 2,100 acres has water-loving vegetation and a shallow water table, which at places is above the land surface. The springs described in foregoing pages are in or at the margins of this area. The remaining 1,400 acres has a relatively deep water table and vegetation that apparently subsists on rainfall alone. Traversing the entire area is the Cuyama River channel, from which a very small amount of evaporation takes place.

Measurements and estimates of spring discharge were made in March and April 1947, and the total discharge was found to be about 1,600 gallons a minute, or 3.6 second-feet, or at a rate of about 2,600 acre-feet a year (table 2). In addition, there was unmeasured discharge from areas of general seepage such as those north and south of the Graveyard Ridges and along the terrace front west of spring 10/27-12E2. Because, it was not possible to measure all this surface discharge, and, further, because a considerable part of the water is transpired by native vegetation and lost by evaporation and seepage into the river, the aggregate measured spring discharge of about 2,600 acre-feet a year is far less than the total natural discharge.

Total natural discharge is evapo-transpiration, plus that part of river flow attributable solely to ground-water discharge, plus ground-water underflow. The latter two elements are necessarily measured below the area of evapo-transpiration and spring discharge. Because the spring discharge either flows into the river or is lost by evaporation and transpiration, it is all accounted for in these elements. The fundamental principle involved in this method is that all natural ground-water discharge, whether by springs or into the river, that is not consumed by native vegetation or evaporation must necessarily be discharged downstream as surface flow or underflow.

Field studies of transpiration and evaporation in the Cuyama Valley were beyond the scope of this investigation, and no such studies by other agencies are known. Consequently, data from studies made in other parts of the State have been largely drawn upon. Chief of these are studies by Blaney and others, referred to and contained in the report (Blaney, 1946, pp. 211–217, and appendix A, tables 20–26) by the California Division of Water Resources on the Salinas Basin. The studies by Blaney and others involve the areas occupied by different classes of water-using plants and the amount of water used by each class. The use of water by each class of plants is based on experimental determinations yielding "coefficients" of water use under different conditions of depth to ground water and other factors. These coefficients are applied to areas where experimental data are lacking in proportion to "consumptive use factors," which are based on relative mean monthly temperatures and number of daylight hours in the respective areas.

Climatic conditions in the Cuyama Valley are considered to be roughly comparable to conditions in the vicinity of King City about 125 miles northwest in the Salinas River valley. For the 2 years during which climatologic data were collected at Cuyama, the mean annual temperature of 58° F. is about the same as that at King City; and temperatures in the Cuyama Valley during June, July, and August, when the rate of transpiration is greatest, have averaged 4° to 10° higher than at King City. The latitude, and hence distribution of daylight hours, is also about the same as at King City. Hence, the consumptive use of water by native vegetation in the Cuyama Valley is considered conservatively to be about

the same as at King City in the upper Salinas Valley. Normal precipitation at King City is about 11 inches, but in the Cuyama Valley it is somewhat less. For the 2 calendar years of record at Cuyama the rainfall has been about 6 inches; for longer periods the average is taken as that figure, which is about the same as at Bakersfield.

The water-loving vegetation in the area of ground-water discharge in the Cuyama Valley is divisible into categories that seem comparable to classes distinguished in the Salinas Valley. These are: (1) extensive swampy areas of tules, cattails, and grasses in which the water table nearly everywhere is probably less than 3 feet deep and in part is at or above the land surface; (2) linear areas of dense trees, grass, and brush along stream courses where the water table is also shallow; and (3) small areas of sparse brush and grass with some scattered trees, where the water table is somewhat deeper. The areal extent of these different vegetative groups is: (1) tules, cattails, and grasses, 1,650 acres, in about 130 of which the water table is at or above the surface; (2) dense trees, grass, and brush, 150 acres; and (3) sparse brush and grass with some trees, 300 acres. These acreages, determined in part from examination in the field and in part from inspection of aerial photographs, are approximate only.

The annual consumptive use of water by swamp vegetation in recent years in the upper valley of the Salinas River as represented by King City (Blaney, 1946, p. 214 and appendix A, tables 20 and 24) is computed to be 4.7 acre-feet per acre. This figure is certainly applicable to the 130 acres in the Cuyama Valley in which the water is at or above the land surface, but it may be too high for some of the remaining 1,520 acres in which the water table may be below 3 feet. Nevertheless, it is used in the accompanying computations for lack of a better value.

The annual consumptive use of water by dense trees, brush, and grass is about 5.2 acre-feet per acre where the water table is less than 3 feet deep, and the use by sparse brush and grass is about 1.7 acre-feet per acre where the water table is about 10 feet deep (Blaney, 1946, p. 217 and appendix A, table 28). These figures give the water used by plants regardless of the source of the water. To obtain the draft on ground water alone, the rainfall (0.5 foot) must be subtracted. Table 6 gives the estimated consumptive

TABLE 6. — *Estimated average yearly evapo-transpiration in the area of natural discharge in the Cuyama Valley*

Type of vegetation	Area (acres)	Annual unit consumptive use less rainfall (feet)	Estimated annual draft on ground water (acre-feet)
Swamp (tules, cattails, and grass)	1,650	4.2	6,930
Dense trees, grass, and brush	150	4.7	705
Sparse grass, brush, and a few trees	300	1.2	360
Total			7,995

use of water by native vegetation in the Cuyama Valley, as obtained by applying the figures for the upper Salinas Valley determined by H. F. Blaney of the United States Department of Agriculture, and the California Division of Water Resources.

Admittedly, the total draft on ground water by plants thus computed is only a crude approximation, although it is considered to represent the correct order of magnitude. The true figure may be as little as 6,000 acre-feet; it probably is not more than 10,000, because that is the figure which would be derived if the entire 2,100 acres had the maximum unit evapo-transpiration loss of 4.7 feet. To refine this estimate adequately would require intensive field investigation and experimentation involving considerable expense.

The second part of the equation to evaluate is that part of the runoff of the Cuyama River immediately below the area of evapo-transpiration that is due to ground-water discharge. It has been shown that the river channel is dry for some 25 miles above the crossing of State Route 166. Thus, below this point all flow in the river is ground-water discharge except during and after the rare storms that produce surface runoff as far downstream as the lower part of the channel. The so-called low flow or continuous base flow is ground-water discharge. A measuring site was selected in the SW¼SE¼ sec. 1, T. 10 N., R. 27 W. (pl. 5.) On April 24, 1947, the flow at this site was 6.6 second-feet. Unfortunately, it is the only discharge measurement available here. However, on the same date, a measurement of 7.1 second-feet was made below the mouth of Cottonwood Creek, about 15 miles downstream, where miscellaneous measurements have been made since January 20, 1942. (See table 7). Between these sites the hydrologic conditions are such that a strict comparison of the perennial low flows cannot be made. Nevertheless, it is believed that an approximation of the average flow at the new site can be obtained by comparison with the record at the lower site. The flow thus obtained, of course, is subject to revision when more measurements are available, spanning a longer period and one perhaps more representative of long-term average conditions.

The miscellaneous measurements below Cottonwood Creek indicate that the perennial low flow during the period 1942–46 has varied from about 9 second-feet during the cold winter months, when evapo-transpiration losses are at a minimum, to about 1 second-foot during the hottest summer months, when such losses are at a maximum. Because both additional discharge by springs and loss by evapo-transpiration occur in the intervening reach, it is likely that at the upstream site the maximum low flow would be slightly less, and the minimum would be slightly more than at Cottonwood Creek. Possibly the average low flow is 4 or 5 second-feet—2,900 or 3,600 acre-feet per year. Because the period 1942–46 followed the excessively wet winter of 1940–41, the low flow may have been somewhat higher than average. Accordingly, a yearly discharge

TABLE 7. — *Miscellaneous measurements of discharge of Cuyama River below Cottonwood Creek, 1942–47*[1]

Date	Discharge (cfs)	Date	Discharge — Con. (cfs)	Date	Discharge — Con. (cfs)
1942		*1943*		*1945*	
Jan. 20	12.8	Nov. 2	8.1	July 11	2.7
28	13.5	30	8.6	Aug. 1	[2].2
Apr. 28	13.0	Dec. 28	22.2	Dec. 5	15
May 6	7.8				
20	6.2	*1944*		*1946*	
Aug. 10	1.9	Mar. 1	65	Jan. 3	15
Sept. 9	.86	Apr. 25	14.5	Feb. 4	22
Oct. 8	1.8	May 30	6.8	14	15
Nov. 30	7.6	June 27	9.1	27	13
Dec. 28	10.5	July 26	[2]7	Mar. 21	10
		Aug. 29	.29	Apr. 22	9.5
1943		Sept. 14	.6	May 20	6.4
Jan. 30	25.8	26	[2]2.0	Sept. 11	3.9
Feb. 5	23.0	Oct. 30	8.1	Oct. 3	9.0
25	22.9	Nov. 15	13		
Apr. 27	11.6	28	14	*1947*	
June 1	7.2	Dec. 27	13	Apr. 16	8.7
30	6.2			24	7.1
July 27	3.4	*1945*		June 2	4.6
Aug. 31	3.3	Apr. 5	14	July 23	[2].05
Sept. 28	5.5	24	8.4	29	2.2
Oct. 22	5.4	June 20	5.1		

[1] Measurements before Oct. 3, 1946 from published water-supply papers of the U. S. Geological Survey.

[2] Estimated.

Finally, an estimate of ground-water underflow is necessary to complete the estimate of total discharge. Computations of underflow are based on Darcy's law, which may be expressed by the formula

$$Q = PIA$$

In the formula, Q is the quantity of water moving per unit of time, P is a coefficient of permeability, which expresses the rate of flow through unit area of the water-bearing material in unit time, I is the hydraulic gradient, and A is the cross-sectional area through which water is being transmitted. For field computations, P is defined as "the number of gallons of water a day that percolates under prevailing conditions through each mile of water-bearing bed under investigation (measured at right angles to the direction of flow) for each foot of thickness of the bed and for each foot per mile of hydraulic gradient"; (Wenzel, 1942, p. 7; Upson and Thomasson, 1951, p. 74) I is expressed in feet per mile measured in the direction of the gradient; and A is expressed in feet of thickness and miles of width of the water-transmitting material measured at right angles to the gradient. Q is obtained in gallons per day.

