Geology and Ground-Water Features of the Eureka Area Humboldt County, California

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By R. E. Evenson

ABSTRACT

The U. S. Geological Survey, in cooperation with the California Department of Water Resources, made a reconnaissance investigation of the major ground-water basins in Humboldt County. The two principal basins are the coastal plain of the Eel River valley—a triangular-shaped area, which is about 8 miles wide along the coast and extends inland for about 12 miles—and the Arcata plain, which is about 5 miles wide and lies betweeen the Mad River and the north end of Humboldt Bay. The area investigated extends for about 34 miles along the coast and about 20 miles inland.

The two principal streams in the area are the Eel River, near the south end of the area, and the Mad River, near the north end. Both discharge directly into the Pacific Ocean. Minor streams that discharge into Humboldt Bay are the Elk River and Jacoby, Freshwater, and Salmon Creeks.

The average annual precipitation is about 40 inches. The mean annual temperature is 52° F, and the annual range in the mean monthly temperature is about 10° F.

Unconsolidated clay, silt, sand, and gravel—3,000 to 4,000 feet in total thickness—make up the dune sand, alluvium, terrace deposits, and Hookton and Carlotta formations of Ogle (1953). These deposits range in age from Pliocene to Recent and contain most of the ground water. Water-table conditions exist in the dune sand, alluvium, terrace deposits, and Pleistocene deposits throughout the area; confined conditions exist in the deposits of Pliocene to Pleistocene age in the Eel River valley and in the Pleistocene deposits around the northern end of Humboldt Bay. Most of the water pumped is derived from unconfined alluvial deposits—the alluvium of Recent age and the terrace deposits of Pleistocene age.

Periodic water-level measurements, which were made in observation wells in the Eel River valley, on the Arcata plain, and in the area north of the Mad River, indicated an average decline of about 5 feet in water levels in each basin during the irrigation season of 1952. These seasonal declines were balanced by recoveries of water levels during the next winter, as in the other years of record; no appreciable difference was noted between water levels in observation wells in the spring of 1951 and the spring of 1955.

Most of the ground water is used for irrigation and is distributed principally through various types of sprinkler systems. About 250 irrigation wells supply water to nearly 12,000 acres, which is used almost entirely as permanent pasture. In 1952 the estimated pumpage of ground water for irrigation, industry, public supply, and domestic use totaled about 15,000 acre-feet. The total ground-water discharge, both natural and pumped, from alluvial deposits in 1952 was

about 25,000 acre-feet. It is based on the estimated net change in the amount of ground water in storage in 1952.

The estimated gross ground-water storage capacity of the alluvium and terrace deposits in the Eel and Mad River valleys is about 150,000 acre-feet. The average seasonal net change in storage during 1951–55 was about the same as that in 1952—about 25,000 acre-feet; storage was depleted by this amount each summer and autumn and was replenished to full capacity each winter and spring.

The quality of the water generally is good, most of it being a moderately hard calcium magnesium bicarbonate water. Iron in concentrations as much as 28 ppm (parts per million) is an undesirable constituent in many wells. Although chloride concentrations of 500 to 1,000 ppm are common in the shallow aquifers near the tidal reaches of the rivers, the concentration according to owners has not changed significantly since the wells were drilled. One well irrigates 60 acres with water having a chloride concentration of 1,810 ppm. The relatively high chloride concentration of well waters near the tidal estuaries probably is due to infiltration of brackish water from the estuaries into the alluvium.

INTRODUCTION

PURPOSE AND SCOPE OF THE WORK

The U. S. Geological Survey in cooperation with the California Department of Water Resources made a reconnaissance geologic and hydrologic investigation of the major ground-water basins in Humboldt County as a part of a cooperative program for reappraisal of the State's ground-water resources. As part of this program, a field study of the geology and ground-water features of the Eureka area was begun in August and completed in November 1952.

The purposes of this reconnaissance study were: (a) to map the extent of the water-bearing deposits and to differentiate the rocks composing the bedrock beneath and adjacent to the valley floor, (b) to determine the geologic features that relate to and control the occurrence and movement of ground water, (c) to identify and report on the sources of recharge and methods of discharge of ground water, (d) to estimate the ground-water storage capacity of the alluvium and low terrace deposits, and (e) to report on the general chemical character of the surface and ground waters in the area.

Findings of the reconnaissance study are presented as outlined in the preceding paragraph. It includes also tables of basic data: records of water wells and of water-level fluctuations in wells, selected drillers' logs, and chemical analyses of water.

The study was made by the Geological Survey under the direction of J. F. Poland and G. F. Worts, Jr., successive district geologists in charge of ground-water investigations in California. The project was started under the immediate supervision of J. E. Upson and was completed under the supervision of A. R. Leonard. G. T. Cardwell, K. S. Muir, F. H. Olmsted, and Fred Kunkel assisted in the collection of basic data used in this report. Chemical analyses of water samples were made at the Quality of Water laboratory of the Geological Survey at Sacramento.

LOCATION AND EXTENT OF THE AREA

The area discussed in this report borders the Pacific Ocean along the northeast-trending coastline of Humboldt County, about 225 miles northwest of San Francisco and 80 miles south of the Oregon border (fig. 1).

The city of Eureka, adjacent to Humboldt Bay, is in the approximate center of the area, which extends from Rio Dell along the Eel River to the mouth of the Little River about 34 miles to the north. The area includes the coastal plains of the Eel and Mad Rivers and the area around Humboldt Bay, and extends inland for as much as 20 miles. It includes approximately 425 square miles of land between 40°30′ and 41°00′ north latitude and between 123°55′ and 124°25′ west longitude. The area includes parts of the Eureka, Ferndale, and Fortuna quadrangles, mapped in the 15-minute series (scale, 1: 62,500) of the Geological Survey, and extends to the western part of the Blue Lake quadrangle, mapped (scale, 1: 62,500) by the Corps of Engineers, Department of the Army.

PREVIOUS WORK

A. C. Lawson (1894) first noted the general features of the area; and since then, reports by Diller (1903), Harmon (1914), Stalder (1914), Averill (1941), and MacGinitie (1942) have been published, most of which emphasize mineral and petroleum occurrences. The geology of the Eel River valley area, including a brief section on water resources, has been discussed in great detail by Ogle (1951, California Univ. unpublished thesis, and 1953). His report and geologic map have been drawn upon rather heavily, with only slight modification of his geologic mapping. The area in the vicinity of Blue Lake has been discussed by Manning and Ogle (1950) in a report on the geology of the Blue Lake quadrangle. Watson, Cosby, and Smith (1925) prepared a report on a soil survey of the Eureka area.

WELL-NUMBERING SYSTEM

The well-numbering system (fig. 2) used by the Geological Survey in California since 1940 is based on the rectangular system for the subdivision of public land. For example, in the number 3N/1W–34J1, which was assigned to a well in the city of Fortuna, 3N indicates the township (T. 3 N.); 1W indicates the range (R. 1 W.); the number following the dash indicates the section (sec. 34); the letter following the section number indicates the 40-acre subdivision of the section as shown in the accompanying diagram.

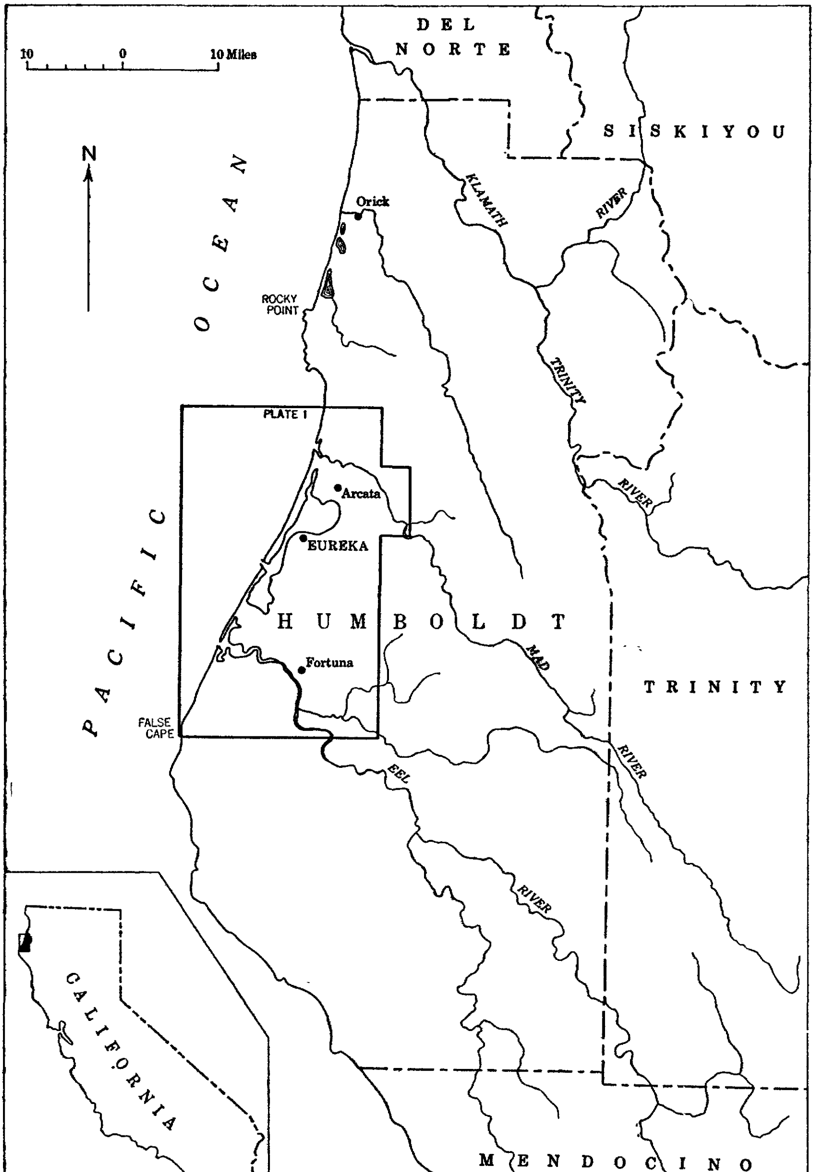

FIGURE 1.—Index map showing report area.

Within each 40-acre tract the wells are numbered serially, as indicated by the final digit of the well number. Thus, well 3N/1W–34J1 is the first well listed in the NE¼SE¼ sec. 34, T. 3 N., R. 1 W. Township and range numbers are from the Humboldt base line and meridian.

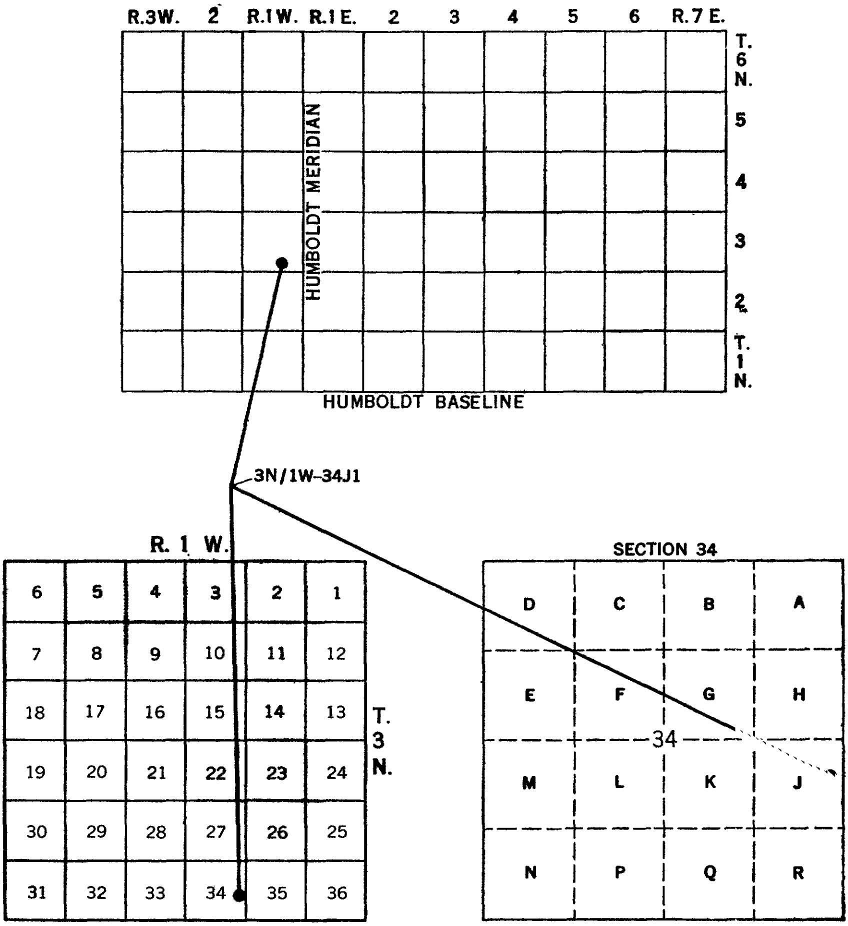

FIGURE 2.—Well-numbering system.

ACKNOWLEDGMENTS

Data from earlier studies of the geology of the area by B. A. Ogle (1953) were used extensively. The collection of data on wells and use of water was greatly facilitated by the cooperation of well drillers, well owners, public officials, and many others who freely supplied information. Special thanks are expressed to the city officials of Arcata, Blue Lake, Eureka, and Fortuna for supplying data on their respective public water-supply systems and water use. Mr. Larson, general manager of the plant of the Golden State Co., Ltd., at Loleta, supplied data on the use of water by that plant.

GEOGRAPHIC FEATURES

PHYSIOGRAPHY AND DRAINAGE

The Eureka area is south of the Klamath Mountains and at the north end of the Coast Range physiographic province. Rugged mountains, scarred by numerous landslides, and stream valleys with steep, narrow canyons characterize the inland topography. Local relief here, from ravine bottom to ridge top, is more than 1,000 feet. Along the coast, however, the stream valleys are broad, and elevated flat or gently rolling terraces characterize the topography. The north-northeast-trending shoreline has a well-developed sand beach, and sand dunes extend inland over the coastal edge of the alluvial plain (pl. 1).

Humboldt Bay, whose northeast end is known as Arcata Bay, is 12 miles long (parallel to the coast) and from 0.5 to 4 miles wide. It is separated from the ocean by a sand spit, broken approximately in the center by the entrance to the bay. Jacoby and Freshwater Creeks discharge into the north end of the bay, and the Elk River and Salmon Creek discharge into the south end. These streams and their corresponding sloughs are tidal from 1 to 2 miles inland from their mouths, and their flood plains along the tidal reaches are uniformly level marshland and mud or tidal flats, which are only a few feet above water during high tide. Many smaller tidal sloughs are present along the north end of the bay near Arcata. The Mad River slough, an abandoned mouth of the Mad River, extends inland for about 3 miles.

The Mad River, the smaller of the two major streams in the area, discharges into the Pacific Ocean about 5 miles north of the bay and is tidal for about 1 mile inland. Between the Mad River and Humboldt Bay the coastal plain is dissected by flood-stage channels of the river, 15 to 20 feet deep. Near the town of Blue Lake, the Mad River flows through a valley about 1 mile wide and 4 miles long. At both ends of this valley the river flows in relatively narrow canyons cut through consolidated rocks. The average annual discharge of the Mad River is about 1,000,000 acre-feet.

The Eel River, the largest stream in the area, empties into the ocean about 5 miles south of Humboldt Bay and is tidal for about 4 miles inland. The coastal plain of the Eel River valley is about 8 miles wide at the coast and extends inland for nearly 12 miles to the confluence of the Eel and Van Duzen Rivers. Upstream from this point the valleys of both the Eel and Van Duzen Rivers are narrow. Near the ocean the flood plain is dissected by numerous tidal sloughs, especially in the area north of the river. South of the river one major slough—the Salt River, an abandoned channel of the Eel River—extends inland for about 6 miles. West of Coffee Creek, near the east end of the Salt River, the valley floor slopes uniformly from the hills south of Ferndale toward the Salt River. However, east of Coffee Creek and between the Salt and Eel Rivers, the valley floor is dissected by numerous gullies, entrenched for as much as 20 feet by distributaries of the Eel River at flood stage. During the winter rainy season, floodwaters cause considerable damage along the major streams. The average annual discharge of the Eel River is about 6,600,000 acre-feet, of which about 900,000 acre-feet is contributed by the Van Duzen River.

VEGETATION AND CULTURE

A zone of soil and weathered rock as much as 20 feet thick has developed over much of the mountainous area, and vegetation is generally dense. Both virgin and second-growth forests of redwood (*Sequoia sempervirens*) and Douglas-fir cover most of the mountains; but the high terraces do not support heavy vegetation and are conspicuously barren, except for grass and weeds and scattered isolated trees or clumps of trees. The coastal plain and broad valley floors are rich pasture land.

The principal industries in the area are associated with timber and wood products, dairies and milk products, and both commercial and recreational fishing. Herds of dairy cattle, many of which are purebred Jersey or Guernsey, are raised on the pasture land; some beef stock also is produced. Ocean vessels drawing less than 30 feet can navigate in Humboldt Bay, and a considerable quantity of lumber is exported by water.