At the lower end of the Cuyama Valley, the line of section used extends northward across the alluvial plain through the middle of secs. 12 and 1, T. 10 N., R. 27 W. Its length is about 1 mile. Because it is believed that essentially all the underflow is conveyed through the alluvium, and that practically none moves through the underlying formations, the pertinent thickness is limited to the saturated portion of the alluvium. Records of wells near the line of section (10/27-11A2, 11C1, 12E1, and 12J1, table 10) show that this thickness is about 115 feet, of which, in general, the lower 60 feet consists of coarse, highly permeable material, and the upper 55 feet is fine-grained, only slightly permeable material. The width of the section being about 1 mile, the cross-sectional area of the lower part is about 60 foot-miles and of the upper, about 55 foot-miles.

The coefficient of permeability of each part of the alluvium necessarily is estimated because no tests have been made. On the basis of specific capacity of wells near this section (table 10) and of data derived from investigations of alluvium in other parts of the county, a coefficient of 1,000 gallons per day per square foot for the lower part and one of 50 for the upper part probably would be conservative.

The hydraulic gradient can be obtained from the water-level contour map (pl. 5) by determining the component of gradient at right angles to the line of section. The average gradient determined from the contours is about 60 feet per mile, and the component at right angles to the section about 35 feet per mile. Because the ground-water body is considered to be in hydraulic continuity throughout at the line of section, this gradient can be applied without adjustment to both the lower and upper parts of the alluvium.

Thus, estimates of ground-water underflow can be computed as follows: (1) For the lower part of the alluvium, the coefficient of permeability of 1,000 gallons per day per square foot times the hydraulic gradient of 35 feet per mile, times the saturated area of 60 foot-miles equals 2,100,000 gallons per day, about 3.2 second-feet, or about 2,400 acre-feet per year; (2) for the upper part, the coefficient of permeability of 50 gallons per day per square foot times the hydraulic gradient of 35 feet per mile, times the saturated area of 55 foot-miles equals about 96,000 gallons per day, about 0.15 second-foot, or about 100 acre-feet per year; and (3) for the entire cross section, the sum of (1) and (2), or about 2,500 acre-feet per year.

Finally, the crude estimate for total yearly natural discharge, as given in general terms on page 52, is the evapo-transpiration of about 8,000 acre-feet, plus the average low-water runoff of about 3,000 acre-feet, plus the underflow of about 2,500 acre-feet, or, in round numbers, about 13,000 acre-feet per year.

This discharge is apparently about the same as in several preceding years. H. S. Russell, part owner of the Cuyama Ranch, has been aware that pumping from wells might cause a decrease in discharge of the Graveyard and Weir Springs, but he maintains that from 1939, when pumping from wells for irrigation first began, to 1946 there was no noticeable decrease in spring or river discharge. The only known measurement of spring discharge in earlier years was made by Olmstead and Bradshaw in 1935, in a private report on irrigation possibilities that was submitted to the Cuyama Ranch. They report a flow of 3.08 second-feet in May 1935 in

the ditch below the springs south and east of the Graveyard Spring. They do not make clear whether or not the flow includes the discharge of the Weir Spring. If the discharge is included in the flow the combined discharge is about the same as that measured by the Geological Survey in 1947. If the discharge is not included in the flow, the discharge in 1935 was about 35 percent greater than in 1947, which seems highly unlikely in view of the other evidence. For example, there is no known evidence that the areas of water-loving vegetation were any more extensive in earlier years than now. Finally, as discussed in the next section of this report, there was no appreciable decline of water level in observation wells south and east of the springs and hence no decrease in hydraulic gradient toward the springs from the summer of 1941 to 1946. If during that period there was no change in hydraulic gradient or in vegetative draft, there probably was no decrease in spring discharge during the same period. Similarly, at the western end of the valley, as discussed on subsequent pages, the water level in observation well 10/27-12R1 declined less than 2 feet from the highest level of 1942 to the highest level of 1946, and that in well 10/26-18F1 declined about 5 feet from 1941 to 1946. These wells are in a local area of concentrated pumping, and the declines doubtless are more than the average decline in the western end of the valley; hence the westward slope of the hydraulic gradient at the western end probably is nearly what it was prior to 1942. Therefore, subsurface discharge and leakage to the river at the western end of the valley probably did not decrease appreciably from 1942 to 1946.

In an undeveloped ground-water basin the long-term natural recharge must equal the long-term discharge. If discharge is on the order of 13,000 acre-feet per year, as estimated, then the average yearly recharge too is on the order of 13,000 acre-feet. This estimate of recharge agrees fairly well with that made by Olmstead and Bradshaw, but it is considerably larger than that made by the Bureau of Reclamation. (See p. 47.)

Total discharge for any year is the total net pumpage (table 5) plus the natural discharge. Thus, it is estimated that in the early forties annual discharge has averaged about 20,000 acre-feet; that in 1946 the total discharge was about 24,000 acre-feet; and that for the period 1939–46 the total was about 160,000 acre-feet, of which nearly two-thirds was natural discharge.

FLUCTUATIONS OF WATER LEVEL

Monthly measurements of water level have been made in 10 wells by the Geological Survey beginning in August 1941, only 2 years after pumping for irrigation began. For the period prior to 1941, very few reported records are available. These measurements and other data assembled by the Geological Survey have been published (Meinzer, Wenzel, and others, 1943, 1944, 1945; Sayle and others, 1947, 1949; La Rocque, and others, 1950).

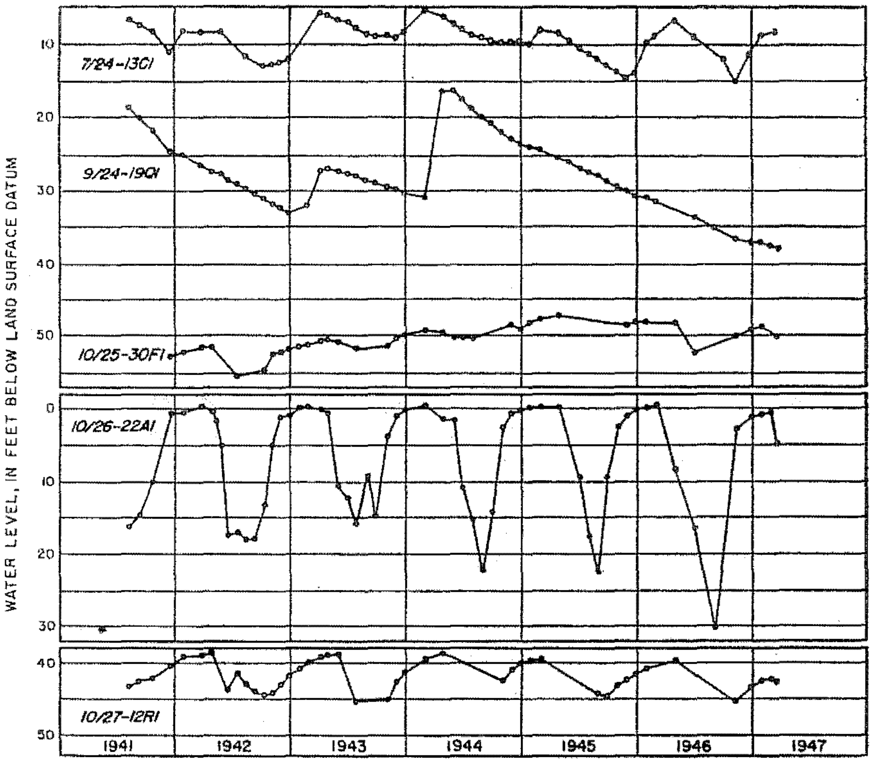


FIGURE 10. Fluctuations of water levels in five wells in the Cuyama Valley, Calif., 1941–47.

Figure 10 shows representative hydrographs for five observation wells in the Cuyama Valley. Wells 7/24-13C1 and 9/24-19Q1 are along the Cuyama River above the principal area of withdrawals. Both graphs show pronounced rises during winters of large river flow, and pronounced recessions in other years due to the natural depletion of ground water by westward drainage and lack of replenishment. For example, in well 9/24-19Q1 from March 1 to May 30, 1944, the water level rose 14.72 feet, owing primarily to recharge from the river. This rise was followed by a nearly steady decline from May 30, 1944, to March 21, 1947, amounting to 21.73 feet, and due primarily to natural depletion during years of small river flow.

Wells 10/25-30F1, 10/26-22A1, and 10/27-12R1 are in the area of withdrawals for irrigation. The graphs for these wells show (1) that the water level declines each year from May to October or November because of pumping, and rises after pumping ceases; and (2) that the peaks to which the water levels rose each year are about the same for the period of record. In well 10/25-30F1, which is near the eastern edge of the area of withdrawals, there was actually a net rise of 4.35 feet, from the 1942 high stage on May 7 to that of 1945 on April 24, followed by a net decline

of 1.68 feet to the 1947 high stage on January 29, or an over-all net rise for the period of 2.67 feet. In the same area, reported measurements in well 10/25-26E1 show no net decline of water level from November 1942 to July 1946; those in well 10/25-27R1 show a decline of 1.5 feet from November 1942 to September 1946.

In well 10/26-22A1, which is near the center of the area of withdrawals and in an area of confined or semiconfined water, there has been a very small net decline — only 0.79 feet from March 24, 1942, to February 26, 1947. And in well 10/27-12R1, which is near the western edge of the area of withdrawals, there has been a slight but progressive net decline from April 28, 1942, to February 28, 1947, amounting to 3.62 feet; but less than 2 feet to the peak level in 1946. In well 10/26-18F1—graph not shown in figure 10—the water level declined about 6 feet from the highest level in 1941 to the end of the record in the spring of 1947. These high levels also precede the pumping seasons.

The fluctuations of water level in these wells show a small decline in the central and western parts of the area of withdrawals, but essentially no over-all change in the eastern part of that area, which is near the area of recharge from the Cuyama River. This indicates that replenishment to the area west of the 2,260-foot water-level contour (pl. 5) has about equaled the total net discharge except at the extreme west end. It seems inconceivable that the large increase in pumpage during the years 1939 to 1946 should not have caused a noticeable lowering of water levels over the entire area, as well as a marked decrease in spring discharge. However, in other parts of the county where rainfall records are available, rainfall in 1936–37, 1937–38, 1940–41, 1941–42, and 1942–43 was above average — in 1940–41 excessively so — hence recharge from the Cuyama River as well as from rain must have been unusually high. Note that the water level in well 9/24-19Q1 shows a marked response to river recharge in 1943 and that it reached the highest level of record for the same reason in 1944. It seems likely that recharge in this series of wet years about balanced the increased pumpage in most parts of the area so that water levels and spring discharge did not decline appreciably throughout that short period.

PERENNIAL YIELD

The perennial yield of a ground-water basin may be defined as the rate at which water can be withdrawn year after year without depleting the ground-water storage to such an extent that a withdrawal at this rate is no longer economically feasible because of increased pumping costs or deterioration of water quality. In a newly developed basin, such as the Cuyama Valley, there is usually a large amount of stored water that can be drawn upon before the economic limit of pumping is approached. As this limit is approached, the yearly rate at which withdrawals can be made becomes the difference between average yearly recharge and the minimum practicable average yearly natural discharge. Because, under natural conditions, long-term natural discharge equals the recharge, the perennial yield then is the amount of discharge that can be practicably salvaged.

Until about 1946, replenishment to the main part of the area of withdrawals (p. 59) approximately balanced the natural discharge, estimated to be on the order of 13,000 acre-feet, and the net pumpage, estimated to have averaged about 7,000 acre-feet — a total of about 20,000 acre-feet a year. However, through 1944 replenishment was above average. Hence, during that period the estimated total yearly discharge of about 20,000 acre-feet was considerably more than the estimated long-term average recharge. With a continued large draft, water levels eventually must decline throughout the entire valley. This decline will increase pumping lifts and costs. However, decline of water levels within the area of withdrawals will doubtless also be accompanied by a decline of water levels within the area of natural discharge. This in turn will cause a decrease in all forms of natural discharge and thereby will salvage water now being lost from the area.

How much of the current natural discharge, crudely estimated at 13,000 acre-feet per year, can be salvaged for pumping is problematical, but with the present distribution of irrigation wells it would not be much. Consequently, the perennial yield as defined would be a quantity considerably less than 13,000 acre-feet a year, and less than the expected future net pumpage by an even larger amount. However, additional large wells strategically located might so lower the water levels in most of the area of natural discharge as to salvage a large proportion of the estimated evapotranspiration loss of 8,000 acre-feet a year, and of the low flow of the Cuyama River, estimated to be 3,000 acre-feet a year. In all, under these conditions, if the long-term average replenishment is on the order of 13,000 acre-feet a year the perennial yield thus induced might be somewhere between 9,000 and 13,000 acre-feet a year. An additional reach of river channel also would be dried up, possibly allowing slightly greater seepage loss from the river in time of flood, and thus actually increasing recharge a little.

To refine this crude estimate for perennial yield involves the continued collection of basic data such as: measurement of stream and spring discharge made at least semiannually at the sites indicated on plates 1 and 5, monthly measurements of water levels in observation wells, determination of yearly pumpage by more refined methods, and refinement of the estimate of ground-water underflow by field tests of permeability.

It is possible that the chemical quality of the water may limit the perennial yield, but too little is known about what the quality of water might be after storage is depleted. If the quality of the water pumped

TABLE 8. — *Chemical analyses of well, spring, and stream waters in the Cuyama Valley, Calif.*

[Analyzed by A. A. Garrett, U. S. Geological Survey]

Well no.	Date of collection	Chloride (Cl) (ppm)	Total hardness as $CaCO_3$ (ppm)	Specific conductance ($K \times 10^5$ at 25° C.)	Temperature (°F.)
7/24–13C1....	Aug. 12, 1942	12	1,050	247	..
8/24–5P1....	......do.......	22	425	208	..
6R1....	......do.......	10	900	160	66
8R1....	......do.......	16	800	175	67
17R1....	......do.......	13	1,100	179	59
27Q1....	......do.......	41	140	73.3	67
9/24–7B1....	Sept. 10	20	240	113	..
19Q1....	Aug. 12	10	900	167	..
30B1....	......do.......	9	900	158	64
30H1....	......do.......	8	900	158	62
32C1....	......do.......	18	975	176	..
9/25–1L1....	Apr. 23, 1947	11	875	165	..
2P1....	July 14, 1942	12	950	156	..
3D1....	......do.......	8	775	148	63
6K1....	......do.......	16	675	135	..
11R1....	June 16	14	1,200	189	64
13G1....	......do.......	7	850	149	60
14G1....	July 14	20	1,600	237	..
27C1....	......do.......	18	1,400	217	..
9/26–4J1....	......do.......	44	3,000	443	..
6B1....	Aug. 12	39	1,050	262	..
6L1....	......do.......	112	1,950	299	..
6P1....	......do.......	101	3,950	581	..
10/25–8P1....	June 17	84	1,075	205	..
15Q1....	Apr. 23, 1947	151	550	201	64
18K1....	......do.......	14	900	188	62
25M1....	......do.......	15	1,050	167	..
26E1....	July 14, 1942	10	975	164	..
10/25–27R1....	......do......	11	950	167	64
29A2....	Aug. 12	13	950	165	..
29K1....	July 14	11	925	160	..
30F1....	Sept. 10	13	775	164	..
30R1....	July 14	11	950	165	64
31A1....	......do.......	14	1,000	171	..
31H1....	......do.......	13	1,100	183	..
32C1....	......do.......	11	940	145	..
33D1....	......do.......	11	875	161	63
35C1....	......do.......	10	1,100	172	..
35F1....	......do.......	17	1,150	178	..
10/26–7P1....	Sept. 10	37	1,250	273	67
9R1....	June 17	14	1,225	194	64
14C1–3[1]....	Apr. 23, 1947	13	950	175	..
11N[2]....	......do.......	15	1,550	255	..
13G1....	......do.......	14	800	169	..
14C3....	......do.......	14	875	172	62
15G1....	......do.......	13	800	163	63
18F1....	June 16, 1942	20	1,150	220	67
18F1....	Apr. 23, 1947	22	875	237	68
21R1....	......do.......	13	957	127	71
22D1....	Sept. 10, 1942	14	925	197	..
22E1....	June 17	11	1,225	200	..
22J1....	......do.......	11	1,100	189	..
22K1....	......do.......	12	1,150	199	71
23H1....	July 14	10	1,000	168	..
23P1....	......do.......	12	1,065	188	68
23R1....	June 1, 1943	14	925	171	68

[1] Sample taken at measurement site at 10/26-11N.
[2] Swamp water north of Graveyard Springs.

TABLE 8. — *Chemical analyses of well, spring, and stream waters in the Cuyama Valley, Calif.*—Continued

Well no.	Date of collection	Chloride (Cl) (ppm)	Total hardness as $CaCO_3$ (ppm)	Specific conductance ($K \times 10^6$ at 25° C.)	Temperature (°F.)
10/27-1R[3]	Apr. 23, 1947	29	1,600	270	..
3L1	Apr. 28, 1942	32	400	104	70
11C1	June 17	50	1,750	279	..
12E2	Apr. 23, 1947	87	2,400	404	65
12J2	Apr. 28, 1942	...	1,250	207	65
11/27-31E[4]	Apr. 23, 1947	224	625	327	64
31M1	......do.......	763	500	284	66
11/28-17K[3]	......do.......	108	1,750	327	..

[3] Cuyama River water.
[4] Green Creek water.

should deteriorate, owing to drawing in deeper water of poorer quality, then perhaps the rate of withdrawals would have to be reduced.

QUALITY OF WATER

In 1942, 1943, and 1947, the Geological Survey collected for chemical analysis 66 samples of water from wells, streams, and springs. Two of the analyses include all the more common constituents and the remainder give only values for chloride, hardness, and specific electrical conductance. The conductivity of water is an important characteristic because it affords a rough measure of the concentration of the dissolved solids. Other agencies and persons have made available for study 29 detailed analyses. The available incomplete analyses are shown in table 8, and all other detailed analyses are shown in table 9.

The analyses show that all the ground water has about the same general chemical characteristics, usually being rather high in dissolved solids. Calcium and magnesium sulfate are the predominant mineral constituents. In most areas of the valley, the waters are extremely hard, ranging in hardness from about 800 to about 1,200 parts per million. The few complete analyses available indicate that the concentration of calcium ranges from about 200 to 275 parts per million, that of magnesium from 50 to 122 parts, and that of sulfate from 750 to 1,500. Nearly all the waters are very low in chloride, ranging in concentration from 7 to 50 parts, except water from two wells in the extreme eastern part of the plain. The waters of the Graveyard, Weir, Turkey Trap, and other main springs have about the same general composition as water from wells and also about the same temperature (60° to 64°F.), indicating that they are part of the same body. However, the Weir Spring and spring 10/26-16C1—at Cuyama ranch headquarters—have considerably higher concentrations of sulfate —1,500 and 1,850 parts per million, respectively—than the water in nearby wells.

The analyses also show, however, that the waters differ somewhat in chemical composition throughout the valley. In the extreme western part of the valley, the chloride concentration is as much as 30 parts higher and hardness as much as 750 parts greater than in the waters in the eastern part of the valley. In one small area in about the middle of the plain, salts are said to have been concentrated in the soil, as a result of irrigation, to the extent that they are injurious to some crops.

Some marked variations of quality occur at several places in the valley. For example, the water from well 10/24-19F1 is extremely high in chloride and boron, but relatively low in hardness. The concentrations are, respectively, 753, 12, and 444 parts per million. The quantities of chloride and boron are of the same order as in water from nearby spring 10/24-20M1. The well penetrates Tertiary consolidated rocks almost exclusively and the chloride and boron concentrations may be characteristic of the waters encountered in these rocks. The water from wells 10/25-8P1 and 10/25-15Q1 has considerably higher concentrations of chloride—84 and 151 parts, respectively—than do those from wells in the main part of the alluvial plain. Similarly, water from well 9/26-6L1 and spring 9/26-6P1 have concentrations of chloride amounting to 112 and 101 parts, respectively. All these wells are in or down gradient from areas underlain by Miocene marine deposits, and it seems likely that these rocks are the source of the higher-chloride water. However, the higher concentration in the water from well 10/25-15Q1 may be due to some nearby source of strongly saline water. If so, further pumping in the area to the south and west such as to develop a broad cone of water-table depression in that area would tend to draw saline water down the hydraulic gradient into the pumped area.