The largest city in the area is Eureka, a seaport on Humboldt Bay and the county seat of Humboldt County. Smaller towns, such as Arcata, Blue Lake, Ferndale, and Fortuna, are agricultural communities which, except for Ferndale, recently have experienced a boom by the construction of new lumber mills. In addition, many smaller communities, such as Loleta, Fields Landing, and Samoa, are scattered throughout the area. Highway 101 (Redwood Highway) extends northward through the area, and Highway 299 has its western terminus near Arcata. The Northwestern Pacific Railroad has its northern terminus in Eureka.

According to the 1950 census, the population of Eureka was 23,058; Arcata, 3,747; Blue Lake, 824; Ferndale, 1,032; and Fortuna, 1,761. In addition, it is estimated that about 20,000 people, or about 50 percent of the rural population of Humboldt County, lived in the area.

CLIMATE

The climate of the Eureka area is characterized by moderate temperatures, frequent dense fogs, and moderate precipitation. The growing season, from last killing frost to first killing frost, averages about 280 days, although crops are generally irrigated for only about 120 days per year. The mean annual temperature at Eureka is 52°F, and the mean monthly temperatures have an annual variation of about 10°F.

The moist, cool climate of the area is due more to the fog and humidity than to the rainfall. The sun shines for less than 50 percent of the daylight hours, and the average annual relative humidity is 90 percent at 8 a. m. and 77 percent at noon. During the summer, prevailing winds are from the north or northwest, and during the winter they are from the southeast.

Precipitation at Eureka has been recorded since 1878; for the 73-year period of record through 1951, the normal precipitation is 39.76 inches per year. The normal precipitation at Eureka is probably a minimum for the area, because the amount of precipitation increases with distance inland and increase in altitude. Figure 3, which shows the average precipitation at Eureka (altitude, 64 feet) and Scotia (altitude, 163 feet) for the calendar years 1926–51, indicates that for the past 26 years the average precipitation at Scotia exceeds that at Eureka by about 7 inches.

Figure 4 shows monthly the maximum precipitation, the minimum precipitation, the precipitation for 1951–52,[1] and the average precipitation at Eureka. The curved line on figure 4 shows the variation in average monthly precipitation.

USE OF GROUND WATER

In the Eureka area, ground water from wells and springs is used for irrigation, industry, and public and domestic water supplies. About 250 irrigation wells supply water to nearly 12,000 acres of land, which is used almost entirely as permanent pasture. Pasture crops consist mostly of various grasses and clover, and they are used chiefly for herds of dairy cattle but also partly for beef cattle.

Lumber is the major industry in the area; and so, there are numerous sawmills, many of which have been built within the past few years. Many of these mills use water from wells to fill and maintain log ponds as well as for fire protection. Some mills also use ground water in boilers for steam plants. In addition, several creameries depend upon the use of ground water.

The city of Fortuna obtains its water supply from wells, and Ferndale obtains its water from nearby springs. Arcata, Blue Lake, and several smaller towns get public water supplies from wells or springs; other towns and rural areas get their water from small privately

[1] The 1951–52 season, or 1952 water year, is the period from October 1, 1951 to September 30, 1952, inclusive.

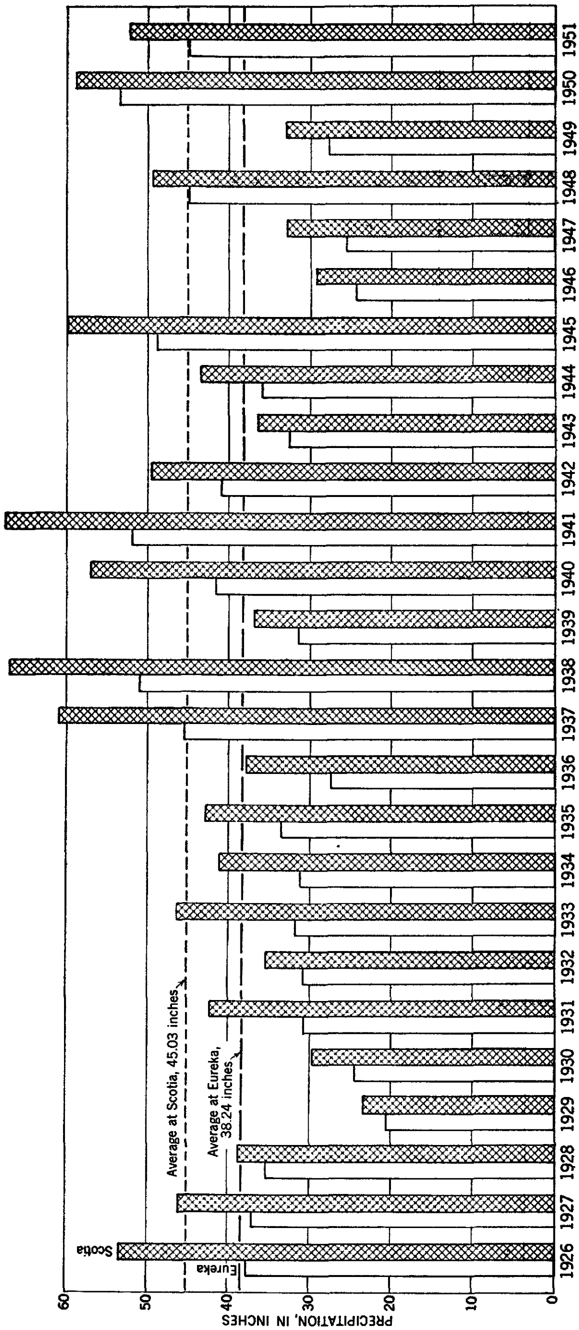

FIGURE 3.—Comparison of annual precipitation at Eureka and Scotia.

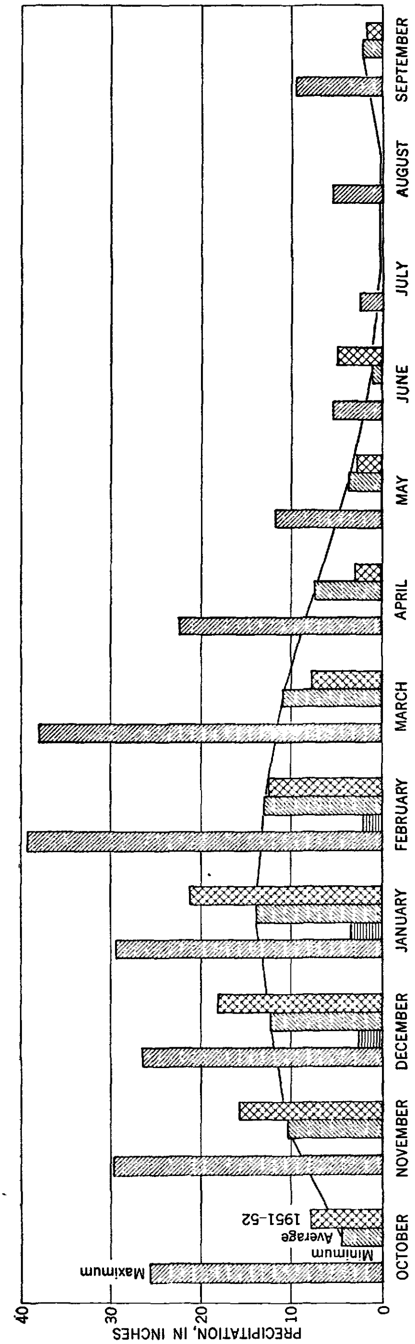

FIGURE 4.—Summary of monthly precipitation at Eureka.

owned wells. Eureka, the largest city in the area, obtains water from the Mad River, although it has standby wells that were used prior to the construction of the reservoir on the Mad River.

GEOLOGY IN RELATION TO GROUND WATER

PRINCIPLES OF GROUND-WATER OCCURRENCE

Water under hydrostatic pressure that saturates the openings in the consolidated rocks and unconsolidated deposits within the earth's crust is termed ground water. In the unconsolidated deposits, particularly beds of gravel and sand, openings (pores) occur between rock particles; in the consolidated rocks, the most common openings are fractures, although some rocks like sandstone also contain pores. The openings in consolidated rocks generally are not as continuous or as uniform as openings in gravel or sand.

Water that reaches the land surface as precipitation or passes over the surface in the form of streamflow or irrigation water (a) evaporates directly into the atmosphere, (b) is used by plants in their growing processes, (c) discharges into the ocean, and (d) seeps into the ground where some is retained as soil moisture; the remainder percolates downward to the zone of saturation. Within the zone of saturation, water may be either unconfined (water-table conditions) or confined (artesian conditions). Confinement occurs where a permeable bed, such as gravel, is overlain and underlain by impermeable (confining) beds, such as clay, between which the water is under pressure. Above the zone of saturation in an unconsolidated gravel or sand formation, called the zone of aeration, an impermeable bed may act as a barrier to the downward-percolating water and thus may support a perched water body.

Where an aquifer has a submarine outcrop open to the sea, the lower part of the aquifer may be filled with sea water and the upper part with fresh water, which floats on the salt water because of its lower specific gravity (Ghyben-Herzberg principle). The extent to which the fresh water is able to displace salt water downward and seaward depends upon the head and the rate of flow of the fresh water. The thickness of a fresh-water lens is proportionate to the ratio of the relative densities of the two types of water; therefore, a head of fresh water 1 foot above sea level will depress the interface between the salt and fresh water to about 40 feet below sea level, assuming that the specific gravity of the sea water is 1.025. If fresh water is pumped out through wells and the hydrostatic head is lowered, the interface tends to rise. Salt water in an aquifer beneath a coastal plain will move inland and eventually invade the wells, if the hydraulic head of fresh water is reduced enough to allow the interface to rise to the bottom of the wells. If samples of water are collected periodically from the wells for chemical analysis, sea-water encroachment can be detected readily by observing an increase in the chloride content.

A detailed discussion of principles of occurrence of ground water is given in U. S. Geological Survey Water-Supply Papers 489 (Meinzer, 1923a) and 494 (Meinzer, 1923b). Water-Supply Paper 537 (Brown, 1925) contains a detailed discussion of ground water in coastal areas.

SUMMARY OF STRATIGRAPHY

The consolidated rocks and unconsolidated deposits within several thousand feet of the surface in the Eureka area are predominantly sedimentary and range in age from Jurassic to Recent. Their areal distribution is shown on plate 1 and their general character, stratigraphy, and water-bearing properties are given in table 1. Water is obtained from wells tapping deposits that range in age from Pliocene to Recent, as shown on plate 2.

The oldest rocks exposed are undifferentiated sedimentary and metamorphic rocks of the Franciscan and Yager formations of Jurassic and Cretaceous age. These rocks crop out in the hills and mountains along the east and south edges of the area and underlie most of the mountainous drainage area. However, they do not yield appreciable amounts of water to wells.

The Carlotta formation of Ogle (1953), of Pliocene and Pleistocene age, crops out along the margin of the alluvial plain of the Eel River valley and extends upstream along the Van Duzen River valley. The strata of continental sand and gravel in the Carlotta formation are downwarped in a synclinal structure beneath the Eel River alluvial plain and form artesian aquifers. North of Table Bluff this continental facies apparently is absent, and there is not enough difference in lithology to distinguish between the fine-grained marine beds of the Carlotta formation and the fine-grained marine sediments underlying it. The fine-grained marine sediments of Tertiary age beneath the Carlotta formation crop out over a large area; together with the rocks of the Carlotta formation, they compose the Wildcat group as used by Ogle (1953). The units beneath the Carlotta, from the top downward, include the Scotia Bluffs, Rio Dell, Eel River, and Pullen formations of Ogle (1953), but they are not differentiated in this area. These units and the fine-grained sediments of the Carlotta formation generally are not tapped by wells.

The Hookton formation of Ogle (1953), of Pleistocene age, is extensive north of the Eel River valley where it caps the seaward slopes of nearly all ridges and hills from Table Bluff to the north end of the area. In the vicinity of Eureka and in the Dows Prairie–McKinleyville area, many domestic wells obtain water from sand in the Hookton formation. In addition, along the north and east margins

TABLE 1.—*Stratigraphic units of the Eureka area, Humboldt County, Calif.*

Geologic age		Formation and symbol on plate 1	Thickness (feet)	Lithologic character	Water-bearing properties
Quaternary	Recent	Dune sand (Qs)	0-100+	Fine to coarse sand, part of which is actively drifting.	Unconsolidated; yields water to wells on the North Spit.
Quaternary	Recent	River-channel deposits (Qrc)	0-50±	Coarse sand and gravel along channels of Eel and Van Duzen Rivers.	Unconsolidated; probably very permeable, but subject to flooding and not penetrated by wells.
Quaternary	Recent	Alluvium (Qal)	0-200±	Clay, sand, and gravel underlying alluvial plains; are of fluvial origin except near the coast where estuarine clay and silt interfinger.	Unconsolidated; coarse sand and gravel yield water readily to wells. With lower, younger terrace deposits forms principal aquifer of area.
Quaternary	——?—— Pleistocene	Terrace deposits (Qtu)	0-100±	Clay, sand, and gravel of fluvial origin; occurs beneath river benches and on higher slopes.	Unconsolidated; yields water to wells in areas where deposits are within zone of saturation and locally from perched water bodies.
Quaternary	Pleistocene	Hookton formation of Ogle (1953) (Qh)	0-400±	Clay, sand, and gravel predominantly of fluvial origin; becomes finer grained and interfingers with marine beds in the northern part of the area.	Poorly consolidated; yields water to wells in small to moderate amounts from sand and gravel strata. Artesian aquifer south of Arcata.
——?——	——?——	——Major unconformity——			
Tertiary	Pliocene	Wildcat group as used by Ogle (1953): Carlotta formation of Ogle (1953) (QTwc)	500-3,300±	Clay, sand, and gravel predominantly of fluvial origin; becomes finer grained and interfingers with marine beds in the central part of the area; not recognized north of Eureka.	Poorly consolidated; locally yields artesian water to wells in moderate to large amounts from sand and gravel strata.
Tertiary	Pliocene to Miocene	Wildcat group as used by Ogle (1953): Scotia Bluffs, Rio Dell, Eel River, and Pullen formations of Ogle (1953) (Twu)	500-11,000±	Compact mudstone, claystone, siltstone, and some sandstone, predominantly of marine origin.	Semiconsolidated; not tapped by wells, probably poorly water bearing.
		——Major unconformity——			
Cretaceous and Jurassic		Pre-Tertiary formations (KJu)	20,000±	Shale, sandstone, conglomerate, schist, chert, and basalt of Franciscan formation and Yager formations of Ogle (1953).	Consolidated; not tapped by wells, probably contains some water in fractures and in deeply weathered rocks.

of Humboldt Bay (Arcata Bay), artesian water is obtained from the Hookton formation. Smaller areas of the Hookton formation cap the hills west of Ferndale, but the formation generally is not recognized south of the Eel River.

Deposits of probable late Pleistocene and Recent age include terrace deposits at several levels above the valley floors. Younger deposits of Recent age include alluvium in the stream valleys and beneath tidal marshlands, river-channel deposits, and dune sand along the coast.

CONSOLIDATED ROCKS

Consolidated rocks comprise the Franciscan and Yager formations and most of the Wildcat group described and subdivided by Ogle (1953). Because these rocks were mapped and described in detail by Ogle and because they are poorly water bearing and not tapped by wells, their principal features are discussed only briefly below. Their areal extent on the geologic map (pl. 1) is shown by two units—the pre-Tertiary formations (undifferentiated) and the Pullen, Eel River, Rio Dell, and Scotia Bluffs formations.

PRE-TERTIARY FORMATIONS

The pre-Tertiary formations comprise the Franciscan formation and the Yager formation of Ogle (1953), of Jurassic and Cretaceous age. These rocks have been discussed in detail by Ogle (1953) and Manning and Ogle (1950). They are shown as undifferentiated by the symbol KJu on the geologic map (pl. 1).

The Franciscan formation, which makes up most of the unit, is predominantly graywacke, shale, chert, basalt, and glaucophane schist. The graywacke beds are massive, fine grained, cemented, and dark gray to grayish green. The Yager formation of Ogle (1953) consists of biotitic graywacke, shale, and conglomerate.

Ground water in these formations occurs along fault zones, in landslide debris, and in joints and is discharged in springs or through seepage zones. No wells were examined that tapped the Franciscan or Yager formations. In many places the rocks are deeply weathered, and a clayey sand mantle has developed to depths of 20 to 30 feet. Where the land is relatively flat, a small yield of water might be obtained from the clayey sand for stock or domestic use; but no wells tapping this material were found.