The water in the springs at the terrace front in secs. 11 and 12, T. 10 N., R. 27 W., is very hard and has a higher chloride content than that found in most wells in the valley. For example, water from spring 10/27-12E2 has 87 and 2,400 parts per million of chloride and hardness, respectively. These concentrations probably largely account for the increase in chloride and hardness of water in wells immediately north.

Still farther west, the water from spring 10/27-3L1, which is along the same general line of seepage as 10/27-12E2, oddly is lower in chloride, hardness, and electrical conductivity than any other waters in the northwestern part of the valley for which analyses are available. No explanation for this difference can be made with the few data now at hand.

The analyses indicate that within the range of existing wells there is no deterioration of quality with depth. Nevertheless, in view of the several variations in quality discussed above, it would be advisable to collect samples of water periodically for analysis from selected wells in the principal area of withdrawal.

TABLE 9. — *Chemical analysis in parts per million, of well, spring, and stream waters in the Cuyama Valley, Calif.*

[Includes two complete analyses by U. S. Geol. Survey and other analyses in which five or more constituents were determined]

Well no.	Source	Date of collection	Temperature (°F.)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Boron (B)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$ (calculated)	Percent sodium
7/23-19L	Cuyama River, at bridge on U. S. Highway No. 399 near Ozena. Sample taken by U. S. Bur. Reclamation (No. 34); analyzed by Nat. Bur. Standards, San Francisco Lab.	May 12, 1943	..	..	..	190	76	54	5.0	7.7	180	730	5.7	..	0.1	0	1,300	787	...
9/24-19F1	U. S. Forest Service. Drilled domestic well, 113 feet deep. Analyzed by W. P. Kelley (No. 187).	1942 or 1943	..	..	..	215	88	34	..	..	188	752	13	..	.33	...	....	898	7.7
9/27-9H1	Hill Bros. Hog Pen Spring. Analysis by Univ. California Citrus Exper. Sta., Riverside (No. 3061, No. 2).	June 7, 1940	..	..	..	146	57	150	..	0	560	404	36	..	....	...	....	599	...
10/24-19F1	Em. H. Mettler & Sons, well 4. Abandoned irrigation well, 811 feet deep. Analyzed by Frank Hornkohl Chem. Lab.	Dec. 18, 1945	..	..	..	....	..	..	..	0	232	940	753	..	12	...	....	444	80
Do.	Do.	Jan. 1, 1946	..	..	..	....	..	..	..	0	217	908	805	..	12	...	....	480	79
10/25-19P1	Adolph Kirschenmann. Abandoned irrigation well, 418 feet deep. Analyzed by W. P. Kelley (No. 178).	......do......	..	..	..	255	78	46	..	..	175	843	13	..	.32	...	....	957	9.5
10/24-20M1	Owner not known. Unnamed spring. Analyzed by W. P. Kelley (No. 182).	1942 or 1943	..	..	..	213	86	420	..	..	222	605	669	..	14	...	....	885	51
10/25-22H1	Em. H. Mettler & Sons, well 3. Drilled irrigation well, 623 feet deep. Analyzed by Frank Hornkohl.	Aug. 4, 1945	..	..	..	....	..	..	..	0	175	762	23	..	.16	...	....	896	7.6
10/25-29A1 or 2	R. B. Smith. Drilled domestic well. Analyzed by W. P. Kelley (No. 183).	1942 or 1943	..	..	..	211	84	50	..	..	168	752	10	..	.36	...	....	872	11
10/25-30F1	Adolph Kirschenmann. Drilled irrigation well, 376 feet deep. Analyzed by W. P. Kelley (No. 179).	......do......	..	..	..	214	88	69	..	..	173	817	14	..	.21	...	....	896	14
10/25-30R1	Adolph Kirschenmann. Drilled irrigation and domestic well, 372 feet deep. Analyzed by Frank Hornkohl (No. 1225).	June 7, 1940	..	..	..	....	..	..	..	0	193	838	16	..	....	...	....	870	...
Do.	Adolph Kirschenmann. Drilled irrigation well, 372 feet deep. Analyzed by W. P. Kelley (No. 177).	1942 or 1943	..	..	..	196	92	54	..	..	182	775	14	..	.27	...	....	867	12
10/25-31H1	Adolph Kirschenmann. Drilled irrigation well, 359 feet deep. Analyzed by W. P. Kelley (No. 180).	......do......	..	..	..	238	100	69	..	..	180	884	15	..	.41	...	....	1,000	13
10/25-32C1	W. J. Wylie. Drilled domestic well, 200 feet deep. Analyzed by	....	..	..	..	....	..	..	..	0	154	517	17	..	.01	...	....	401	...
10/25-32C2	W. J. Wylie. Drilled irrigation well; depth unknown. Analyzed by W. P. Kelley (No. 9).	Nov. 4, 1942	..	..	..	238	93	52	..	..	190	965	11	..	.24	...	....	976	14
10/25-33D1	Adolph Kirschenmann. Drilled irrigation well, 354 feet deep. Analyzed by W. P. Kelley (No. 181).	1942 or 1943	..	..	..	252	83	34	..	..	171	819	13	..	.35	...	....	970	7.0
10/26-14C1, 2, 3	H. S. Russell. Graveyard Springs. Analyzed by Univ. California Citrus Exper. Sta., Riverside (No. 2410).	Feb. 13, 1934	..	..	..	242	50	184	..	0	226	970	18	..	....	...	....	810	...
Do.	H. S. Russell. Graveyard Springs. Analyzed by Univ. California Citrus Exper. Sta., Riverside (No. 3067, No. 1).	July 9, 1940	..	..	..	242	70	73	..	0	183	887	17	..	....	...	....	892	...
10/26-16C1	H. S. Russell. Cuyama ranch house spring. Analyzed by Frank Hornkohl (No. 15, 1934).	Mar. 20, 1947	..	..	..	234.4	97	521	..	0	200	1,850	20	..	....	...	3,070	982	...
10/26-18F1	William Kirschenmann Estate. Drilled irrigation well, 240 feet deep. Analyzed by W. P. Kelley (No. 186).	1942 or 1943	..	..	..	274	122	98	..	..	194	1,140	14	..	.27	...	....	1,180	15
10/26-22D1	Goehring Bros. Drilled irrigation well, 407 feet deep. Analyzed by W. P. Kelley (No. 8).	Nov. 4, 1942	..	..	..	257	114	86	..	..	180	1,110	26	..	.27	...	....	1,110	19
10/26-22E1	Ed. Kirschenmann. Drilled irrigation well, 514 feet deep. Analyzed by W. P. Kelley (No. 7).	......do......	..	..	..	249	100	92	..	..	156	1,070	8.9	..	.30	...	....	1,030	21.0
10/27-3L1	California State Highway Dept. spring zone. Sample taken by U. S. Geol. Survey; analyzed by G. J. Petretic, U. S. Geol. Survey (No. 27, 413).	Apr. 28	70	27	.13	104	36	75	2.6	0	205	324	29	.3	....	16	766	408	...
10/27-12E1	William Kirschenmann Estate. Drilled stock well, 248 feet deep. Analyzed by Frank Hornkohl (No. 1,224).	June 7, 1940	..	..	..	....	..	..	..	0	156	1,210	45	..	....	...	....	1,060	...
10/27-12J1	William Kirschenmann Estate. Drilled irrigation well, 138 feet deep. Analyzed by Frank Hornkohl (No. 1,223).	......do......	..	..	..	....	..	..	..	0	219	1,510	44	..	....	...	....	1,030	...
Do.	William Kirschenmann Estate. Drilled irrigation well, 138 feet deep. Analyzed by Univ. California Exper. Sta., Riverside (No. 3,067, No. 2).	Mar. 20, 1947	..	..	..	358	116	207	..	0	220	1,630	43	..	....	...	....	1,370	...
10/27-12J2	William Kirschenmann Estate. Drilled irrigation well, 294 feet deep. Sample taken by U. S. Geol. Survey; analyzed by G. J. Petretic, U. S. Geol. Survey (No. 27,425).	Apr. 28, 1942	65	32	1.1	272	112	101	8.8	0	168	1,150	21	.3	....	.5	1,930	1,140	...
10/27-34D1	Hill Bros. Domestic well. Analyzed by Univ. California Citrus Exper. Sta., Riverside (No. 3,061, No. 1).	June 7, 1940	..	..	..	358	60	326	..	0	213	1,540	50	..	....	...	....	1,140	...
11/28-17K	Cuyama River, at bridge on State Route 166 below Cottonwood Creek. Sample taken by U. S. Bur. Reclamation (No. 35); analyzed by Nat. Bur. Standards, San Francisco Lab.	May 12, 1943	..	..	..	....	..	..	..	5.1	260	1,500	95	..	.5	...	2,800	.....	...

LOGS OF WELLS

Table 10 contains the available logs of water wells in the Cuyama Valley. In addition to the material penetrated, the table also gives, wherever known, the casing size and perforations, the yield and drawdown, and the static level when drilled of each well listed.

TABLE 10.—*Logs of wells in the Cuyama Valley, Calif.*

[Stratigraphic correlations by J. E. Upson and G. F. Worts, Jr.]

9/24-19F1, U. S. Forest Service, Cuyama ranger station. On alluvial plain, about 1.6 miles northwest of Ventucopa. Altitude 2,755 feet. Casing 10-inch, perforated 85–113 feet. Domestic and stock well. Drilled in alluvium.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil, brown	27	27	Gravel, coarse, water-bearing	3	77
Gravel, fine, dry	37	64	Sand, coarse, water-bearing	8	85
Gravel, fine, "small water seepage"	3	67	Gravel, fine, water-bearing	6	91
Gravel, fine, dry	7	74	Clay and gravel, dry	6	97
			Gravel, fine, water-bearing	16	113

9/24-30B2. W. W. Johnson. On alluvial plain, about .07 mile northwest of Ventucopa. Altitude 2,830 feet. Log reported by owner. Casing 10-inch, perforated 50–169 feet. Yield in 1946 about 900 gallons a minute with drawdown of 10 feet; static level about 39 feet below land surface.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Older continental deposits (?):		
Silt and sand	50	50	Clay, sandy	11	180
Sand and gravel, "good"	119	169	Quicksand	10	190

9/25-111. G. E. Cawelti. On alluvial plain, about 3.5 miles northwest of Ventucopa. Altitude 2,655 feet. Casing 8-inch, perforated 338–368 feet. Stock well. Drilled in alluvium and older continental deposits, undifferentiated.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium and older continental deposits, undifferentiated:			Older continental deposits:		
Sand, gravel, and boulders; occasional layers of clay			Sand, gravel, and boulders; water-bearing	13	347
Clay, sticky, dark	328	328	Clay, yellow	2	349
Gravel	2	330	"Shale," muddy	9	358
Sand, hard	2	332	Sand and gravel	8	366
	2	334	Clay, sandy, light-colored	2	368

TABLE 10. — *Logs of wells in the Cuyama Valley, Calif.*—Continued

9/25-3D1. G. E. Cawelti. On alluvial plain, about 5 miles southeast of Cuyama. Altitude 2,408 feet Casing 6-inch, perforated 198–240 feet. Domestic and stock well. Drilled in alluvium, terrace deposits, and older continental deposits, undifferentiated.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium, terrace deposits, and older continental deposits, undifferentiated: No record (bases of alluvium and terrace deposits probably within this unit)	190	190	Older continental deposits:		
			Gravel, coarse, dry	7	197
			Gravel, coarse, water-bearing	14	211
			Gravel, coarse, and boulders	39	250

9/26-4J1. J. G. James. In Salisbury Canyon, about 4 miles southwest of Cuyama. Altitude 2,575 feet. Casing 6-inch, perforated 57–327 feet. Domestic and stock well.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Older continental deposits:		
Soil	3	3	Sand, hard	3	200
Sand and gravel, brown	7	10	Clay and sand	60	260
Older continental deposits:			Clay, hard, yellow	23	283
Clay, yellow	10	20	Sand, water-bearing	12	295
Clay, yellow, and boulders	18	38	Clay, yellow	2	297
Clay, hard, yellow, and fine sand	27	65	Sand, water-bearing, "about 3 gpm"	5	302
Clay, yellow	20	85	Clay, yellow	2	304
Clay, yellow, and streaks of sand	112	197	Sand, water-bearing	5	309
			Clay	18	327

10/24-19F1. Em. H. Mettler & Sons, well 4. On alluvial fan, about 8 miles east of Cuyama. Altitude 2,680 feet. Casing 16- to 10-inch, perforated 29–811 feet. Water level 85.36 feet below top of casing on Oct. 2, 1946. Unused gravel-packed irrigation well.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Terrace deposits: Surface sand and gravel	15	15	Pre-Pliocene continental deposits:		
Pre-Pliocene continental deposits:			Sand, gravel, and boulders	170	410
Sand and gravel	210	225	Gravel and boulders	75	485
Clay, sandy	15	240	Clay, gravel, and boulders	190	675
			Gravel and boulders	136	811

10/25-14Q1. Em. H. Mettler & Sons, well 2. On alluvial fan, about 6 miles east of Cuyama. Altitude 2,430 feet. Casing 16-inch, perforated 138–506 feet. Water level 155.17 feet below top of casing on Oct. 2, 1946. Unused gravel-packed irrigation well.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Pre-Pliocene continental deposits (?):		
Surface sand	42	42	Sandy clay and streaks of gravel	210	355
Sand, gravel, and boulders	103	145	Sand, gravel, and boulders	151	506

TABLE 10.—*Logs of wells in the Cuyama Valley, Calif.* — Continued

10/25-19P1. Adolph Kirschenmann. On alluvial plain, about 1.7 miles southeast of Cuyama. Altitude 2,295 feet. Casing 16-inch, perforated 118–142, 148–154, 160–166, 172–178, 184–190, 196–232, 244–256, 262–268, 274–280, and 286–340 feet. Water level 34.47 feet below top of casing on July 14, 1942. Abandoned irrigation well.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium and older continental deposits, undifferentiated:			Older continental deposits:		
Soil	14	14	Clay, sandy, gravel and boulders	11	144
Sand	3	17	Clay, sandy, and gravel	57	201
Clay, sandy, hard	25	42	Sand and gravel	6	207
Clay, brown	18	60	Clay, sandy, and gravel, "free streaks"	23	230
Clay, sandy, and gravel, "free"	4	64	Clay, sandy	10	240
Clay, sandy	9	73	Sand and gravel	6	246
Gravel	4	77	Clay, sandy, gravel and boulders	38	284
Clay, sandy, and gravel	10	87	Clay, sticky	5	289
Clay and small boulders	7	94	Clay, sandy, and gravel, "free streaks"	31	320
Sand, gravel, and boulders	4	98	Clay, sandy, gravel and boulders	35	355
Boulders	3	101	Clay, sandy	29	384
Sand and boulders	14	115	Clay, sandy, and gravel, "free streaks"	8	392
Sand	5	120	Clay, sandy, gravel and boulders	19	411
Sand, gravel, and boulders	13	133	Clay, sandy	7	418

10/25-20H1. H. S. Russell. On alluvial plain, about 3.3 miles east of Cuyama. Altitude 2,335 feet. Casing 16- to 10-inch, perforated 108–656 feet, gravel-packed. Yield in 1946 on test 4,400 gallons a minute with drawdown of 13.9 feet; static level about 59 feet below land surface. Drilled in alluvium and older continental deposits, undifferentiated.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sand and coarse gravel	187	187	Gravel, coarse with some clay	41	626
Clay and coarse gravel	248	435	Gravel, coarse	22	648
Gravel, coarse	150	585	Clay and coarse gravel	8	656

10/25-21G1. Em. H. Mettler & Sons, well 7. On alluvial plain, about 4 miles east of Cuyama. Altitude 2,357 feet. Casing 16- to 10-inch, perforated 108–348 and 354–655 feet, gravel-packed. Yield in 1946 about 2,500 gallons a minute with drawdown of about 15 feet; static level 77.41 feet below land-surface datum on Jan. 29, 1947. Drilled in alluvium and older continental deposits, undifferentiated.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sand and coarse gravel	234	234	Gravel, coarse	111	492
Clay and coarse gravel with streaks of sand	80	314	Clay and coarse gravel	75	567
Clay and coarse gravel	67	381	Sand and coarse gravel	51	618
			Gravel, coarse	39	657

10/25-22E1. Em. H. Mettler & Sons, well 6. On alluvial plain, about 4.3 miles east of Cuyama. Altitude 2,368 feet. Casing 16- to 10-inch, perforated 108–402 and 408–655 feet; gravel-packed. Yield in 1946 about 2,500 gallons a minute with drawdown of about 5 feet; static level about 90 feet below land surface. Drilled in alluvium and older continental deposits, undifferentiated.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sand and coarse gravel	19	19	Sand and coarse gravel	30	410
Sand and boulders	17	36	Sand and boulders	40	450
Sand and coarse gravel	7	43	Sand and coarse gravel	25	475
Sand and boulders	57	100	Sand and boulders	39	514
Sand and coarse gravel	59	159	Sand and boulders with streaks of clay	91	605
Sand and boulders	67	226	Sand and coarse gravel	54	659
Sand and coarse gravel	103	329			
Sand and boulders	51	380			

TABLE 10.—*Logs of wells in the Cuyama Valley, Calif.* — Continued

10/25-22M1. Em. H. Mettler & Sons, well 3. On alluvial plain, about 5 miles east of Cuyama. Altitude 2,372 feet. Casing 16- to 10-inch, perforated 84–623 feet; gravel-packed. Yield in 1946 about 2,500 gallons a minute with drawdown of about 5 feet; static level about 92 feet below land surface. Drilled in alluvium and older continental deposits, undifferentiated.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Clay, sandy	20	20	Sand, gravel, and boulders	159	364
Sand, hard, and gravel with boulders	150	170	Gravel and boulders with streaks of clay	259	623
Clay	35	205			

10/25-22P1. Em. H. Mettler & Sons, well 5. On alluvial plain, about 4.8 miles east of Cuyama. Altitude 2,392 feet. Casing 16- to 10-inch, perforated 108–402 and 408–655 feet; gravel-packed. Yield in 1946 about 2,500 gallons a minute with drawdown of about 6 feet; static level about 98 feet below land surface. Drilled in alluvium and older continental deposits, undifferentiated.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sand and coarse gravel	50	50	Gravel, coarse	147	602
Gravel, coarse	107	157	Gravel, coarse, with streaks of clay	58	660
Gravel, coarse, with streaks of clay	298	455			

10/25-23E1. Em. H. Mettler & Sons, well 1. On alluvial plain, about 5.6 miles east of Cuyama. Altitude 2,397 feet. Casing 16- to 12- to 10-inch, perforated 175–810 feet; gravel-packed. Yield in 1945 on test 1,394 gallons a minute with drawdown of 29 feet; static level about 106 feet below land surface. Drilled in alluvium and older continental deposits, undifferentiated.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Surface soil	52	52	Sand, hard, with streaks of clay	72	558
Sand, gravel, and boulders	150	202	Clay, sandy, with streaks of gravel	42	600
Sand, gravel, and boulders with streaks of clay	128	330	Sand, gravel, and boulders	40	640
Sand and gravel, hard	50	380	Clay, sand, and gravel	107	747
Clay, sand, and gravel	55	435	Sand, gravel, and boulders	63	810
Clay, sand, gravel, and boulders	51	486			