PULLEN, EEL RIVER, RIO DELL, AND SCOTIA BLUFFS FORMATIONS OF OGLE (1953), UNDIFFERENTIATED

The Wildcat series of Lawson (1894) was used to define several thousand feet of undifferentiated sandstone, siltstone, and mudstone of Tertiary age exposed along Wildcat ridge south of Ferndale. The

Wildcat was designated as a group by Ogle (1953), who divided it into 5 formations ranging in age from Miocene to Pleistocene. The lower 3 formations, the Pullen, Eel River, and Rio Dell, are predominantly marine siltstone and claystone. The upper 2 formations, the Scotia Bluffs and the Carlotta, are predominantly nonmarine sandstone. Of this group the Carlotta formation, which is loosely consolidated and locally water bearing, is discussed separately. The Pullen, Eel River, Rio Dell, and Scotia Bluffs formations are undifferentiated and are so referred to in the text and on the geologic map (map symbol Twu, pl. 1). The few sand and gravel beds in the Scotia Bluffs sandstone may locally be water bearing, but they are not tapped by wells.

PRINCIPAL DEPOSITS THAT YIELD WATER TO WELLS

Water for agricultural, industrial, municipal, and domestic uses is obtained from wells penetrating deposits that range in age from Pliocene and Pleistocene to Recent.

CARLOTTA FORMATION OF OGLE (1953) (PLIOCENE AND PLEISTOCENE)

The Carlotta formation of Ogle (1953), which is the uppermost formation of the Wildcat group as used by Ogle (1953), is of Pliocene and Pleistocene age. It consists of poorly consolidated brown conglomerate and sandstone of continental origin and some shallow marine blue-gray claystone and siltstone. Ogle (1953, p. 35) named the formation and described about 3,300 feet of deposits from the type locality near the town of Carlotta. Another excellent exposure of the Carlotta formation occurs in road cuts along Wildcat Ridge south of Ferndale where Wildcat road crosses normal to the strike of the formation. In this locality Ogle (1951, California Univ. unpublished thesis, p. 133) measured 1,620 feet of beds in the lower part of the Carlotta, but the upper part of the formation is missing. Although the northernmost outcrop of the Carlotta is at Buhne Point, just east of the entrance to Humboldt Bay, the Carlotta formation has been identified tentatively in the log of well 5N/1W-28B1 and in the subsurface it may extend as far north as the Mad River (pl. 2). The Carlotta formation in this locality is a dense fossiliferous blue clay that is unconformably overlain by the yellow sand and gravel and bluish-gray clay of the Hookton formation of Ogle (1953). It contains more shallow marine clays and less conglomeratic material here than it does in either the Ferndale or Van Duzen area (Ogle, 1951, California Univ. unpublished thesis, p. 184). Along the southern part of the Eel and Van Duzen River valleys the sediments consist chiefly of poorly sorted cobble conglomerate of nonmarine origin and fairly well-sorted sandstone, containing minor interfingering clay beds of marine origin.

The Carlotta formation of Ogle (1953) is designated as late Pliocene to early Pleistocene by Ogle (1953, p. 38), who explains the age determination:

> The fossils identified are not diagnostic of age but they give some information as to environment. Most of the species are living today; many are species which range from at least Pliocene to Recent, and some are typical of Pleistocene deposits of other areas in California. The fauna and flora noted in beds believed to be Carlotta are typical of that unit and different from the assemblages found in Scotia Bluffs and Rio Dell.

The Carlotta conformably overlies the Scotia Bluffs sandstone of Ogle (1953) of late Pliocene age and is separated from the overlying Hookton formation of Ogle (1953) by an angular unconformity. Ogle (1953, p. 39) noted the similarity of Carlotta and Hookton deposits:

> Part of the difficulty in the northern area is that both the Carlotta and Hookton appear to have become finer-grained and both show marine interfingering, while to the south they are respectively coarser in grain and are nonmarine.

The difficulty of identifying the contact between the Carlotta and Hookton formations on the basis of well logs is discussed on page 17. It is even more difficult to differentiate between marine sediments of the Carlotta formation and other units of the Wildcat group, because all contain bluish-gray, fine-grained marine deposits.

As recorded in drillers' logs, the Carlotta formation of Ogle (1953) consists of alternating beds of "clay," "sand and clay," "sandstone," "clay and gravel," "sand and gravel," and "gravel." Blue is the predominant color, but "brown" and "gray" are also used to describe what probably is the upper part of the formation. The "sand" in places is called "sandstone" and is described as "hard," and the "gravel" as "cemented." These cemented gravel beds yield water as shown by the record of well 3N/2W–32N1. This well flowed from 200 to 300 gpm when completed (Ogle, 1951, California Univ. unpublished thesis, p. 366). Wood is found locally in the clay and the gravel beds, and shells are also reported.

On the plain near Ferndale several wells penetrate at least two separate aquifers in the Carlotta formation of Ogle (1953). The upper aquifer in places may be connected hydraulically to the overlying gravel beds in the alluvium. Wells 2N/2W–1H1, 1Q1, 12F1, and 2N/1W–7K1 range from 150 to 180 feet in depth; and in 1952 their water levels ranged from 6 feet above sea level to 1 foot below sea level. This corresponded to water levels in nearby wells in the alluvium. Wells 3N/2W–32Q1, 32N1, and 3N/1W–7K2 are more than 250 feet deep and are believed to tap the lower aquifer; in 1952 they were flowing at altitudes between 8 and about 45 feet. Both of these aquifers are on the south limb of the Eel River syncline (pl. 1) and are apparently not hydraulically connected with the aquifers on the north flank of the syncline and east of the Eel River. Additional evidence of the separation of aquifers in the Carlotta formation is furnished by differences in the chemical character of water from different depth zones in the same well (pl. 15).

Yields of wells tapping aquifers in the Carlotta formation of Ogle (1953) vary from one place to another and generally are less than those in the alluvium and terrace deposits. However, the yields are considerably larger than the wells tapping the aquifers of the Hookton formation of Ogle (1953). Well 3N/2W-32N1 flowed 200 to 300 gpm of water and had a specific capacity[2] of 100 gpm per foot of drawdown. However, in most of the other well-production tests on aquifers in the Carlotta formation, the specific capacities ranged from 15 to 20 gpm per foot of drawdown, and the specific capacity of one well was only 5 gpm per foot of drawdown.

HOOKTON FORMATION OF OGLE (1953) (PLEISTOCENE)

The Hookton formation named by Ogle (1953) is described as late Pleistocene in age and consists of as much as 400 feet of reddish-yellow to yellowish-brown loosely consolidated clay, silt, sand, and gravel. It is predominantly of continental origin, partly interfingering with bluish-gray marine clay and silt. This formation is extensive on the seaward slopes of the hills from the Van Duzen River northward to the valley of the Little River and is most prominently exposed in road cuts in Table Bluff. The formation generally becomes finer grained to the north and, on the basis of information from well logs, closely resembles the underlying Carlotta formation of Pleistocene and Pliocene age.

Ogle (1953) inferred that his Hookton formation is probably middle to late Pleistocene in age. Although no positive age determination was made, the stratigraphic position of the Hookton formation is between the older Carlotta formation of Ogle (1953) and the younger terrace deposits and alluvium. This, together with its lithologic and structural features, is indicative of middle to late Pleistocene age.

The Hookton formation of Ogle (1953) unconformably overlies and locally is in fault contact with the Franciscan formation and the Wildcat group as used by Ogle (1953). Locally the formation has been warped gently by crustal movements. Beds that dip more than 30° are uncommon, whereas flat-lying or gently dipping beds are common.

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[2] The specific capacity of a well is its yield, in gallons per minute, divided by the drawdown, in feet.

In many places resistant seams of iron oxide minerals, probably a mixture of limonite and goethite, occur as erratic stringers in massive yellowish-gold sand which is fine to medium grained and well sorted. These erratic seams generally are nearly parallel to the bedding, and are commonly about one-tenth of an inch thick and of irregular length and width. Near the base of the hills on the south side of Freshwater Creek, the seams are interlaced with thin sandstone beds that form an extensive resistant ledge of impermeable rock, nearly 4 feet thick. This layer, at the base of the Hookton formation of Ogle (1953), overlies the Wildcat series of Lawson and is traceable for about one-half of a mile. It serves as a barrier to downward-percolating ground water, which discharges as springs along the ledge.

Identification of the base of the Hookton formation of Ogle (1953) from well logs is difficult, especially in the area north of Eureka, because of the occurrence of interbedded marine sand, silt, and clay in the lower part of the Hookton and also in the upper part of the underlying Carlotta formation of Ogle (1953). This similarity between the Hookton and Carlotta formations also was noted by Ogle (1951, California Univ. unpublished thesis, p. 194). Vivid colors of characteristic Hookton sediments are recorded by drillers as "yellow," "gold," "red-brown," and "yellow-brown"; and where described they are useful in the identification of the Hookton formation.

The Hookton formation of Ogle (1953) is second to the alluvium as a ground-water reservoir and source of water supply. In the area north of Freshwater Creek and south of Arcata, wells produce artesian water from sand or gravel in the formation. The deepest well in that area, 6N/1E–32F1, presumably terminates in the Hookton formation at a depth of 640 feet and flows about 2 gpm. Because of the difficulty in screening the fine sand of the Hookton, this well is filling with sand.

In the Dows Prairie–McKinleyville area and in an area adjacent to the city of Eureka, relatively flat-lying deposits of the Hookton formation of Ogle supply unconfined water to many domestic wells.

Although numerous individuals and some industries depend on wells in the Hookton formation of Ogle for their water supply, the yield from individual wells is small—commonly less than 10 gpm from flowing wells and seldom more than 30 gpm from pumped wells. For example, well 5N/1E–8J1 pumped 30 gpm and had a drawdown of 60 feet for a specific capacity of 0.5 gpm per foot of drawdown.

TERRACE DEPOSITS (PLEISTOCENE)

The terrace deposits consist mostly of poorly sorted gravel and sand; small amounts of brown or yellowish-brown sandy clay and pebbly clay also occur. These deposits include the Rohnerville formation of Ogle (1953)—a high terrace deposit, which Ogle (1953) describes as ocherous clay, silt, sand, and gravel as much as 50 feet thick. Terrace deposits that occur high on the hillsides, such as the Rohnerville formation, are prominent along the Van Duzen River valley and probably are Pleistocence in age. The lower terrace deposits are also believed to be Pleistocence in age (pl. 1). The several terrace deposits are grouped together in this report, and on the geologic map (pl. 1) are shown as undifferentiated (map symbol Qtu).

The most striking of terraces are steplike surfaces along the Eel and Van Duzen River valleys, although other prominent terraces appear along the Mad River and small streams. Ogle (1953) mapped 8 distinct steplike terrace levels to the north of the Van Duzen River and east of Hydesville, and 5 similar surfaces along the Eel River in the vicinity of Metropolitan.

The maximum thickness of the terrace deposits as interpreted from well logs probably is about 100 feet. The log of well 2N/1E–31F1 describes 82 feet of unconsolidated sediments; and the log of well 2N/1W–22C1, on a terrace near the southeast corner of the plain near Ferndale, shows 99 feet of coarse unconsolidated materials which probably are terrace deposits.

Near Rio Dell, which is situated on a terrace along a bend of the Eel River, a well drilled to a depth of 187 feet showed 78 feet of terrace material, including 5 feet of "water gravel" at the base, overlying mudstone or siltstone typical of undifferentiated Tertiary sedimentary rocks (Rector well, Ogle, 1951, California Univ. unpublished thesis, p. 365). However, wells in the Rio Dell area yield only 10 to 30 gpm.

North of Rio Dell and across the Eel River in the vicinity of Metropolitan, wells yielding more than 150 gpm are common; one well, 2N/1W–35C1, was tested at 650 gpm with a drawdown of 7 feet, for a specific capacity of about 90 gpm per foot of drawdown. Most of the water obtained from wells tapping the terrace deposits is in the Metropolitan area; and most of these wells are less than 60 feet deep.

On a terrace near the northwest end of the Blue Lake valley, a well (6N/1E–13N1) 70 feet deep penetrates 16 feet of terrace gravel at the top. This well yielded 10 gpm. The "shale and sandstone" described in the log at depths from 16 to 70 feet may be part of the Franciscan formation.

In scattered localities throughout the area, contact springs occur where saturated coarse terrace deposits overlie impermeable older rocks.

ALLUVIUM (RECENT)

The alluvium is of Recent age and is composed of gravel, sand, silt, and clay. In addition, it includes the clay, mud, and silt underlying the tidal marshes and swamplands. It underlies most of the irrigated agricultural land and is the most productive deposit in the area, yielding water to wells in large amounts. The Recent alluvium, as used in this report, does not include the river-channel deposits, which are also alluvium.

The clay, mud, and silt of the tidal marshes and swamplands occur along the north and south margins of Humboldt Bay and extend to the tributary valleys. These deposits are not penetrated by many wells; and even where there are wells, it is extremely difficult to determine the thicknesses of these deposits from well logs. However, about 156 feet of fine-grained deltaic sediments was penetrated by wells 5N/1E–8J1 and 6N/1W–36C1, and nearly 330 feet of similar deposits was penetrated by well 5N/1E–18Q1. The lower part of well 18Q1 probably taps deposits older than the alluvium. A few layers of gravel and sand are interbedded with the bay silt, mud, and clay, but most of the coarse deposits are thin lenses, some of which may contain brackish water.

The deposits underlying the delta of the Eel River consist of blue clay or sandy clay, ranging from less than 1 foot to more than 75 feet in thickness. The maximum thickness of the alluvium overlying older deposits in the synclinal trough of the Eel River valley is not known. South of the Eel River and north of the Salt River, coarse alluvial deposits of sand and gravel are continuous from the surface to depths of 60 feet or more (pl. 2). North of the river to Table Bluff these coarse alluvial deposits are overlain by 20 to 30 feet of fine sand, silt, or clay (pl. 2, well 3N/2W–24E1).

In the vicinity of Ferndale, south of the Salt River, and east from the ocean to the Coffee Creek School (fig. 5), the alluvium contains none of the coarse material typical of large river deposits; instead it contains fine deposits derived from the adjacent hillsides. These deposits were washed down the slopes by heavy rains and deposited on the plain near Ferndale by streams capable of carrying only a small load. Wells in this area encounter a considerable thickness of fine-grained deposits (pl. 2, wells 3N/2W–34R and 2N/2W–1H1).

The major part of the Eel River valley is underlain by poorly sorted sand and gravel, possibly as much as 200 feet in thickness. These sediments were deposited by the combined discharge of the Eel and Van Duzen Rivers (pl. 2). Most of the ground water used in the Eureka area is obtained from wells tapping these beds in the alluvium, and most of the wells are less than 70 feet in depth and do not penetrate the entire thickness of the alluvium. Coarse gravel and sand containing minor amounts of silt and clay extend upstream along the Eel River to its confluence with the Van Duzen River. Upstream in the Eel River valley the alluvium becomes narrow; whereas in the Van Duzen River valley, it is relatively broad. A moderate-sized alluvial valley extends northward from the Van Duzen River valley along Yager Creek. The log of well 2N/1E–16J2, along Yager Creek, shows at least 40 feet of alluvial deposits; and the log of well 2N/1E–29B1, along the Van Duzen River, shows at least 35 feet of alluvial deposits.

The Arcata plain, which covers about 12 square miles, is another major area of irrigation development and extends northward from Humboldt Bay to the break in slope on the north side of the Mad River and east for about 3 miles from the dune sand to the west edge of Fickle Hill (pl. 1). In the northeastern part of the Arcata plain the alluvium has been intrenched for as much as 20 feet by meanderings of the Mad River at flood stage. As in the Eel River valley, only a few wells penetrate the thickness of the alluvium because the gravel and sand, which yield abundant supplies of water, commonly are found within 50 feet of the land surface. Therefore, more than one-half the wells in the Arcata plain are less than 30 feet deep. The alluvium, as interpreted from well logs, is similar to that along the Eel River in that the upper 10 feet or less consists of varied combinations of soil, sand, silt, and blue or yellow clay. These deposits are underlain by coarse sand and gravel to an undetermined depth. A log typical of the alluvium is that of well 6N/1E–17E2, which shows 13 feet of soil and silt, 1 foot of blue mud, and 14 feet of sand and gravel. The log of well 6N/1E–7Q1, which is almost a mile away, is different and shows that 72 feet of "blue mud" was penetrated before the well tapped water-bearing gravel adequate for irrigation needs. The material logged as "mud" in these wells is a silty sand, which forms a distinctly soupy mixture when saturated with water.

In the vicinity of Blue Lake the alluvium of the Mad River forms a roughly oblong valley floor, which has an area of about 3.5 square miles. The log of well 6N/1E–25H1 on the south side of the river shows 30 feet of "river gravel" overlying "blue clay with some gravel." Again, most of the wells in the valley are less than 30 feet deep and do not penetrate the thickness of the alluvium.

Wells in the alluvium are the most productive in the Eureka area and have specific capacities ranging from 20 to 350 gpm per foot of drawdown.

RIVER-CHANNEL DEPOSITS (RECENT)

The river-channel deposits are of Recent age and are composed predominantly of coarse pebbles and cobbles, containing minor amounts of coarse sand which were intermittently transported by the Eel and Van Duzen Rivers during flood stage. The contact between the river-channel deposits and the other alluvium shown on plate 1 is approximate and indicates only the general extent of the channel materials that have not developed a soil cover. The thickness of these deposits is unknown, but the maximum may be about 50 feet (pl. 2). No known wells tap the river-channel deposits, which are saturated and presumably highly permeable.