10/25-26E1. Father Forde. On alluvial plain, about 5.7 miles east of Cuyama. Altitude 2,435 feet. Casing 16-inch, perforations not known. Yield in 1946 on test 2,008 gallons a minute with drawdown of 6.4 feet; static level about 155 feet below land surface. Drilled in alluvium and older continental deposits, undifferentiated.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil	40	40	Gravel, water-bearing	40	409
Gravel and boulders	91	131	Sandstone	7	[illegible]
Sand, sticky	29	160	Gravel, water-bearing	41	467
Gravel, water-bearing	36	196	Clay	9	476
Clay	40	236	Gravel	16	492
Gravel, water-bearing	55	291	Clay	9	501
Clay and boulders, hard	27	318	Clay, sandy	62	563
Gravel, water-bearing	5	323	Sand, "poor" (not water-bearing)	15	578
Boulders	7	330	Clay and "poor" sand	34	612
Gravel, water-bearing	42	372	Sand, water-bearing	233	845
Clay	7	379			

TABLE 10. — *Logs of wells in the Cuyama Valley, Calif.*—Continued

10/25-27G1. Swaner, well 1. On alluvial plain, about 5 miles east of Cuyama. Altitude 2,420 feet. Casing 16- to 10-inch, perforated 119–400 and 410–665 feet; gravel-packed. Yield in 1947 about 2,500 gallons a minute; drawdown and static level not known. Drilled in alluvium and older continental deposits, undifferentiated.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sand with some gravel	121	121	Clay and gravel	103	549
Gravel with streaks of clay	292	413	Sand and gravel	117	666
Gravel	33	446			

10/25-30E1. Adolph Kirschenmann. On alluvial fan, about 1.6 miles southeast of Cuyama. Altitude 2,345 feet. Casing 14-inch, perforated 138–381 feet. Water level 81.84 feet below top of casing on Sept. 10, 1942. Abandoned irrigation well.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Older continental deposits (?):		
Soil	52	52	Sand and cobbles as much as 3 inches in diameter	1	218
Sand and boulders as much as 8 inches in diameter	16	68	Sand, packed	1	219
Clay, sandy, soft, red	8	76	Sand and cobbles as much as 4 inches in diameter	4	223
Sand and cobbles as much as 2 inches in diameter	2	78	Clay, sandy, brown	28	251
Clay, sandy, red	27	105	Clay, tough, gray	5	256
Sand and gravel as much as 1 inch in diameter	3	108	Clay, red with gray streaks	7	263
Clay, sandy, red	41	149	Sand and gravel	3	266
Sand, "muddy," and cobbles as much as 6 inches in diameter	12	161	Clay, tough, brown	37	303
Clay, sandy, red	6	167	Sand and cobbles as much as 3 inches in diameter	5	308
Sand, "muddy," and gravel	8	175	Clay, sandy, with gravel	20	328
Clay, sandy, red	3	178	Clay, tough, red	5	333
Sand, "muddy," and cobbles as much as 3 inches in diameter	4	182	Sand, coarse	2	335
Older continental deposits (?):			Clay, sandy, red	23	358
Clay, sandy, tough, brown	11	193	Sand, coarse	2	360
Clay, sandy, hard	24	217	Sand, packed	45	405
			Clay	5	410
			Clay, tough, red	7	417
			Sand, packed	7	424

10/25-30F1. Adolph Kirschenmann. On alluvial fan, about 1.9 miles southeast of Cuyama. Altitude 2,320 feet. Casing 16-inch, perforated 124–160, 170–187, 196–202, 229–232, 241–250, 265–268, 274–313, and 332–370 feet. Yield in 1946 on test 2,225 gallons a minute with drawdown of about 64 feet; static level about 52 feet below top of casing.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Older continental deposits (?):		
Soil	15	15	Sand, not water-bearing	17	227
Sand, packed, non water-bearing	17	32	Clay	16	243
Sand, "free"	3	35	Sand and gravel	5	248
Sand, packed, not water-bearing	62	97	Clay with streaks of sand	12	260
Sand and boulders	64	161	Clay	14	274
Older continental deposits (?):			Sand and boulders	8	282
Clay, sandy	9	170	Clay with streaks of sand	14	296
Sand and boulders	10	180	Clay with streaks of shale	39	335
Clay with streaks of sand	30	210	Boulders	6	341
			Shale with streaks of sand	15	356
			Sand and boulders	6	362
			Gravel, cemented	14	376

TABLE 10. — *Logs of wells in the Cuyama Valley, Calif.*—Continued

10/25-30R1. Adolph Kirschenmann. On alluvial fan, about 2.6 miles southeast of Cuyama. Altitude 2,360 feet. Casing 14-inch, perforated 120–140 and 192–369 feet. Yield in 1945 on test 1,198 gallons a minute with drawdown of 14.7 feet; static level about 100 feet below land surface.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Older continental deposits (?):		
Soil	30	30	Clay, tough, yellow	4	287
Sand and boulders	5	35	Clay, sandy, soft	1	288
Silt, packed	28	63	Clay, tough, yellow	4	292
Sand, gravel, and boulders	11	74	Clay, sandy, soft	1	293
Clay, silty, soft	25	99	Clay, tough	4	297
Sand, gravel, and boulders	39	138	Clay, sandy, soft	1	298
Older continental deposits (?):			Clay, tough, yellow	3	301
Clay, yellow	132	270	Gravel and boulders	3	304
Clay, sandy, soft	3	273	Sandstone	1	305
Clay, tough, yellow	4	277	Clay, sandy	13	318
Clay, sandy, soft	1	278	Clay, gray	24	342
Clay, tough	4	282	Clay, tough, yellow	12	354
Clay, sandy, soft	1	283	Sand, gravel, and boulders	6	360
			Clay, tough, yellow	12	372

10/25-31B1. Adolph Kirschenmann. On alluvial fan, about 3 miles southeast of Cuyama. Altitude 2,398 feet. Casing 16-inch, perforations not known. Yield in 1945 on test 642 gallons a minute with drawdown of 36.6 feet; static level about 126 feet below land surface.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Older continental deposits (?):		
Soil	15	15	Clay	4	224
Sand, not water-bearing	121	136	Clay and sand	12	236
Sand, free	10	146	Sand, not water-bearing	30	266
Older continental deposits (?):			Clay	4	270
Clay, sandy	24	170	Sand and boulders	6	276
Sand, free	10	180	Sand, not water-bearing	6	282
Clay, sandy	7	187	Clay and boulders	15	297
Sand and boulders	7	194	Sandstone	7	304
Clay and sand, not water-bearing	11	205	Gravel, cemented	6	310
Cap rock	3	208	Sand and boulder	10	320
Clay and boulders	6	214	Clay, sand, and boulders	20	340
Sand, not water-bearing	6	220	Sand, fine	10	350
			Sand, not water-bearing	9	359

10/25-31H2. Adolph Kirschenmann. On alluvial fan, about 3 miles southeast of Cuyama. Altitude 2,404 feet. Casing 16-inch, perforated 153-300 feet. Yield in 1942 about 450 gallons a minute; drawdown and static level not known. Well caved and abandoned about 1944.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Older continental deposits (?):		
Silt	150	150	Gravel and boulders	2	299
Older continental deposits (?):			Sandstone	6	305
Clay, tough	7	157	Clay	75	380
Sand	2	159	Clay, soft	7	387
Clay	138	297	Clay	17	404

TABLE 10. — *Logs of wells in the Cuyama Valley, Calif.* — Continued

10/25-32C1. W. J. Wylie. On alluvial fan, about 3.1 miles southeast of Cuyama. Altitude 2,375 feet. Casing 6-inch, perforations not known. Water level 113.16 feet below top of casing on July 14, 1942. Domestic well.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:					
Sandy loam	75	75	Older continental deposits (?):		
Sand and gravel, water-bearing	10	85	Gravel, fine	5	147
Gravel, good	20	105	Clay and muck	47	194
Clay and sand	35	140	Sand and "good" gravel	6	200
Gravel	2	142	Gravel, "good"	?	200

10/25-33D1. Adolph Kirschenmann. On alluvial plain, about 3.9 miles southeast of Cuyama. Altitude 2,405 feet. Casing 16-inch, perforated 156–351 feet. Yield in 1945 on test 1,525 gallons a minute; drawdown not known; static level roughly 130 feet below land surface.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Older continental deposits (?):		
Soil	60	60	Clay, sandy, red	3	226
Sand and boulders as much as 6 inches in diameter	82	142	Gravel and boulders as much as 6 inches in diameter	15	241
Older continental deposits (?):			Clay, red	3	244
Clay, sandy, soft	11	153	Gravel and cobbles as much as 3 inches	41	285
Gravel and cobbles as much as 4 inches in diameter	4	157	Clay, red	12	297
Clay, tough, red	14	171	Gravel and boulders as much as 6 inches in diameter	16	313
Gravel and cobbles as much as 2 inches in diameter	4	175	Clay, red	4	317
Clay, red	2	177	Gravel and cobbles as much as 3 inches in diameter	7	324
Gravel and boulders as much as 6 inches in diameter	6	183	Clay, tough, blue	6	330
Clay, sandy, red	12	195	Gravel and boulders as much as 8 inches in diameter	24	354
Gravel and boulders as much as 6 inches in diameter	28	223			

10/25-35C1. H. C. Faulkner. On alluvial plain, about 6.1 miles east of Cuyama. Altitude 2,485 feet. Casing 7-inch, perforated 196–236 feet. Water level in 1942 about 196 feet below land surface. Domestic well. Drilled in alluvium and older continental deposits, undifferentiated.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil	1	1	Clay, yellow	3	94
Boulders	1	2	Gravel	5	99
Clay, sandy	7	9	Gravel and boulders	37	136
Boulders	1	10	Gravel with streaks of clay	20	156
Clay, sandy	42	52	Clay, yellow	16	172
Sand and gravel	17	69	Gravel	12	184
Boulders	10	79	Clay, yellow	12	196
Gravel	12	91	Gravel	40	236