DUNE SAND (RECENT)

The area along the coast is marked by an almost continuous strip of beach sand and typical windblown, shifting dune sand. This strip is broken at the south end by the mouth of the Eel River, in the center by the dredged entrance to Humboldt Bay, and at the north end by the mouth of the Mad River. The dunes are best developed along the North Spit between the entrance to Humboldt Bay and the mouth of the Mad River, where they reach an altitude of more than 70 feet and attain a maximum width of three-fourths of a mile. The dune sand is loose, subangular to subrounded, fairly well sorted, fine to coarse grained, and gray or brownish gray. The base is not exposed, and no wells are known to penetrate the full thickness of the deposit. Therefore, the thickness is uncertain, but it may be more than 100 feet.

On North Spit the dune sand forms an important aquifer. Most wells are sand points driven deep enough to penetrate the fresh-water lens overlying the ocean water. They supply water for domestic, municipal, and industrial purposes.

The well installation used by the Hammond Lumber Co. at Samoa to satisfy its requirements for water for industry and public supply is of interest. Six sand points, each 3 inches in diameter and 7 feet in length, were driven into the sand at the apices of a hexagonal pattern; each well point is 15 feet from a common center. The 6 wells are connected at the center of the hexagon, or "spider," and 1 pipe connects the spider to the pump. Wells of adjacent spiders are rarely less than 12 feet apart, and commonly from 2 to 8 spiders are connected to 1 pump. Similar well installations are used by the Coast Guard station and by other industries on the North Spit.

STRUCTURAL FEATURES

The structural features of the Eureka area are dominated by the general eastward trend of the Tertiary sedimentary rocks in the Eel River valley (pl. 1). The Eel River syncline (pl. 1), which plunges toward the west, is the most significant major structure in the area; and together with other minor folds, it is generally eastward trending. In the south flank of the Eel River syncline, which is steeper than the north flank, is exposed a thick section of coarse-grained continental sediments of the Carlotta formation of Ogle (1953) which dip beneath the alluvial deposits of the Eel River and thus form an artesian aquifer (pl. 2).

Structural relationships in the area north of Eureka are not clear. Coarse-grained continental and marginal deposits of the Hookton formation of Ogle have been complexly warped into a myriad of small northwest-trending anticlines and synclines. The general structure of the Hookton formation of Ogle (1953) is, however, favorable to the development of artesian wells along the margin of Arcata Bay (pl. 1).

The faults are generally older than the folds; although, recently, there has been some movement along faults because of earthquakes. The faults, however, do not apparently cut any of the deposits of Pliocene age or younger; and hence, do not appear to affect the movement or occurrence of ground water.

GROUND-WATER FEATURES

GROUND-WATER BODIES

Ground water in the Eureka area occurs in most of the unconsolidated deposits, described previously. It is under confined (artesian) conditions or unconfined (water-table) conditions, or both. The coarse sand and gravel of the alluvium, the dune sand, and the terrace deposits are lying in an almost flat position and contain unconfined water at depths generally less than 30 feet below the land surface. In the higher terrace deposits, such as those near Rohnerville and Hydesville, impermeable clay lenses or strata may act as barriers to the downward percolation of ground water, and these clay beds locally support perched water bodies which commonly discharge in springs.

The principal ground-water body of the Eel River valley is unconfined and occurs in the coarse sand and gravel of the alluvium and river-channel deposits along the Eel and Van Duzen Rivers. It is in hydraulic continuity with water in adjacent low terrace deposits. This water body extends upstream along the narrow part of the Eel River valley, past Rio Dell and Scotia, along the Van Duzen River and Yager Creek, and to both sides of the Eel River in the main part of the valley downstream from Alton. The largest part of this water body is south and west of the river and north and east of a line extending east along Salt River to about Arlynda Corners. From Arlynda Corners, southeast, to the Coffee Creek School a dotted line has been drawn on figure 5. Southwest of this imaginary line and south of the Salt River, most of the alluvial deposits are poorly permeable and are tapped only by wells along the mouths of the streams, draining the Wildcat Hills. North and northeast of this indicated line, highly permeable deposts are tapped by numerous irrigation wells.

There are two aquifers, and possibly three, in the Eel River valley beneath the alluvium in the Carlotta formation of Ogle (1953). All are partly confined. Just south of Fortuna the Eel River flows north-

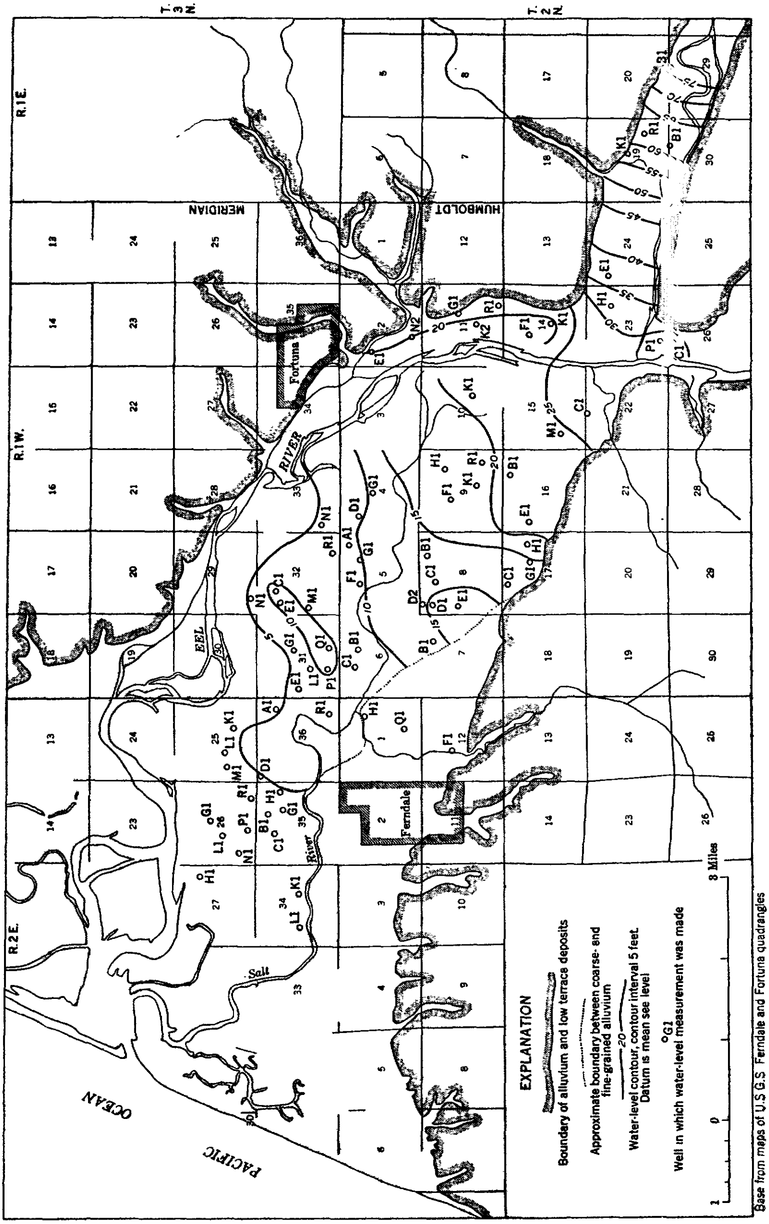


FIGURE 5.—Water-level contour map of the Eel River valley, August 1952.

ward and crosses the valley normal to the general strike of the Carlotta formation and normal to the eastward-trending Eel River snycline (pl. 1). Well 2N/1W–12D2, which is 190 feet deep, is on a high terrace to the east of the Eel River, near Rohnerville, but it penetrates the underlying Carlotta formation. In the spring of 1952, it flowed at a small rate. In the Eel River valley, west of the river, the alluvial deposits probably extend to depths of more than 90 feet and may separate the shallow aquifers in the Carlotta formation that are east of the river from those west of the river. In the vicinity of Ferndale, where the coarse gravel in the alluvium is absent, there are at least two aquifers in the Carlotta formation. In 1952 well 2N/1W–7K2, which is 340 feet deep, had a slight flow at an altitude of about 45 feet; whereas in well 2N/2W–12F1, 180 feet deep, the water level was about 3 feet above sea level. Wells 3N/2W–32N1 and 3N/2W–32Q1, both more than 250 feet deep, had flows from 200 to 300 gpm over the tops of their casings at an altitude of about 8 feet above sea level. Obviously these deep flowing wells tap confined aquifers that are distinctly separate from, and have a higher head than, the shallow aquifers tapped by other wells in the vicinity of Ferndale. There may be some hydraulic continuity between aquifers in the Carlotta formation that are less than 200 feet beneath the surface and the main ground-water body in the alluvium of the Eel River valley.

Another water body, also unconfined, occurs in the deposits beneath the alluvial plain of the Mad River in the vicinity of Arcata and upstream in the vicinity of Blue Lake, but it probably is not connected hydraulically to the water in the dune sand along the coast. Minor ground-water bodies occur along the small alluviated valleys draining into Humboldt Bay; but these are undeveloped, except for a few small domestic wells.

North of Arcata and the Mad River in the vicinity of McKinleyville, the Hookton formation of Ogle (1953) lies in an almost flat position and supplies unconfined water to wells. The depth of wells, which tap water-bearing strata, is less than 30 feet in this area, but the yields are sufficient for only domestic use.

Around the margins of Humboldt Bay, between Arcata and Eureka, the Hookton formation of Ogle (1953) is deformed, and wells tap confined sand aquifers in the Hookton formation at depths ranging from 70 to 600 feet below sea level. Because of the fine texture of materials in the aquifers, the flow from these artesian wells generally is less than 10 gpm, and the yield when pumped commonly is less than 100 gpm. In the outcrop area east of Bayside, well 5N/1E–4H2 was drilled to a depth of 65 feet in the Hookton formation at a land-surface altitude of about 125 feet and a water-level altitude (1952) of about 75 feet above sea level. If the head in this well was representative of water levels in the outcrop area, sufficient head existed to account for the flowing wells on the coastal plain.

Along the southwest side of Table Bluff and about 1.5 miles from the coast, wells 3N/2W–2A1 and 3N/2W–2A2, which are less than 20 feet deep, yield water from sand of the Hookton formation of Ogle (1953). The static water level in these wells is about 1 foot above the land surface. Their logs show that about 15 feet of silt and clay is in the alluvium, which confines water in the underlying sand of the Hookton formation.

The ground water in the dune sand along the North Spit occurs in accordance with the Ghyben-Herzberg principle, which has been explained (p. 11). A fresh-water lens probably lies under the South Spit as well as in other areas of coastal dune sand, but the only development of ground water has been on the North Spit.

RECHARGE AND MOVEMENT OF GROUND WATER

During this investigation, water levels—depth to water below land surface—in most wells were measured. Altitudes of the measuring points were partly interpolated from 50-foot contours, which on the coastal plains provided information that was too general to enable construction of water-level contour maps. Therefore, the altitudes of most of these wells were determined by aneroid barometer and probably are accurate to about 5 feet of tolerance. The altitudes of the nonpumping water levels, for August 1952, were computed and plotted on a map. They showed some disparities of water levels in wells, tapping all deposits, except the alluvium and low terrace deposits of the coastal plains and major stream valleys. Therefore, the water-level contours for August 1952, shown on figure 5, were drawn by connecting points of equal head in wells, tapping the alluvium and low terrace deposits of the Eel River valley. Data for the Mad River valley were insufficient for constructing an adequate contour map.

The water-level contours on figure 5 show that ground water generally flows down the Eel and Van Duzen River valleys toward the coast. The contours show also that there is some contribution of ground water along the sides of the valleys from the Carlotta formation of Ogle (1953). In the coastal plain the contours show that ground water in the alluvium flows toward the tidal part of the Eel River. The minor ground-water mound on the coastal plain is probably the residual feature of recent relatively heavy pumping southeast of the mound.

The contours and other evidence show that recharge to the alluvium beneath the coastal plain is from precipitation, by upstream seepage from the Eel and Van Duzen Rivers, and to some extent by seepage from adjacent deposits. Ground water from the alluvium of the coastal plain is discharged naturally by seepage into the tidal estuary of the Eel River. The rate of this natural discharge is probably influenced by the rise and fall of the tide; that is, at high tide natural ground-water discharge is at a minimum, and at low tide natural discharge is at a maximum. In August 1952 the seaward hydraulic gradient in the coastal plain was about 5 feet per mile. Unfortunately, it was not possible to determine whether static water levels were below sea level. However, pumping levels in some wells on the seaward side of the 5-foot water-level contour ranged from 1 to 3 feet below sea level.

Precipitation on the coastal plain and adjacent areas is about 40 inches per year (pl. 3), and in areas that are underlain by water-bearing deposits a relatively large part percolates downward to become ground water. In addition, there is some recharge from the minor streams and by downward movement of water from the alluvium to the underlying pumped aquifers in the Carlotta formation of Ogle (1953). Wells 2N/2W–1H1, 1Q1, and 12F1 are between 150 and 180 feet deep but have water-level altitudes similar to those in nearby shallow wells in the alluvium. On the other hand, well 2N/1W–7K2, about 1 mile east, taps deep gravel beds in the Carlotta formation that have an artesian head higher than the levels in wells in the alluvium; and, therefore, these aquifers probably receive recharge from precipitation and streams in their outcrop areas.

In the Mad River valley and on the Arcata plain, ground water is recharged by seepage from the river and small streams and by deep percolation of precipitation. On the Arcata plain precipitation on water-bearing deposits of the Hookton formation of Ogle (1953), along the east and north sides, also recharges ground water.

Water levels in wells in August 1952 on the Arcata plain between Arcata Bay and the Mad River indicate that the hydraulic gradient of the ground water in the alluvial deposits is seaward, and the water probably discharges into the Mad River slough and into Arcata Bay. Static levels and pumping levels in all but one well in the small alluvial plain north of the Mad River were below sea level. Heavy pumping in this area established a hydraulic gradient from the river toward the wells. Because this reach of the river is not tidal, there is little chance for sea-water encroachment from this source. In the Dows Prairie-McKinleyville area north of the Mad River, water levels in wells in the Hookton formation of Ogle (1953) in August 1952 were between 30 and 190 feet above sea level.

In the artesian areas of the coastal plain between the Eel and Mad Rivers, most of the recharge is from deep percolation of rainfall on the outcrop areas of the Hookton and Carlotta formations of Ogle (1953) and subsequent lateral percolation into the parts of these formations beneath the confining beds in the alluvium or bay muds, underlying the coastal plain.

The alluvial deposits adjacent to the Mad, Eel, and Van Duzen Rivers receive a substantial amount of recharge as the result of flooding during the winter and early spring, although the Mad River has been controlled somewhat since the completion of Sweesey dam, about 5 miles southeast of Blue Lake. Nearly every winter the Eel River inundates a large part of the land between Ferndale and Fortuna, including all the flat land north of the river as far as Table Bluff. This river undoubtedly contributes a substantial amount of water to the shallow alluvial aquifers.

Finally, the fresh-water lens in the dune sand on North and South Spits is recharged almost wholly from deep percolation of rainfall. The topography of the dunes forms natural catchment basins, which provide sufficient water for deep percolation. Discharge from the fresh-water lenses is by pumping and by natural discharge to the Pacific Ocean.

DISCHARGE OF GROUND WATER

Ground water in the Eureka area is discharged by natural and artificial means. Artificial discharge is considered to be the flow and pumpage from wells.

NATURAL DISCHARGE

Most ground water is naturally discharged by subsurface flow to streams and tidal estuaries in the coastal plain, by evaporation and transpiration, and by flow through spring orifices. As previously discussed in the section on recharge and movement of ground water, the discharge of ground water to the sea or to the tidal estuaries is partly controlled by the rise and fall of the tide. The magnitude of the natural discharge is no doubt large, but no data were available to estimate it. An indication of the magnitude of natural discharge from the alluvium of the Eel and Mad Rivers may be obtained from the numerical difference between total pumpage and the estimated depletion of storage during 1952. This difference indicates about 10,000 acre-feet of natural discharge per year from the Eel and Mad River alluvial deposits.

In addition, ground-water discharge to the sea from the older water-bearing deposits probably takes place at some distance offshore, and ground water from the coastal dune sand probably discharges near the beach.

PUMPING FROM WELLS

During this investigation of the Eureka area, 315 wells were located (pl. 1), and the available data for each well were recorded and are shown in table 6. The main objective of the well survey was to locate most of the irrigation and public-supply wells and a representative group of industrial and domestic wells to obtain information on the depths to water, the pumpage, the quality of ground and surface waters, and the materials penetrated by wells.