TABLE 10. — *Logs of wells in the Cuyama Valley, Calif.* — Continued

10/26-9R1. H. S. Russell. On alluvial plain, about 2.5 miles northwest of Cuyama. Altitude 2,135 feet. Casing 14-inch, perforated 42–84, 123–168, 177–186, 192–198 and 204–218 feet. Yield in 1946 on test 726 gallons a minute with drawdown of 38 feet; static level 41.5 feet below land surface.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Alluvium:		
Soil	24	24	Clay and boulders	9	145
Clay	4	28	Sand and gravel	9	154
Sand and boulders	12	40			
Gravel, cemented	8	48	Older continental deposits:		
Sand and boulders	12	60	Clay	5	159
Gravel, cemented	8	68	Sand and gravel	2	161
Sand and gravel	14	82	Clay, blue	19	180
Clay	10	92	Sand, gravel, and boulders	8	188
Clay, sandy	9	101	Clay, blue	16	204
Sand, fine	13	114	Gravel and boulders	4	208
Clay and boulders	4	118	Clay and boulders	4	212
Sand and gravel	8	126	Gravel, cemented	7	219
Clay	7	133	Clay and boulders, not water-bearing	3	222
Sand and gravel	3	136			

10/26-9R2. H. S. Russell. On alluvial plain, about 2.5 miles northwest of Cuyama. Altitude 2,135 feet. Casing 14-inch, perforated 33–54, 97–111, 118–131, 155–168, and 175–212 feet. Water level 29.85 feet below top of casing on June 17, 1942. Abandoned irrigation well.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Older continental deposits:		
Clay	33	33	Gravel, "tight"	26	202
Gravel, "free"	15	48	Clay	28	230
Gravel, "tight"	6	54	Clay with some gravel	10	240
Clay, blue and brown	45	99	Clay, blue	10	250
Gravel, "free"	10	109	Clay, brown	25	275
Clay	11	120	Gravel, tight	14	289
Gravel, "free"	9	129	Sand and boulders, hard	31	320
			Clay, brown	15	335
Older continental deposits:			Clay, sandy, red	20	355
Clay	28	157	Clay, sticky, brown	5	360
Gravel	9	166	Clay, blue	10	370
Clay	10	176	Clay, sticky, brown	10	380

10/26-18F1. William Kirschenmann Estate. On alluvial fan, about 4.6 miles west of Cuyama. Altitude 2,090 feet. Casing 14-inch, perforated 58–237 feet. Yield in 1946 about 600 gallons a minute; drawdown not known; static level about 55 feet below land surface.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Alluvium:		
Soil	14	14	Clay and boulders, brown	7	142
Boulders as much as 8 inches in diameter not water-bearing	8	22	Gravel as much as 1 inch in diameter	3	145
Clay, sand, and gravel streaks	36	58	Sand and gravel, cemented	5	150
Gravel and boulders as much as 6 inches in diameter, water-bearing	2	60	Cobbles as much as 4 inches in diameter	1	151
Clay, sandy, yellow	15	75	Clay, brown	5	156
Boulders, loose, as much as 10 inches in diameter	10	85	Gravel and cobbles as much as 3 inches in diameter	2	158
Clay, yellow	14	99			
Gravel and boulders as much as 6 inches in diameter	1	100	Older continental deposits:		
			Clay, hard, brown, with cobbles	28	186
Clay, yellow	12	112	Clay, blue	19	205
Gravel, coarse, as much as ½ inch in diameter	2	114	Clay, yellow	5	210
			Clay, blue	7	217
Clay, yellow	19	133	Clay, yellow	11	228
Sandstone	2	135	Clay, tough, blue	12	240

TABLE 10. — *Logs of wells in the Cuyama Valley, Calif.* — Continued

10/26-21Q1. S. Germain, well 1. On alluvial fan, about 2.4 miles west-southwest of Cuyama. Altitude 2,295 feet. Casing 16-inch, perforated 144–809 feet. Yield in 1943 about 800 gallons a minute with drawdown of 46 feet; static level about 109 feet below land surface.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Older continental deposits (?):		
Soil	10	10	Clay and sand in streaks, yellow-gray	128	520
Clay, sandy, and boulders	54	64	Clay, sandy, gray-blue	172	692
Clay, sandy, yellow	53	117	Clay and sand in streaks, blue-gray	70	762
Clay, sandy, and gravel; yellow	9	126	Clay, gray, with streaks of sand	42	804
Clay, sandy, yellow	24	150	Sand, white	6	810
Clay and boulders, yellow	22	172	Clay, blue	50	860
Sand and gravel; not water-bearing	11	183	Sand	5	865
Older continental deposits (?):			Clay, sandy, blue	98	963
Clay, yellow	158	341	Sand, blue-white	7	970
Clay, yellow, with streaks of sand	51	392	Clay, blue	23	993

10/26-22A1. Ed. Kirschenmann. On alluvial fan, about 1.2 miles west of Cuyama. Altitude 2,225 feet. Casing 12-inch, perforated 103–115, 124–145, 176–187, 208–237, 250–305, 327–343, 355–391, and 402–423 feet. When completed in 1941, well flowed. Abandoned irrigation well.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Older continental deposits (?):		
Soil	5	5	Sand	6	257
Clay, sandy	27	32	Clay	3	260
Sand	3	35	Sand	6	266
Clay, sandy	34	69	Clay and "shale"	15	281
Clay, sandy, blue	10	79	Sand	7	288
Sand	14	93	"Shale"	5	293
Clay, sandy, with streaks of sand	88	181	Sand	12	305
Older continental deposits (?):			Clay	23	328
Sand	8	189	Sand	5	333
"Shale"	21	210	Clay	17	350
Sand	6	216	Clay with streaks of sand	31	381
Clay	19	235	"Shale"	15	396
Sand	5	240	Sand	6	402
Clay	11	251	Clay with streaks of sand	20	422
			"Shale"	1	423

10/26-22D1. Goehring Bros. (formerly Bell Ranch). On alluvial fan, about 1.8 miles west of Cuyama. Altitude 2,215 feet. Casing 16-inch, perforated 133–151, 160–169, 178–196, 214–250, 256–262, 274–280, 292–298, 304–322, 328–334, and 340–407 feet. Yield in 1946 on test 585 gallons a minute with drawdown of 116.9 feet; static level 80 feet below land surface.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Older continental deposits (?):		
Soil	15	15	Shale with streaks of sand	22	218
Sand; not water-bearing	13	28	Clay	12	230
Sand and gravel	12	40	Sand	5	235
Clay	20	60	Clay with streaks of sand	87	322
Sand and gravel	5	65	Gravel, cemented	4	326
Clay	47	112	Clay, dry	8	334
Gravel, cemented	4	116	Gravel, cemented	15	349
Clay	8	124	Clay with streaks of sand	9	358
Gravel, cemented	2	126	Gravel, cemented	4	362
Sand and gravel	6	132	Clay with streaks of sand	23	385
Clay and boulders	20	152	Gravel, cemented	2	387
Clay	8	160	Sand	3	390
Clay and boulders	10	170	Clay and shale	14	404
Shale	17	187	Gravel, cemented	3	407
Sand and gravel, "free"	9	196			

TABLE 10. — *Logs of wells in the Cuyama Valley, Calif.* — Continued

10/26-22E1. Ed. Kirschenmann (formerly Bell Ranch). On alluvial fan, about 1.8 miles west of Cuyama. Altitude 2,242 feet. Casing 16-inch, perforations not known. Yield in 1946 on test 587 gallons a minute with drawdown of 121.1 feet; static level about 125 feet below land surface.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Older continental deposits (?):		
Soil	6	6	Sand, dry	10	260
Sand, dry	22	28	Shale and sand	22	282
Clay	8	36	Shale	8	290
Clay with streaks of sand	17	53	Shale and sand	5	295
Gravel, cemented	3	56	Shale	5	300
Clay and sand	19	75	Shale and sand	16	316
Shale and clay	3	78	Shale	5	321
Clay with streaks of sand	7	85	Shale and sand	9	330
Clay and sand, dry	6	91	Shale	2	332
Sand, packed	2	93	Shale and sand	14	346
Sand	2	95	Shale	8	354
Shale	9	104	Clay and sand	4	358
Sand, dry	22	126	Clay	8	366
Clay and gravel	12	138	Clay and sand	11	377
			Sand, dry	5	382
Older continental deposits (?):			Clay and sand	23	405
Shale, brown	2	140	Clay	10	415
Shale and clay	10	150	Clay and sand	5	420
Shale, brown	12	162	Shale	8	428
Sand, "free"	3	165	Sand	2	430
Clay and sand	17	182	Shale	7	437
Shale	3	185	Clay and sand	13	450
Sand, "free"	10	195	Clay	5	455
Shale, brown	3	198	Shale	5	460
Clay and sand	12	210	Clay and sand	10	470
Shale, brown	4	214	Sand, dry	22	492
Sand, fine	6	220	Clay and sand	6	498
Clay and sand	12	232	Sand	2	500
Sand, "free"	13	245	Clay and shale	10	510
Clay and sand	5	250	Shale	4	514

10/26-22J1. Ed. Kirschenmann. On alluvial fan, about 1.0 mile west of Cuyama. Altitude 2,252 feet. Casing 14-inch, perforated 106–194, 218–250, 268–280, 318–326, 344–356, 366–390, and 410–454 feet. Yield in 1945 about 850 gallons a minute; drawdown and static level not known.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Older continental deposits (?):		
Soil	4	4	Shale	13	264
Clay, sandy	13	17	Clay, sandy	6	270
Sand	6	23	Sand and gravel	6	276
Clay, sandy	25	48	Clay, sandy	5	281
Shale with streaks of sand	8	56	Clay and sand in streaks	12	293
Clay	12	68	Shale	22	315
Shale with streaks of sand	27	95	Clay, sandy, dry	7	322
Clay, sandy	12	107	Clay and sand, gray	10	332
Shale	13	120	Sand, "free"	14	346
Sand and gravel	15	135	Clay with streaks of sand	13	359
Older continental deposits (?):			Clay, sand, and gravel	10	369
Clay	19	154	Sand, coarse	7	376
Shale with streaks of sand	44	198	Clay with streaks of sand	16	392
Sand, dry	17	215	Sand	6	398
Sand with streaks of clay	9	224	Clay	12	410
Sand and gravel with streaks of shale	27	251	Shale with streaks of sand	55	465