Although 222 wells were classified as being used for irrigation, many of these also were used for domestic, stock, and dairy purposes. However, the additional water pumped for stock, dairy, or domestic use from any well used for irrigation is only a small part of the total. The majority of irrigation wells were drilled or dug since the end of World War II, and in 1952, an estimated 250 irrigation wells supplied water to about 12,000 acres of land.

The irrigated acreage is planted almost entirely in grass and clover for permanent pasture, and the few fields of silage crops, such as stock beets, carrots, and corn, receive little, if any, irrigation water. Most of the fields are irrigated by overhead systems, equipped with revolving sprinklers or perforated pipe; only two irrigation systems were observed that used flooding as a means of applying water. Many of the pumps have automatic time switches, which turn the pump off after a certain period so that the sprinkling system then may be moved and irrigation continued on another plot. By this controlled and uniform method of applying water, an estimate of the quantity of water pumped for irrigation can be made simply.

Dairymen interviewed during the investigation supplied the following data: (a) number of acres irrigated, (b) the number of times during the season that land was irrigated, and (c) the depth of water (in inches) applied during each period of irrigation based on the assumption that water is discharged by revolving sprinklers at about half an inch per hour and by perforated pipes at about 1 inch per hour. The quantity of water pumped for irrigation, computed from these data, ranged from 3 to 36 acre-inches per installation. The annual average for the irrigation season from June to September or October was 10 acre-inches. Because of leakage and various irrigation practices that result in loss of some water, these figures are probably low. Therefore, it is estimated that the water pumped from wells averaged about 1 acre-foot per year for about 12,000 acres under irrigation as of 1952; thus, the annual pumpage of water for irrigation was about 12,000 acre-feet. Irrigation is generally less necessary near the ocean than it is a few miles inland, where commonly less fog occurs and more evaporation takes place. Table 2 shows pumpage of water for irrigation at the three major irrigated areas in the vicinity of Eureka.

The table also shows that in 1952 about 9,600 acre-feet, or 80 percent, of the estimated total water for irrigation was withdrawn in the Eel and Van Duzen River valleys. Because some of the irrigation water applied to the soil percolates into the ground and becomes ground water, the net draft—the pumpage less that part of the applied water that returns to become ground water—was somewhat less than the pumpage.

TABLE 2.—*Estimated pumpage, in acre-feet, for irrigation in the Eureka area, Humboldt County, Calif., in 1952*

Area	Pumpage
Eel and Van Duzen River valleys, upstream from the confluence	1, 200
Eel River valley coastal plain	8, 400
Mad River valley coastal plain (Arcata plain)	1, 600
Other areas	800±
Total	12, 000±

There are several creameries in the area, and of these the plant of the Golden State Co. at Loleta probably is the largest consumer of ground water. Mr. Larson, general manager of the Loleta plant, estimated the ground-water consumption to be 700 gpm, or about 1,100 acre-feet per year. One large lumber mill has a log pond that is about 6 feet deep and covers 18 acres. It is necessary to pump water about one day a week to maintain sufficient water in the pond to float logs. This mill and the other mills and industries in the area probably pumped an additional total of about 1,000 acre-feet in 1952. Other industrial pumpage was small. Thus, the industries in the Eureka area pumped a total of about 2,000 acre-feet of ground water in 1952.

The water supply for the cities of Arcata and Fortuna is largely from ground water obtained from shallow wells penetrating alluvial deposits, although from May to September, inclusive, it is necessary for Arcata to supplement its water supply from surface reservoirs. Loleta and Rio Dell use ground water for their supplies, and Blue Lake and Fields Landing use some ground water from wells during the summer, when their regular supplies from springs are low. Table 3 shows the increase in water consumption from 1946–47 to 1951–52 for the cities of Arcata and Fortuna.

TABLE 3.—*Metered water consumption, in thousands of gallons, for the cities of Arcata and Fortuna, Humboldt County, Calif., 1947–52*

Year ending May 31	Arcata [a] (ground and surface water)	Fortuna [b] (ground water)
1946–47	103, 507	47, 500
1947–48	107, 868	58, 382
1948–49	121, 903	69, 540
1949–50	130, 320	71, 706
1950–51	151, 901	78, 082
1951–52	170, 048	80, 103

[a] Population 3,747 in 1950 census.
[b] Population 1,761 in 1950 census.

Table 3 shows that the annual consumption of surface and ground water by the cities of Arcata and Fortuna nearly doubled from 1946–47 to 1951–52. In 1951–52 the consumption was about 520 acre-feet for Arcata and about 250 acre-feet for Fortuna. Because the city of Arcata supplements its ground-water supply from surface-water sources from May to September, inclusive, the ground-water pumpage in 1951–52 was somewhat less than the 520 acre-feet consumed. Ground-water pumpage in the Eureka area for all public and domestic supply, including rural use, was estimated at about 1,000 acre-feet in 1952.

The estimated pumpage for all uses in the Eureka area in 1952 is summarized, as follows:

Use	Acre-feet
Irrigation	12, 000
Industry	2, 000
Public and domestic supply	1, 000
Total	15, 000

This total pumpage of 15,000 acre-feet is probably a conservative estimate of the draft from the alluvium and terrace deposits. No studies were made to estimate what part of the pumpage returns to become ground water. Even though the soils and deposits are moderately permeable in the areas of large withdrawal, the return of water from irrigation, public supply, and industry probably is a relatively small percentage of the pumpage.

Application of irrigation water by means of sprinkler systems results in much less return than by flooding. Use of automatic timers on many pumps also helps to prevent excessive application of water and assists in maintaining a high efficiency in the application of irrigation water.

FLUCTUATIONS OF WATER LEVEL

Water-level measurements in 21 wells were made by the Geological Survey, beginning in June 1951. In 1952 measurements were made in May and monthly from August to November. In addition, a water-level recorder was operated continuously at a deep well (3N/1W–34J1) for 11 weeks from August 9 to November 19, 1952, to obtain a continuous record of water-level fluctuations in the deep aquifers. Water-level measurements were made again in observation wells in the spring and summer of 1953, 1954, and 1955 (table 7).

Most of the rainfall and, therefore, most of the recharge occur from late autumn to spring, and most of the pumping during early summer to early autumn; under these conditions the result is a rise in water level during the period of recharge, and a decline during the period of discharge. The seasonal fluctuations of the water level from the spring high to the autumn low are a measure of the net change of ground water in storage in the ground-water body.

Figure 6 shows hydrographs of 5 representative wells in the Eel River valley, and figure 7 shows hydrographs of 4 wells in or near the Arcata plain. Wells 3N/2W–26R1 and 2N/1W–8B1 penetrate the alluvium beneath the Eel River plain and are in the principal area of irrigation. Well 2N/1W–8B1 had a net water-level decline of about 7 feet during each irrigation season; whereas well 2N/1W–32C1, not shown on figure 6, had a decline of about 5 feet, and well 3N/2W–26R1 a decline of 3 feet for the same period. Thus, the greatest net decline and recovery each year took place upstream, where there is a relatively steep slope of the water table; and the least decline took place near the coast, where the water table was at or near sea level and the ground-water gradient was relatively slight.

Well 2N/2W–4K1 is a shallow domestic well near the mouth of a small stream valley along the south edge of the Eel River plain. The hydrograph of this well shows a net decline in water level ranging from about 2 to 4 feet in the 1952–54 irrigation seasons. Well 3N/1W–18D1, north of the Eel River, penetrates fine-grained materials in aquifers in the Hookton formation of Ogle (1953). These aquifers are pumped only lightly in the immediate area. The hydrograph shows an annual fluctuation from only 1 to 2 feet for 1952–54.

The fluctuation of water levels in the irrigated area of the Arcata plain is shown by hydrographs of wells 6N/1E–19Q1 and 6N/1E–20C1 on figure 7. These hydrographs show that seasonal fluctuations in 1952–54 were from 4 to 6 feet for well 19Q1, and from 5 to 6 feet for well 20C1.

Water-level fluctuations north of the Mad River in the vicinity of McKinleyville are represented by hydrographs of wells 6N/1E–6H1 and 7N/1E—31D1, tapping the Hookton formation of Ogle (1953) (pl. 1 and fig. 7). There are no large consumers of ground water in this area, because ground water is used only for domestic and stock needs. In 1952–54 the water level in well 6N/1E–6H1 had a seasonal fluctuation ranging from 8 to 13 feet, and the fluctuations in well 7N/1E–31D1 ranged from 5 to 6 feet. The water levels in these wells probably are influenced by large withdrawals from irrigation wells along the Mad River, about 1 to 2 miles to the south. No water-level contour map of this area was made.

The hydrographs on figures 6 and 7 and the water-level records in table 7 generally show no net change in water levels of wells from the spring of 1952 to the spring of 1955. The recovery of water levels each spring to approximately the same level indicates that there was no overdraft in the area during the 3-year period. Fur-

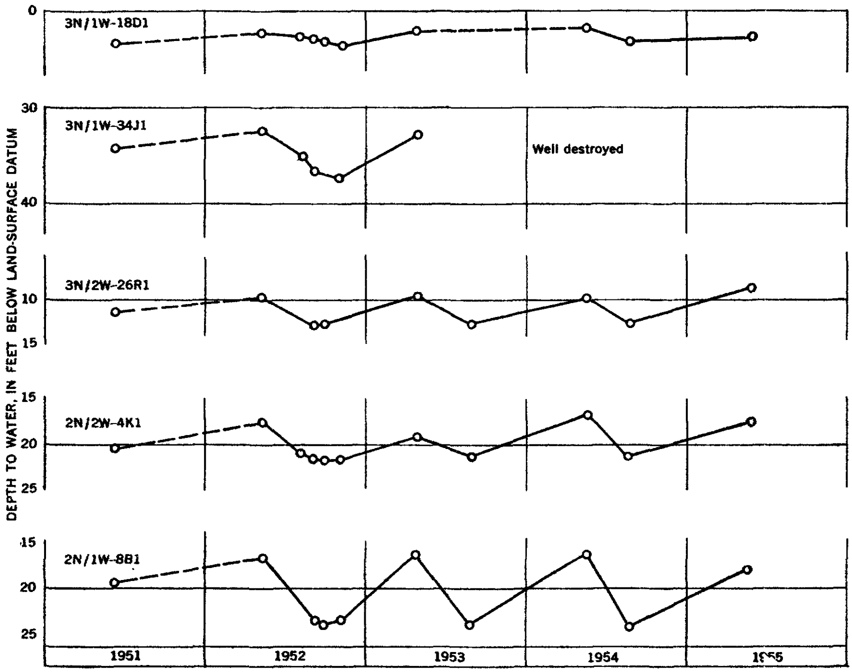


FIGURE 6.—Fluctuations of water levels in five wells in the Eel River valley.

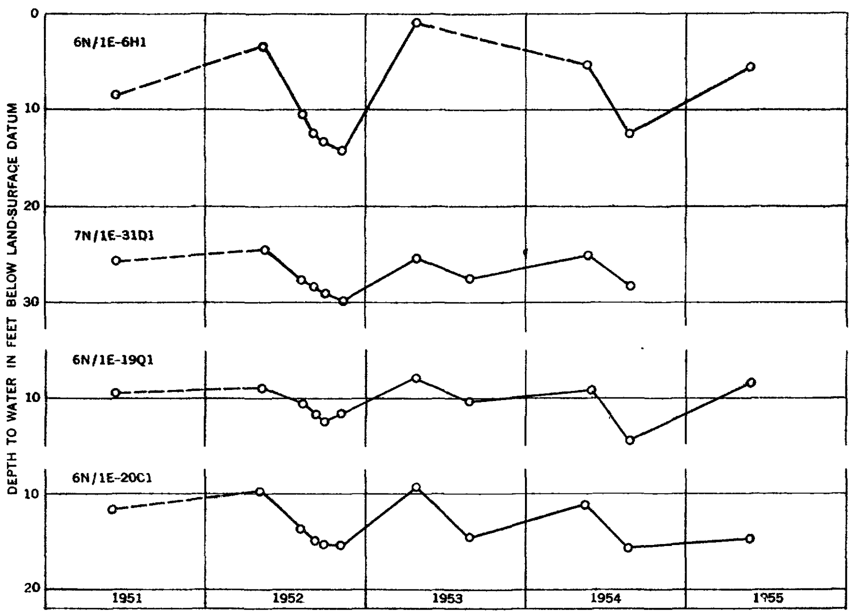


FIGURE 7.—Fluctuations of water levels in four wells near Arcata.

thermore, well owners reported that the high levels during the spring of 1952 were approximately the same as those for many years past; that is, there was essentially no difference between the levels in 1952 and the levels when the wells were drilled.

An automatic water-level recorder was operated continuously from August 9 to November 19, 1952, at well 3N/1W-34J1 in the town of Fortuna. This well is 496 feet deep and is perforated from 182 to

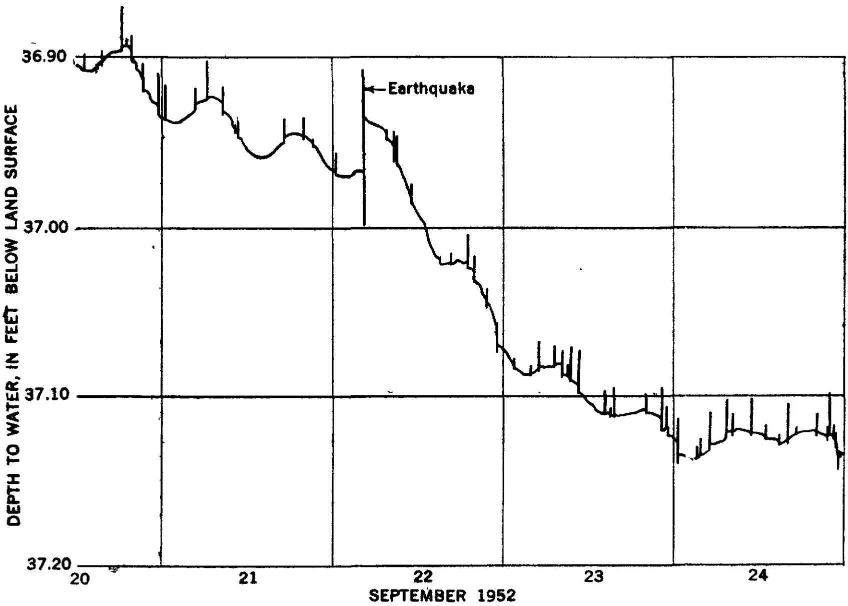


FIGURE 8.—Fluctuations of water level in well 3N/1W-34J1.

226 feet and from 285 to 365 feet opposite partially confined aquifers of the Carlotta formation of Ogle (1953). Fluctuations of water levels recorded in this well were due to tidal movements, passing trains, earthquakes, and possibly, on one occasion, tsunami. The record for the period September 20 to September 24 is shown on figure 8 and illustrates most of these fluctuations. The railroad depot of the city of Fortuna is less than 200 feet from the recording site, and the accumulative load of each passing train caused a rise in water level of as much as 0.025 foot. The effect of tidal loading and unloading, about 5 miles distant, caused fluctuations of about 0.04 foot twice daily and resulted in a regular sinuous curve such as that for September 21. An earthquake, whose epicenter was some 15 or 20 miles south of Fortuna, accounted for a total fluctuation of 0.09 foot in the morning of September 22. When the shock ended, an increase of 0.03 foot in the water level was recorded.

GROUND-WATER STORAGE CAPACITY

To determine the ground-water storage capacity of a ground-water reservoir, it is necessary to know the areal extent of the aquifer, the depth to which the aquifer is saturated with fresh water, and the coefficient of storage of the aquifer. The coefficient of storage of an unconfined aquifer is essentially the same as the specific yield, which is defined as the ratio of the volume of water it will drain by gravity from a saturated rock to the total volume of the rock, expressed as percentage.

The deposits for which estimates of storage capacity are considered are the alluvium, channel deposits, and the lower terrace deposits of the Eel, Van Duzen, and Mad Rivers. The following specific-yield values, assigned to these deposits encountered in wells in the Eureka area, have been adapted with slight modification from those figures used in estimating the ground-water storage capacity of similar deposits in the Sacramento Valley (Poland and others, 1951).

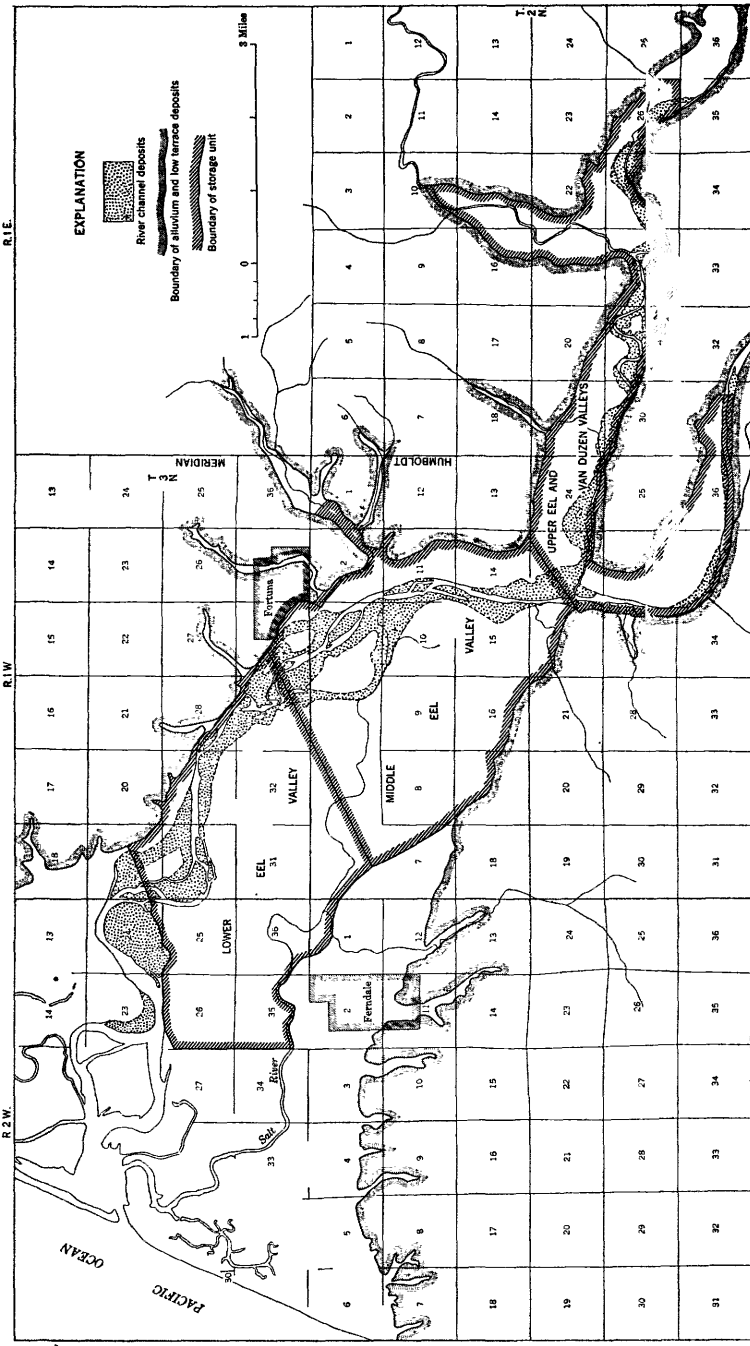
Material	*Specific yield (percent)*
Gravel	25
Sand and gravel, sand	20
Sand and silt	15
Sand and clay, soil and clay, gravel and clay	10
Clay	3

SUBDIVISION OF AREA INTO STORAGE UNITS

The Eureka area was divided into five storage units, which are shown on figures 9 and 10. These units are the lower Eel Valley, the middle Eel valley, the upper Eel and Van Duzen valleys, the Arcata plain, and the Blue Lake valley.

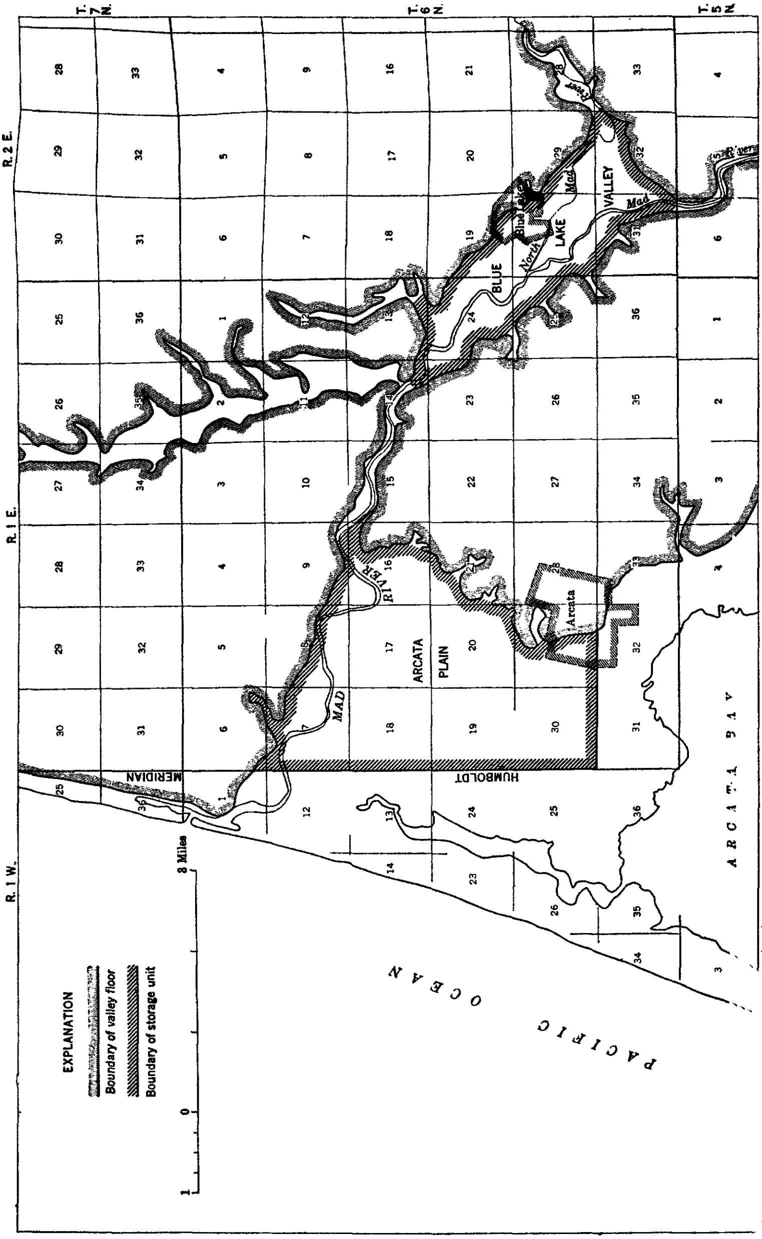
Few well logs are available for estimating the specific yield of the deposits in each of these units, and none show that the entire thickness of the alluvium was penetrated. Therefore, it is not possible to determine the thickness of deposits saturated with fresh water. Most of the material penetrated by shallow wells in the alluvial deposits along the Eel, Van Duzen, and Mad Rivers consists of fine- to coarse-grained sand and gravel and a few thin streaks of silt or clay—ordinarily not thick enough to be noted on well logs. The deposits probably are lithologically similar throughout each storage unit; and therefore, the few available well logs are believed to be representative. The specific yields computed for each unit are shown in table 4.

Alluvial areas, for which no storage estimates were made, include: (a) small areas in which few or no wells were located; (b) areas in which most of the sediments are fine grained, such as the small stream valleys, valley mouths, and areas adjacent to the bay or tidal sloughs;



Base from maps of U.S.G.S Ferndale and Fortuna quadrangles

FIGURE 9.—Ground-water storage units in the Eel River valley.



Base from maps of U.S.G.S. Eureka and Blue Lake quadrangles

FIGURE 10.—Ground-water storage units in the Mad River valley.

and (c) areas where the chemical quality of the water is poor. The coastal plain north of the Eel River (Loleta bottom) is excluded because the quality of the ground water in much of the area is poor; and where the quality is good, not enough data were available on the lithology of the alluvium.

In areas of possible sea-water encroachment, such as the lower Eel River valley and the Arcata plain, the deposits saturated with fresh water probably extend for many feet below sea level. However, it would be impracticable in these areas to lower ground-water levels to below sea level because of possible sea-water encroachment. Therefore, the practical limits of the water levels of saturated deposits for the lower Eel River valley and Arcata plain extend from the highest known water level in each unit to sea level. The water levels of saturated deposits average 10 feet above sea level in the lower Eel valley storage unit and 15 feet in the Arcata plain storage unit. In the middle Eel River valley, the thickness of saturated deposits extends from the highest known water level in the unit (average, 25 feet above sea level) to a minimum depth of 15 feet below sea level at the downstream end. In the upper Eel and the Van Duzen valleys and in the Blue Lake valley, the saturated thickness extends from the estimated highest average water level to the maximum depth of wells in the area. The surface areas and saturated thicknesses of depth zones for the five storage units are shown in table 4.

TABLE 4.—*Estimated ground-water storage capacity of the alluvium, river-channel deposits, and lower terrace deposits of the major ground-water basins in the Eureka area, Humboldt County, Calif.*

[See figs. 9 and 10]

Storage unit	Surface area (acres)	Saturated thickness (feet)	Volume (acre-feet)	Specific yield (percent)	Well logs available [a]	Storage capacity [b] (acre-feet)
Eel River valley:						
Lower	6,600	10	66,000	19	3	12,000
Middle	7,300	40	292,000	23	9	67,000
Upper	5,500	40	220,000	21	5	46,000
Subtotal	19,400		578,000	22		125,000
Mad River valley:						
Arcata plain	5,100	15	76,000	15	4	11,000
Blue Lake valley	2,200	25	55,000	25	1	14,000
Subtotal	7,300		131,000	19		25,000
Eurkea area, total	26,700		709,000	21		150,000

[a] The number of well logs available for estimating specific-yield values.
[b] Ground-water storage of units is to the nearest thousand acre-feet and total storage is rounded to two significant figures.

COMPUTATION OF STORAGE CAPACITY

The estimated storage capacity of each unit is calculated by multiplying the acreage, as determined by a planimeter, with the saturated thickness of the depth zone, as described above. The specific yield, expressed as a percentage, multiplied by the figure obtained for the volume is the ground-water storage capacity. Table 4 shows the estimated storage capacities computed for the five units in the Eureka area.

NET CHANGE OF GROUND WATER IN STORAGE

The change of ground water in storage is represented by changes in water levels in wells and is equal to the difference between the elements of recharge and the elements of discharge. A decline in water level indicates a depletion of the ground water in storage, and a rise in water level indicates a replenishment of the ground water in storage. By applying the specific-yield value to the change in saturated volume of the deposits, determined by the average water-level change multiplied by the area, a quantitative figure for change of ground water in storage may be obtained.

During 1952, the seasonal decline of the water level from spring to autumn in the five storage units of the Eureka area averaged about 5 feet. With overall specific yield of about 22 percent and an area of about 19,000 acres in the Eel River valley (table 4), the net depletion of ground water in storage was about 20,000 acre-feet. Similarly, the net depletion of ground water in storage in the Arcata plain was about 4,000 acre-feet, and in the Blue Lake valley was about 3,000 acre-feet. Total depletion in the Eureka area was about 25,000 acre-feet. This total is much larger than the estimated total pumpage of 15,000 acre-feet in 1952. The difference of about 10,000 acre-feet between the estimated depletion in storage and the pumpage is attributed to the excess of natural discharge plus the pumpage over the ground-water recharge during the relatively dry late spring, summer, and early autumn; it also includes any errors in the quantitative estimates.

QUALITY OF THE WATER

All the water in or on the ground contains minerals in solution or suspension, or both. Minerals in the soil and rocks are dissolved by water, particularly that containing carbon dioxide derived from the atmosphere and the soil, and organic acids leached from the soil. The chemical characteristics of the water in any particular area thus are related to the composition of the soils and bedrock in that area.

Most of the mineral constituents in natural waters are ionized to form positive ions, or cations, and negative ions, or anions. Silica is the principal constituent that is not ionized. The cations of calcium, magnesium, sodium, and potassium and the anions of bicarbonate, carbonate, chloride, sulfate, and nitrate are commonly reported in water analyses. Some other constituents commonly present in lesser amounts are iron, fluoride, and boron. Surface waters generally have a lower concentration of dissolved solids than do ground waters.

The collection and analyses of water samples for this report provide data by which to determine the general chemical quality of the water in each aquifer or subarea and to determine the existence, or extent, of salt-water encroachment. Water samples from 95 wells and 21 streams were collected and analyzed by the U. S. Geological Survey. Chemical analyses of waters from 8 wells were also obtained from the owners of the wells. Table 8 shows analyses of well waters in which 4 or more constituents were determined. Table 9 shows analyses of well waters in which only chloride content, electrical conductivity, and either hardness or hydrogen-ion concentration, which is expressed as pH, were determined. The 21 analyses of surface waters appear in table 10.

WATER-QUALITY CRITERIA

Criteria for the quality of ground water depend on the use for which the water is obtained. Domestic, industrial, and agricultural water supplies have different quality standards. Water suitable for domestic use may have constituents that are unsuitable for certain industrial uses; other constituents may be detrimental to certain agricultural crops. Each use of water, therefore, has a specific standard of water quality. The water-quality data in this report indicate only the general chemical character of the waters sampled.

The U. S. Public Health Service Drinking Water Standards of 1946 are used generally in evaluating domestic water supplies. Recommended maximum limits given in these standards, in parts per million (ppm), for some of the more common chemical substances are:

Chemical substances	*Ppm*
Iron and manganese combined	0.3
Magnesium	125
Chloride	250
Sulfate	250
Total solids:	
Desirable maximum	500
Permitted maximum	1,000

In general, water for domestic use should be soft, low in dissolved solids, and free from unpleasant taste and odor.

Quality requirements of water used for industrial purposes are as diversified as the industries themselves; probably the one common requirement is that the concentrations of constituents be relatively constant. When the concentrations remain constant, removal or reduction of undesirable constituents for a specific industry is facilitated.

The quality of water necessary for agricultural use depends on whether the supply is for stock or for irrigation. It may be assumed that water that is safe for human consumption is safe for stock. However, animals can tolerate higher salinities than man. The plant tolerance of salinity, soil type, climatic conditions (temperature, rainfall, and humidity), and irrigation practices are important factors in determining the suitability of irrigation water. Good drainage of the soil, however, may be a more important factor for crop growth than the concentration of salts in the water. The interrelationships between constituents may also be a significant factor.

RELATION BETWEEN SPECIFIC CONDUCTANCE AND DISSOLVED SOLIDS IN WATERS OF THE AREA

In most waters a relation exists between the dissolved solids and the specific electrical conductance. In this report the relation between the sum of determined constituents and specific conductance is considered because the content of dissolved solids as a residue after evaporation was determined for only a few ground-water samples in the Eureka area. The sum of determined constituents generally is slightly less than the dissolved solids because it does not include the relatively small amounts of some of the minor dissolved constituents. These minor constituents, however, would constitute only a small part of the residue on evaporation; and thus, the sum of determined constituents is essentially the equivalent of dissolved solids.

Figure 11 shows the relation of specific conductance, in micromhos at 25° C, to the sum of determined constituents in parts per million. The mean curve of figure 11 can be expressed approximately by the formula

$$S=0.56\ (K \times 10^6),$$

where S=sum of dissolved constituents, in parts per million, and K=specific conductance, in mho-centimeters.

CHEMICAL CHARACTER OF WATER

Except for water from a few wells near the coast, the chemical quality of ground water in the Eureka area generally is good. Tables 8–10 and the diagrams on figures 12–14 show the character of representative surface and ground waters in 1952.

Plate 13 shows the distribution of chloride and iron concentrations in the Eel River valley in 1952, and plate 14 shows chloride concentrations of water in 5 wells in August 1953. Most waters in the

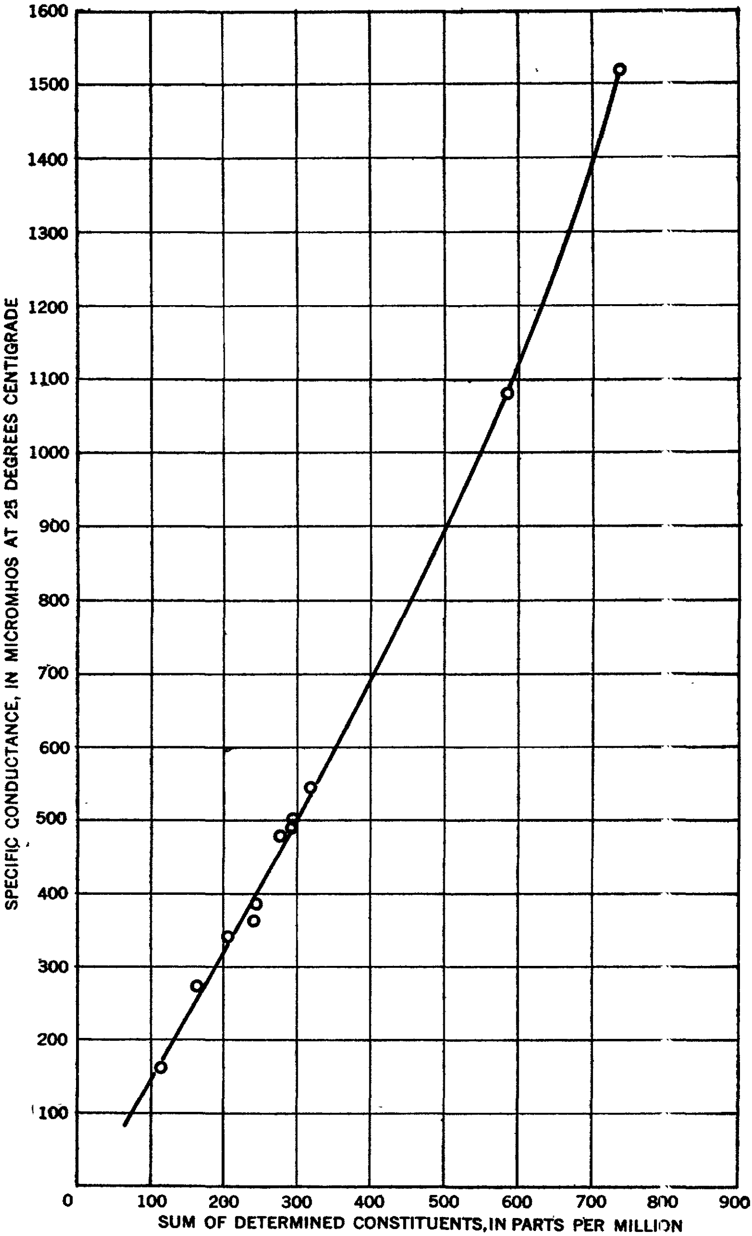


FIGURE 11.—Relation of specific conductance to sum of determined constituents.