TABLE 10. — *Logs of wells in the Cuyama Valley, Calif.* — Continued

10/26-22J2. Ed. Kirschenmann. On alluvial fan, about 1.2 miles west of Cuyama. Altitude 2,252 feet. Casing 14-inch, perforated 85–97, 109–115, 127–133, 139–175, 181–247, 253–259, 271–277, 289–295, and 301–349 feet. Yield in 1945, about 700 gallons a minute with drawdown of about 140 feet; static level about 45 feet below land surface.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Older continental deposits (?):		
Soil	15	15	Clay and gravel	10	246
Sand, fine, packed	20	35	Clay	67	313
Sand, coarse	13	48	Sand and gravel with streaks of clay	32	345
Shale, sandy	9	57	Clay	35	380
Shale with streaks of clay	22	79	Clay with some gravel	40	420
Clay and gravel	9	88	Shale	10	430
Shale, sandy	27	115	Clay	21	451
Older continental deposits (?):			Shale with streaks of clay	24	475
Shale with streaks of clay	30	145	Shale, hard	7	482
Clay, sand, and boulders	23	168	Clay with streaks of shale	24	506
Sand with streaks of clay	27	195	Shale	19	525
Sand, coarse, and gravel	41	236	Clay, blue	50	575

10/26-22K1. Ed. Kirschenmann. On alluvial fan, about 1.5 miles west of Cuyama. Altitude 2,252 feet. Casing 14-inch, perforated 112–118, 130–136, 142–160, 166–172, 184–190, 196–214, 220–226, 231–232, and 340–394 feet. Yield in 1945 about 560 gallons a minute; drawdown and static level not known.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Older continental deposits (?):		
Soil	50	50	Gravel, cemented	6	291
Gravel, dry	5	55	Clay with streaks of sand	39	330
Clay, sandy	33	88	Clay	7	337
Clay with streaks of mud	12	100	Gravel	13	350
Sand and gravel	5	105	Clay with streaks of sand	60	410
			Gravel, cemented	8	418
Older continental deposits (?):			Clay	5	423
Clay and gravel	7	112	Gravel, tight	4	427
Clay, sandy	49	161	Clay	11	438
Shale	9	170	Gravel, tight	7	445
Clay, sandy	5	175	Clay	4	449
Clay, sandy	15	190	Sand and gravel	3	452
Shale	4	194	Shale and gravel	6	458
Sand with streaks of clay	5	199	Clay with streaks of sand	12	470
Gravel, cemented	20	219	Shale	21	491
Clay	29	248	Clay	5	496
Clay with streaks of sand	20	268	Gravel, cemented	2	498
Shale and gravel	6	274	Clay with streaks of sand	7	505
Clay with streaks of sand	11	285	Gravel, cemented	2	507

10/26-23P1. Goehring Bros. On alluvial fan, about 0.8 mile southwest of Cuyama. Altitude 2,280 feet. Casing 16-inch, perforations not known. Yield in 1945 about 750 gallons a minute with drawdown of, roughly, 25 feet; static level about 130 feet below land surface.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Older continental deposits (?):		
Soil	8	8	Gravel, cemented	4	226
Sand, dry	42	50	Sand, dry	5	231
Sand, coarse	5	55	Sand, "free"	19	250
Sand, dry	10	65	Sand, coarse	14	264
Sand, coarse	4	69	Sand, dry	7	271
Clay and sand	27	96	Sand, coarse	14	285
Sand, coarse	4	100	Sand, dry	19	304
			Sand, "free"	10	314
Older continental deposits (?):			Sand, dry	12	326
Sand, dry	52	152	Sand, "free"	6	332
Sand, "free"	14	166	Sand, dry	24	356
Sand, dry	34	200	Sand, "free"	4	360
Sand, "free"	22	222	Sand, dry	11	371

TABLE 10. — *Logs of wells in the Cuyama Valley, Calif.* — Continued

10/26-23R1. Goehring Bros. On alluvial plain, about 0.7 mile south of Cuyama. Altitude 2,298 feet. Casing 16-inch, perforated 82–88, 100–106, 112–121, 130–148, 157–175, 190–196, 208–214, 220–256, 262–268, 274–283, 292–310, 316–322, 328–346, 355–364, and 373–400 feet. Yield in 1945 about 700 gallons a minute; drawdown and static level not known.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Older continental deposits (?):		
Soil	20	20	Sand and gravel, cemented	4	232
Sand, hard, with streaks of clay	47	67	Sand	6	238
Clay, sandy, and gravel; "free" streaks	9	76	Clay, sandy, "free" streaks	7	245
Clay, sandy, with small gravel	19	95	Sand	7	252
Sand, "free"	3	98	Sand, hard, with little clay	20	272
Clay, sandy; gravel, and small boulders, "free" streaks	22	120	Sand	8	280
			Sand, cemented	4	284
Older continental deposits (?):			Clay, sandy, and gravel, "free" streaks	20	304
Clay, sandy, hard; and small gravel	5	125	Clay, sandy, and gravel, hard	35	330
Sand, gravel, and boulders, cemented	8	133	Clay, sandy, and gravel, hard, "free" streaks	11	350
Clay, sandy, and small boulders, "free" streaks	12	145	Sand	5	355
Sand and small gravel	9	154	Clay, sandy, hard	13	368
Clay, sandy, and small gravel, "free" streaks	24	178	Clay, sandy, hard streaks	22	390
Sand	6	184	Clay, sandy, "free"	5	395
Sand and gravel	44	228	Sand, cemented	19	414
			Clay, sandy, and small gravel, cemented	19	433

10/26-24R1. Adolph Kirschenmann. On alluvial fan, about 1.2 miles southeast of Cuyama. Altitude 2,303 feet. Casing 14-inch, perforated 53–125 and 137–275 feet. Yield in 1945 on test 1,640 gallons a minute with drawdown of 26.4 feet; static level about 55 feet below land surface.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Older continental deposits (?):		
Soil	20	20	Sand, coarse, with streaks of shale	44	198
Sand, fine	25	45	Sand, coarse, with streaks of clay	35	233
Sand, coarse	22	67	Clay and sand	42	275
Sand, coarse, and small gravel	56	123	Boulders, hard	3	278
Shale, hard	3	126	Clay, yellow	20	298
Sand, fine, hard-packed	9	135			
Sand, cemented	6	141			
Boulders, hard	13	154			

10/27-11A2. A. P. Anderson. On alluvial plain, about 6.5 miles west of Cuyama. Altitude 1,980 feet. Casing 16- to 10-inch, perforated 59–275 and 280–530 feet. Abandoned irrigation well.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Older continental deposits:		
Soil	20	20	Clay	51	226
Clay with sand and gravel	35	55	Clay and gravel	39	265
Sand and gravel	60	115	Clay, sand, and gravel	15	280
Older continental deposits:			Clay, sticky, yellow	210	490
Sand and gravel with streaks of clay	60	175	Clay, sandy, yellow	43	533

TABLE 10. — *Logs of wells in the Cuyama Valley, Calif.* — Continued

10/27-11C1. A. P. Anderson. On alluvial plain, about 7.1 miles west of Cuyama. Altitude 1,963 feet Casing 14-inch, perforated 36–117 feet. Yield in 1942 on test 520 gallons a minute with drawdown of 55 feet; static level 25 feet below top of casing.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Alluvium:		
Soil	26	26	Sand and cobbles up to 2 inches in diameter	7	90
Clay, blue	2	28	Clay, black, and boulders	7	97
Clay, gray, with soft streaks	18	46	Sand with cobbles up to 3 inches in diameter	3	100
Clay, blue	1	47	Older continental deposits:		
Clay, black	10	57	Clay, yellow-brown, and cobbles	121	221
Sand and gravel	5	62	Clay, blue	157	378
Clay, black, and boulders	21	83			

10/27-12E1. William Kirschenmann Estate. On alluvial plain, about 6.3 miles west of Cuyama. Altitude 1,990 feet. Casing 12-inch, perforations unknown. Water level 11.47 feet below top of casing on May 7, 1942. Yield not known. Drilled for irrigation, now used for stock only.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium:			Older continental deposits:		
Clay	33	33	Shale, hard	50	177
Sand	4	37	Sand and boulders, hard	10	187
Clay	27	64	Clay, brown	30	217
Sand and gravel	6	70	Clay, blue	2	219
Clay, blue	14	84	Clay, yellow, and coarse sand	9	228
Gravel	43	127	Clay, blue	20	248

10/27-12J1. William Kirschenmann Estate. On alluvial fan about 5.4 miles west of Cuyama. Altitude 2,035 feet. Casing 14-inch, perforations not known. Yield in 1942 on test 1,055 gallons a minute with drawdown of 46 feet; static level about 29 feet below land surface. Drilled in alluvium.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Clay	36	36	Clay	2	70
Gravel	4	40	Gravel	27	97
Clay	2	42	Clay	9	106
Gravel	5	47	Gravel	28	134
Clay	6	53	Clay	4	138
Gravel	15	68			

10/27-12J2. William Kirschenmann Estate. On alluvial fan, about 5.4 miles west of Cuyama. Altitude 2,035 feet. Casing 14-inch, perforations not known. Yield in 1942 on test 1,990 gallons a minute with drawdown of 43 feet; static level about 31 feet below land surface. Drilled in alluvium and older continental deposits.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
No record	71	71	No record	4	188
Sand	14	85	Sand	3	191
No record	46	131	No record	62	253
Sand	1	132	Sand	5	258
No record	50	182	No record	32	290
Sand	2	184	Sand	4	294

TABLE 10. — *Logs of wells in the Cuyama Valley, Calif.* — Continued

10/27-12R1. William Kirschenmann Estate. On alluvial fan, about 5.3 miles west of Cuyama. Altitude 2,045 feet. Casing 12-inch, perforated 53–128 feet. Yield in 1942 on test 440 gallons a minute with drawdown of about 12 feet; static level 44 feet below land surface. Drilled in alluvium.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil	36	36	Sand and boulders as much as 6 inches in diameter	4	76
Sand, water-bearing	6	42	Clay, yellow	32	108
Gravel and boulders as much as 6 inches in diameter	25	67	Sand and boulders as much as 6 inches in diameter	2	110
Clay, brown	5	72	Clay, brown	21	131

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