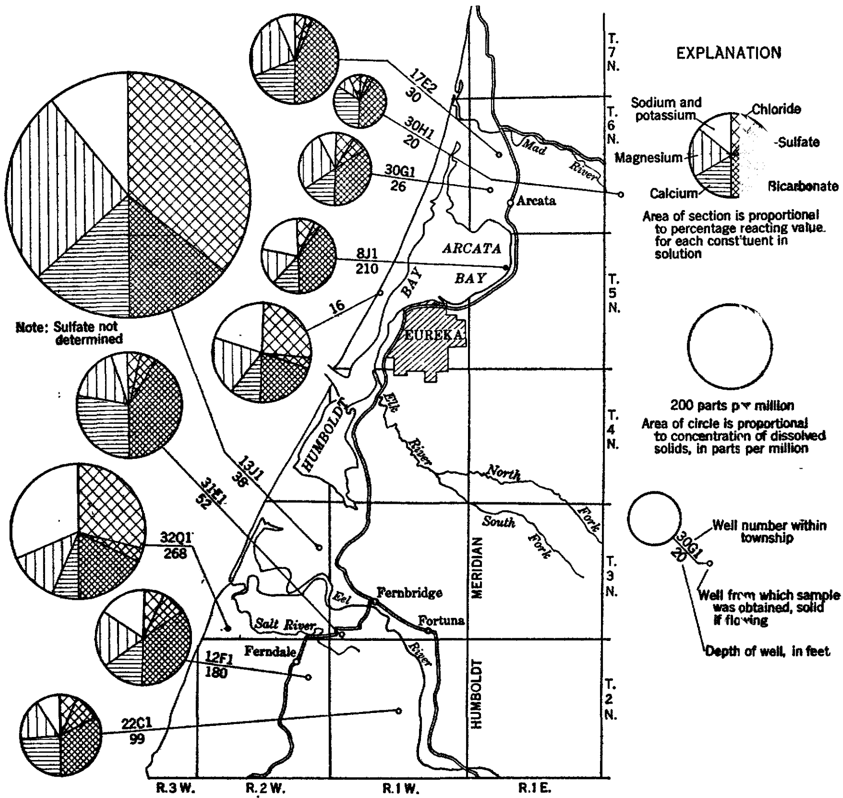


FIGURE 12.—Composition of representative ground waters from wells in the Eureka area, 1952.

Eureka area are of the calcium magnesium bicarbonate type [3] and are moderately hard. Near the estuary of the Eel River, sodium chloride water occurs in several wells (figs. 13 and 14). Moderate and, in places, heavy contamination with sodium chloride in these wells probably is due to the mixing of the saline water from the Eel River estuary and the adjacent ground water. Figures 13 and 14 show that there was an appreciable increase in chloride concentration at only 1 of 5 wells from August 1952 to August 1953. Well 3N/2W-27G1 showed an increase in chloride concentration from 765 ppm in August 1952 to 1,060 ppm in August 1953. The increase of chloride concen-

[3] Terms describing the general chemical character of a water are patterned after Piper and others (1953, p. 26), as in the following examples: (a) "calcium bicarbonate" designates a water in which calcium amounts to 50 percent or more of the bases and bicarbonate to 50 percent or more of the acids, in chemical equivalents; (b) "sodium calcium bicarbonate" designates a water in which sodium and calcium are first and second, respectively, in order of abundance among the bases but neither amounts to 50 percent of all the bases; and (c) "sodium sulfate bicarbonate" designates a water in which sulfate and bicarbonate are first and second in order of abundance among the acids, as above.

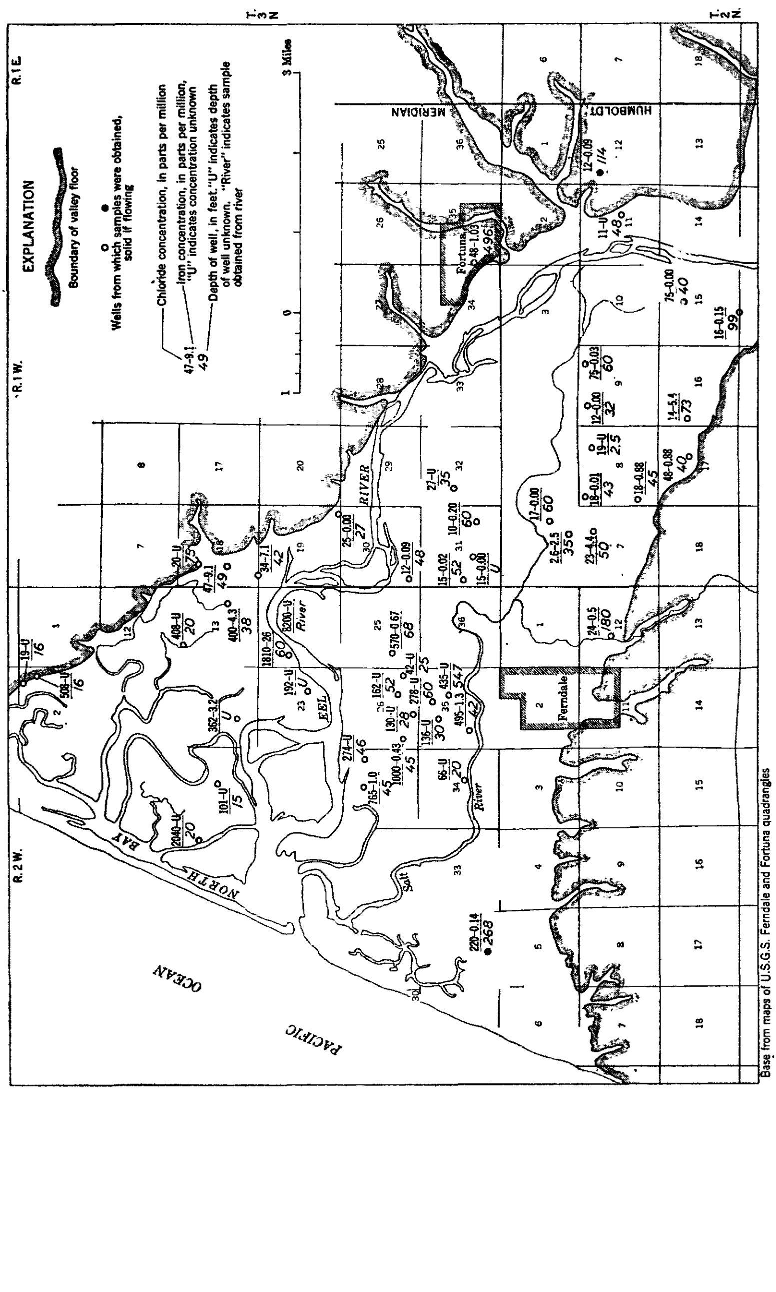
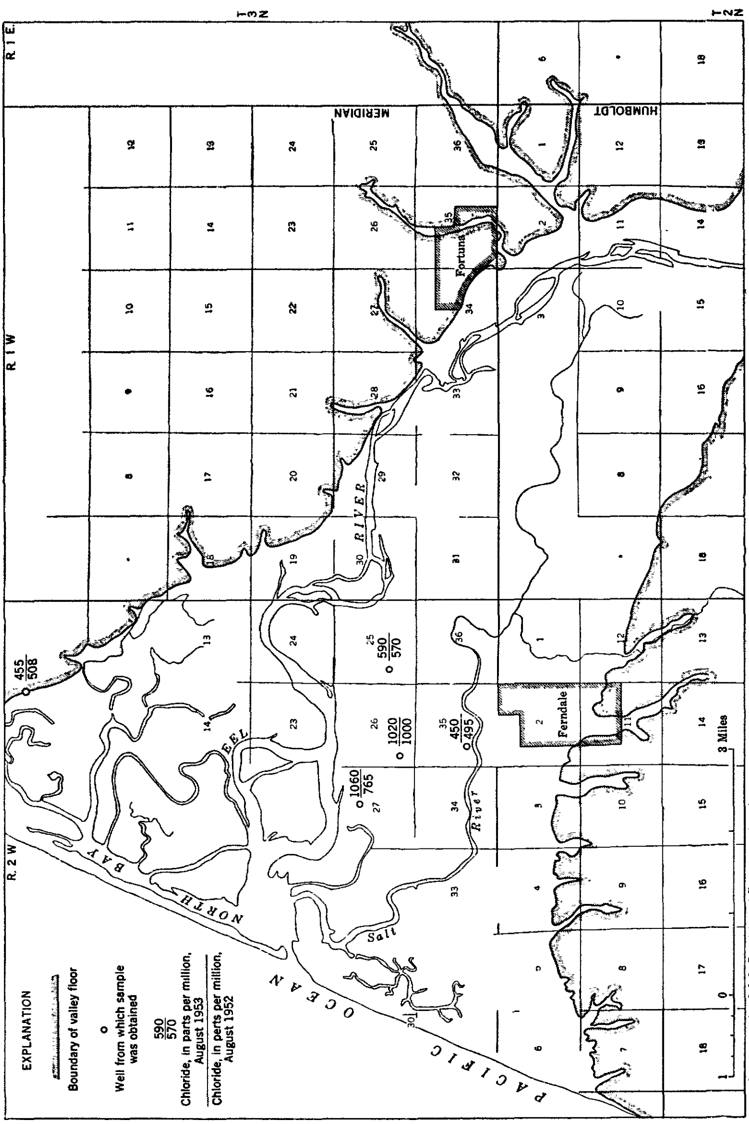


FIGURE 13.—Distribution of chloride and iron concentrations in the Eel River valley.



Base from maps of U.S.G.S Ferndale and Fortuna quadrangles

FIGURE 14.—Comparison of chloride concentrations in selected wells in the Eel River valley in August 1952 and August 1953.

tration may or may not be indicative of salt-water encroachment. Unknown factors, such as the local pattern of pumping, the static fresh-water head, the effect of tidal forces, and the duration of pumping prior to sampling, may have had an effect on the quality of water sampled. Additional periodic analyses would be necessary to determine whether salt-water encroachment is occurring.

Table 5 shows that iron occurs in undesirable quantities in many well waters throughout the area. Relatively high concentrations of manganese, which have a disagreeable effect similar to that of iron, occurred in some waters, but not all samples were analyzed for this constituent.

TABLE 5.—*Range in chemical character of ground water in the Eureka area, Humboldt County, Calif., 1951–53*

Area aquifer	Number of analyses [a]	Iron (ppm)	Chloride (ppm)	Hardness as $CaCO_3$ (ppm)	Specific conductance (micromhos at 25° C)	Dissolved solids (ppm)
Terrace deposits along Eel River south of confluence with Van Duzen River.	3	0.00– 0.01	20–?	159–179	404–410	[b] 230–?
Terrace deposits and alluvium along Van Duzen River.	2	.00–?	6–9	95–152	235–315	[b] 130–180
Alluvium of the Eel River Ferndale area.	34	.00– 5.4	7–1,060	144–840	341–3,670	[b] 190–2,100
Alluvium of the Eel River and terrace deposits, Fortuna area.	2	[c] .08–[b] 1.03	11–28	93–212	235	[b] 130
Loleta bottom, north of Eel River to Table Bluff.	10	.00–26	25–2,040	153–1,520	391–7,200	[b] 220–4,100
Carlotta formation of Ogle (1953).	5	.08– 1.03	12–240	87–290	231–1,080	[b] 130–600
Hookton formation of Ogle (1953).	9	.32– .94	11–508	32–445	132–1,830	[b] 74–1,000
Alluvium of the Mad River and terrace deposits near Arcata.[a]	25	.04– 6.5	9–26	83–206	214–443	[b] 120–250
Alluvium of the Mad River and terrace deposits near Blue Lake.	5	.02– .18	4–8	24–117	84–244	[b] 47–140
Dune sand near Samoa	3	.0 – .6	69–145	80–138	------------	235–291

[a] Excluding well 6N/1W–1P1.
[b] Approximated from specific conductance.
[c] Analyses from city of Fortuna Water Department.

RELATION TO THE GEOLOGY

Dune sand.—Even though the analyses of waters from the dune sand represent samples from a small area, it is reasonable to assume that these analyses are typical of the general chemical character of fresh water from wells in the North Spit. The water is of the sodium chloride type, and the 4 samples had chloride concentrations that ranged from 69 to 145 ppm. Iron concentrations in 3 of these samples ranged from 0 to 0.6 ppm. When water from a well in the North Spit becomes contaminated with sea water, the well is abandoned and a new one is constructed.

The sodium chloride in the water of the dune sand is due (a) largely to the diffusion of salt water across the interface between the fresh-water lens and the salt water and (b) also to the precipitation, which dissolves salts deposited by the ocean spray and subsequently percolates downward to the fresh-water lens.

Alluvium.—Analyses of ground waters from the alluvial deposits show that the waters are predominantly of the calcium magnesium bicarbonate type and have low chloride concentrations, usually less than 30 ppm. Iron concentrations vary widely from well to well and reach a maximum of 26 ppm in one well in the Loleta bottom.

In the Eel River valley, wells near the tidal reach of the river yielded predominantly sodium chloride waters in which chloride concentrations exceeded 400 ppm in 9 wells and 1,000 ppm in 3 wells. A water sample from the Eel River (September 30, 1952), collected about 4 miles from the mouth, contained 8,200 ppm of chloride, indicating that the tidal reach of the river is the principal source of contamination. Two wells at a considerable distance from the estuary (3N/2W–13J1 and 35M1) yielded magnesium chloride waters, whereas wells nearest to the estuary yielded sodium chloride waters. The magnesium chloride waters are probably the result of base-exchange reactions in which the sodium in the water from the estuary has been replaced by magnesium as the estuary water percolates through magnesium-rich alluvial sediments. Piper and others (1953, p. 87) state that in the Long Beach–Santa Ana area "base exchange reactions in the contaminated zones have substituted calcium (and locally some magnesium) for a large part of the sodium in the contaminating water."

In water samples from 25 wells in the alluvium of the Mad River near Arcata, chloride concentrations were less than about 30 ppm and dissolved solids were less than 250 ppm (table 5). The analysis of water from 1 well (6N/1W–1P1), which is on the lee of the dune sand and near the tidal reach of the Mad River, showed sodium chloride water containing 528 ppm of chloride. This analysis was not included in table 5 because no other sample in the vicinity showed a similar composition.

Terrace deposits.—Water from wells in the terrace deposits is of the same type as that from the alluvium (calcium magnesium bicarbonate). The concentration of iron in these deposits, however, is somewhat less than it is in the alluvium.

Hookton formation of Ogle (1953).—Water samples were obtained for analysis from three wells that penetrate the Hookton formation in the vicinity of Arcata Bay. These samples were classified in the following different types: calcium magnesium bicarbonate, sodium magnesium calcium bicarbonate, and sodium chloride. The chloride concentration in the sodium chloride water was 138 ppm and in the other two types less than 16 ppm. The iron concentration ranged from 0.32 to 0.94 ppm.

Carlotta formation of Ogle (1953).—Water from 2 wells in the Carlotta formation was of the magnesium calcium bicarbonate type

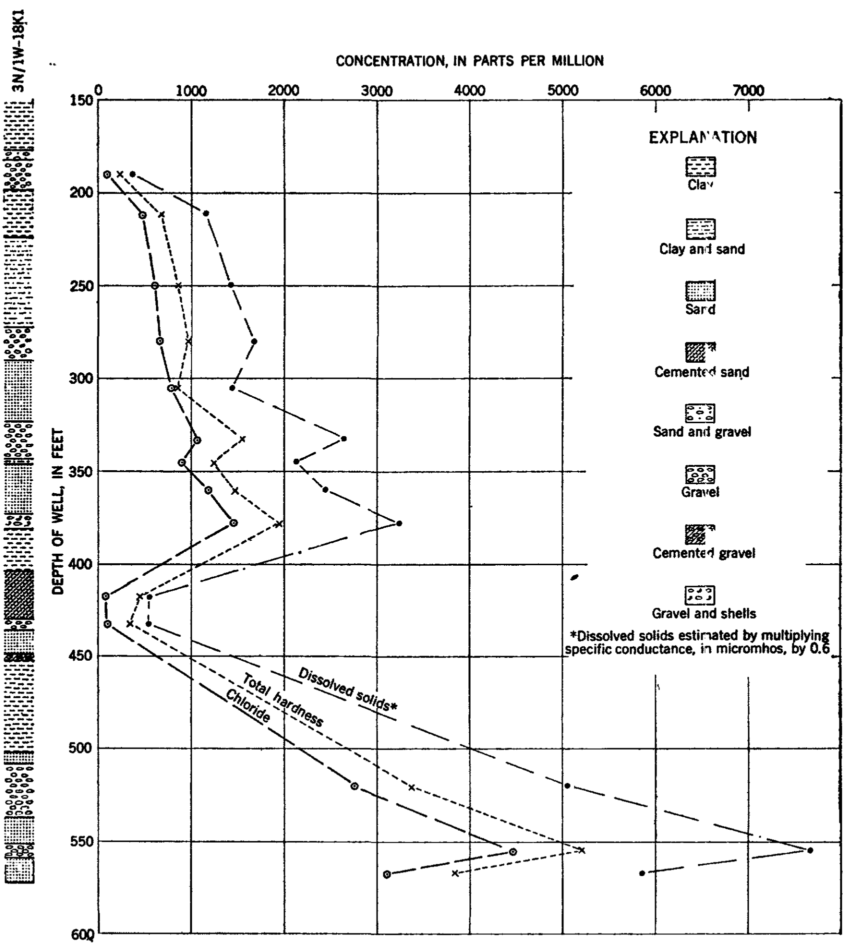


FIGURE 15.—Partial log and chemical character of ground water during drilling of well 3N/1W–18K1.

and from 2 flowing wells near the ocean, of the sodium chloride type. The 2 flowing wells (3N/2W–32N1, and 32Q1) yielded water having concentrations of chloride, 220 and 240 ppm; and iron, 0.08 and 0.14 ppm. The other 2 wells, on opposite sides of the Eel River valley, yielded water having concentrations of chloride, less than 24 ppm; and of iron, 0.51 and 0.09 ppm. A third well, in Fortuna, yielded water having concentrations of iron, 1.03 ppm; manganese, 1.24 ppm; and chloride, 48 ppm.

Figure 15, prepared from chemical and log data collected during the drilling of well 3N/1W–18K1, shows the distinctly different chemical quality of waters in various aquifers in the Carlotta formation. Chemical analyses of water samples taken from the bailer of a cable-tool drilling rig were made by a chemist for the Golden State Co.

Pre-Tertiary formations.—Wells were not available from which samples could be obtained for rocks older than the Carlotta formation of Ogle (1953). However, surface waters that drain the Yager formation of Ogle (1953) and the Franciscan formation are calcium bicarbonate waters, containing less than 170 ppm of dissolved solids and less than 12 ppm of chloride, whereas waters that drain the Tertiary or Tertiary and Jurassic formations are of the calcium magnesium bicarbonate type, containing as much as 480 ppm of dissolved solids and as much as 85 ppm of chloride.

TABLES OF BASIC DATA

TABLE 6.—*Descriptions of water wells in the Eureka area, Humboldt County, Calif.*

Altitude: Altitude given is land-surface datum, which is the plane of reference at the well, interpolated to the nearest 5 feet from topographic maps, except for the coastal plain where altitudes were determined by barometric traverses.
Depth of well: Depths shown to the nearest foot were reported by owners or obtained from drillers' logs; those given in feet and tenths were measured below land-surface datum by the Geological Survey.
Type of well: The type of well refers to the method of construction and, except where shown as "dug" (by hand), is indicated by symbols, as follows: D, drilled by rotary or cable-tool method; Dr, driven; and G, gravel packed.
Type of pump: The type of pump is indicated by symbols, as follows: C, centrifugal; T, deep-well turbine; Ts, submersible turbine; J, jet; and L, lift.

Horsepower: Only the horsepower of electric motors that drive the pumps is given.
Use of well: The use of wells is indicated by symbols, as follows: Irr, irrigation; Dom, domestic; S, stock; PS, public supply; Ind, industrial; O, observation for periodic water-level measurements (table 7); and Un, unused.
Remarks: The area irrigated, in acres (A), and the estimated water applied, in acre-inches (A-in.), are given for each well in 1952, where known; also shown are the reported yield, in gpm, and the feet of drawdown (ft/dd). Other symbols, C, chemical analysis in which five or more constituents were determined; Cp, partial chemical analysis in which less than five constituents were determined; and L, log, indicate that these data are shown in tables 8 to 11 or are in the files of the Geological Survey.

Well	Owner or user	Year completed	Altitude of land-surface datum (feet above sea level)	Depth of well (feet)	Type of well	Diameter of casing (inches)	Water-bearing material			Water level		Temperature of water (° F)	Pump		Use	Remarks
							Depth to top (feet)	Thickness (feet)	Geologic formation	Date measured	Depth below land-surface datum (feet)		Type	Horsepower		
								T. 2 N., R. 2 W.								
2N/2W-1A1	Manuel Toste	1952	29	52	D	12	20	32	Qal	8-19-52	[a] 28.68	54	C	30	Irr	70A
1B1	Earl Ambrosini	1942	30	56	D	14	------	------	------	8-21-52	[a] 23.20	------	T	10	Irr	54A, 15A-in.
1B2	Paul Peterson	1951	30	55	D	14	------	------	------	------	------	------	T	15	Irr	40A, 4A-in.
1H1	Otto Wright	1951	28	155	D	12	------	------	------	8-21-52	22.34	------	C	10	Irr	25A, 12A-in.
1Q1	Leo W. Coppini	1950	33	183	D	12	------	------	------	8-18-52	33.65	------	T	15	Irr	90A
4K1	A. Hansen	------	28	34.4	Dug	24	------	------	------	6- 8-51	20.30	------	J	½	Dom, S, O	
12F1	Terkelsen	1948	63	180	D	12	------	------	------	8-18-52 1948	60.31 35	58	T	15	Irr	200 gpm, C
								T. 2 N., R. 1 W.								
2N/1W-1C1	Lloyd Casacca	1949	70	100	D	12	------	------	------	1949	20	------	T	7½	Irr	30A
1D1	Joe Senaestraro	1949	65	56	D	14	30	26	Qal	8-26-52	[a] 30.76	------	T	7½	Irr	L, 35A, 9A-in.
1P1	George M. Woodcock	1951	120	143	D	12	------	------	QTwc	8-26-52	39.15	------	------	------	Un	L
1P2	do	1952	100	104	D	12	------	------	QTwc	8-26-52	20.51	------	T	20	Irr	L, 100A

1P3	E. L. Morris		100	85	D					8-26-52	20.67		T	10	Irr	26A
2C1	Star Hamilton	1948	45	39	D	12	30	9	Qtu	8-22-52	13.20		C	5	Irr	L, 15A
2D1	Cellsoe Pedrotti	1948	31	72	D				QTwc (?)	8-21-52	[a] 37.17		T	7½	Irr, S	L, 26A, 9A-in.
2E1	Tom Twohig	1947	37	35	D	14	15	20	Qal	8-22-52	[b] 19.73		C		Irr	280 gpm, L, 16A
2N1	Clay Brown & Co: Well 1	1950	40	60	D	14			do	8-22-52	21.86		T	30	Ind	L, 18A, pond 6 ft deep
2N2	Well 2	1949	42	60	D	14				8-22-52	23.24		T	25	Ind	
2N3	Clay Brown & Co.	1949	42	30	D	10				8-22-52	24.60		T	7½	Dom	
4D1	Alex Capaul	1948	31	48	D					8-12-52	21.57		T	7½	Irr	250 gpm, 28A
4F1	M. Nunes	1947	31	58	D	12				8-12-52	[a] 23.31		C	20	Irr	450 gpm, 100A
4G1	do	1949	32	40	D	12				8-12-52	20.97		C	15	Irr	70A
5A1	A. Leonardi	1949	28	45	D	24				8-13-52	21.45		T	15	Irr, Dom	350 gpm, 50A
5F1	Antone Martin		30	41	D					8-15-52	22.65		C		Irr	133A
5G1	J. Welker, Jr.	1950	33	45	D	12				8-13-52	[b] 24.85		T	10	Irr	40A
5G2	Herman Greve	1950	35	55	D	14	18	37	Qal	8-13-52	22.25		C	20	Irr	L, 70A
5H1	S. A. Scilacci	1924	30	48									C	10	Irr	25A
5M1	J. Losa		37		D	12				8-15-52	[a] 26.29		T	15	Irr	80A
5N1	E. Laffranchi	1945	29	45	D	14				8-18-52	[a] 22.43		C	25	Irr	600 gpm, 80A
5R1	J. Lourenzo	1926	35		Dug	16							C	20	Irr	450 gpm, 80A
6B1	A. Fisher	1949	20	52	D					8-15-52	17.20		C	25	Irr	82A
6C1	Dick H. Zweck	1937	23	50	D	12	2	48	Qal	8-15-52	19.08		T	10	Irr	40A
6F1	Louis Gabrielli		26	50	D	12	40	10	do	8-18-52	[a] 24.85		T	10	Irr	40A
6J1	John Saottini	1948	37	62	D	12	22	40	do	8-15-52	[a] 24.73	54	T	15	Irr	400 gpm, C, 69A
6J2	do	1930	37	60									T	7½	Un	
6Q1	L. F. Lucchini	1948	34	35	D	24				8-15-52	[a] 23.20	56	T	25	Irr	500+ gpm, C, 110A
7B1	Wilson Bros.	1950	30	50	D					8-15-52	22.31		T	25	Irr, Dom	450 gpm, 115A
7H1	James Belloni	1948	36	37	D	12				8-15-52	[a] 21.86		C	10	Irr	40A
7K1	Henry DaOro	1948	40	155	D	10	128	16	QTwc	4- -49	15		T	20	Irr	500 gpm, 25 ft/dd, L, 70A
7K2	do	1948	45	340	D	12				8-15-52	(g)				Un	2 gpm
8A1	J. Lourenzo		35	25	D										Dom	Cp
8B1	do		28	40	D	14				6- 9-51	19.41		T	15	Irr	400 gpm, 2 ft/dd, 80A
8C1	H. Giacomini	1945	30	48	D	14	18	30	Qal	8-18-52	19.18		C	15	Irr, Dom	75A
8D1	J. Belloni	1951	30	39	D	12				8-15-52	14.06		C	10	Irr	30A
8D2	L. Laffranchi	1951	35	43	D	12				8-15-52	19.78	55	C	7½	Irr	C, 20A
8E1	Harry Christensen	1949	34	55	D	14				8-15-52	21.19		T	15	Irr	60A
8M1	J. E. Barri	1949	37	45	D	14				8-18-52	[a] 25.03	54	T	25	Irr	C, 50A
9A1	Wm. Renner	1952	44	60	D	12	12	48	Qal	8-12-52	[a] 29.18	56	T	10	Irr	L, C, 35A
9C1	J. L. Silva	1943	38	32	D					8-12-52	[a] 26.19	54	T	10	Irr	C, 65A
9F1	do	1946	39	32	D					8-12-52	22.76		C	15	Irr	65A
9H1	Lougher Bros.	1951	38	55	D	12	11	44	Qal	8-12-52	23.64		C	25	Irr	500 gpm, 4.2 ft/dd, 140A
9K1	M. P. Jacobson	1947	36	28	Dug					8-12-52	18.85		C	10	Irr	250 gpm, 9 ft/dd, 42A
9L1	Wm. Christiansen	1947	39	48	D	14				8-12-52	[a] 27.05		T	10	Irr	350 gpm, 50A
9M1	David Hansen	1946	41	46	D					8-13-52	[a] 29.90		T	15	Irr	80A
9Q1	E. Valentino	1947	42	38	D	24				8-13-52	[a] 29.03		T	10	Irr	62A
9R1	H. J. Cuglielmina	1948	43	42	D	24	10	32	Qal	8-13-52	25.76		T	15	Irr	40A
10F1	J. J. Nunes	1920	30		Dug								C	15	Irr	450 gpm, 50A

See footnotes at end of table.

TABLE 6.—*Descriptions of water wells in the Eureka area, Humboldt County, Calif.*—Continued

Well	Owner or user	Year completed	Altitude of land-surface datum (feet above sea level)	Depth of well (feet)	Type of well	Diameter of casing (inches)	Water-bearing material: Depth to top (feet)	Water-bearing material: Thickness (feet)	Water-bearing material: Geologic formation	Water level: Date measured	Water level: Depth below land-surface datum (feet)	Temperature of water (° F)	Pump: Type	Pump: Horsepower	Use	Remarks
									T. 2 N., R. 1 W.—Continued							
2N/1W-10K1	J. Godinho, Jr.	1940	46	40	D	14				8-14-52	25.18		C	20	Irr	90A
10M1	George Pedrotti	1930	35	49										20	Irr	50A
11G1	City of Fortuna: Well 1.	1950	44	48	D	14				6- 8-51	[b] 22.75	55	C	40	PS, O	300 gpm, 2 ft/dd, Cp
11G2	Well 2	1947	38	56	D	14				6- 8-51	16.54		T	75	PS, O	300 gpm, 0.5 ft/dd
11G3	Well 4	1952	43	76	D	14	24	52	Qal	9-27-52 11-11-52	23.80 23.55				PS	700 gpm, 2 ft/dd, L
11K1	R. L. Thomas	1940	41	52	D									10	Irr	46A
11K2	Gene Senestraro	1949	48	59	D	12				8-11-52	25.75		T	15	Irr	42A
11R1	C. Crossland		46	36	D	14				8-11-52	23.14		C	5	Irr	260 gpm, 5A
12C1	Jess Miller	1949	110	150	D	8	140	7	QT wc	8-27-52 1949	[c] 32.03 (s)		J	2	Irr	L, 4A
12D1	Albert Johnston	1952	70	114	D		79	34	QTwc	8-26-52	(s)		T	20	Irr	500 gpm, 35 ft/dd, L, C, 80A
12D2	L. P. Connick	1951	100	190	D	10				9-19-52	8.83		J		Dom	L, stopped flowing in June
12D3	Moe		95	47	D	10				9-19-52	35				PS	
12P1	Thelma Wood		250	315	D	12	298	18	QTwc	9-27-48	25		T		PS	500 gpm, 30 ft/dd, L
12P2	do		250	225	D	12				8- 8-52	[c] 11.46				Un	
12P3	do		220	55	D	24				8- 8-52	27.85		T	1½	S	
14F1	Frank Sousa		43	39.6	D	14				8- 7-52	15.02		C	20	Irr	
14F2	Alex Beattie	1948	51	45	D, G	24				8- 8-52	[a] 27.66		T	5	Irr	8A
14K1	A. Spini & M. Ravo	1930	51	38	D	10				8- 8-52	26		C	15	Irr	
15A1	J. Berti	1947	48	45	D					8-14-52	[a] 29.55		C	15	Irr	40A
15C1	Lyle Taylor	1949	49		D	6				6- 9-51	26.7		J	½	Dom, O	Cp.
15C2	R. Regli	1948	53	45	D	24				8-14-52	[a] 33.07	53.5	T	15	Irr, Dom	C, 90A
15D1	J. F. Brazil	1945	53	54	D	14				8-14-52	29.82		T	10	Irr	30A
15E1	A. Albini	1948	45	36	D	24							T	10	Irr	50A
15G1	J. Berti	1947	51	40	D	14				8-14-52	[a] 31.00	54	T	20	Irr	C, 50A
15K1	Tony Marshall	1948	54		D					8-14-52	[a] 34.28		T	30	Irr	90A
15M1	Amato Dusina	1952	52	56	D					9-30-52	27.96		T	15	Irr	50A, 12A-in.
16B1	J. Rocha		44	34	D	24				8-14-52	21.68		T	7½	Irr	30A

16C1	Clark Anderson	1951	43	45	D	12				8-15-52	[a] 25.48		T	15	Irr	40A
16D1	Louis Terribini	1950	41	41	D					8-14-52	[a] 23.24		T	7½	Irr	20A
16E1	H. B. Harbers	1952	46	73	D	14	24	49	Qal	8-14-52	26.61	55	T	10	Irr	400 gpm, 11 ft/dd, L, C, 20A
16E2	do		45	63	D								L	Wind	Dom	Cp
16H1			45		D	14				8-14-52	[a] 29.73		T	10	Irr	
16J1	J. Webster	1946	51	46	D					8-14-52	[a] 32.04		T	10	Irr	40A
17C1	Carl I. Christensen	1947	30	32	D	12	16	14	Qal	8-15-52	16.95		T	7½	Irr	175 gpm, L, C, 30A
17G1	Charles Anderson	1930	40	40	D	12	0	40	do	8-15-52	25.62	52	J	5	Irr	200 gpm, L, C, 20A
17H1	Regli Bros	1944	40	32	D	26	0	32	do	8-15-52	23.27	55	T	10	Irr	500 gpm, 5 ft/dd, C, 60A
22C1	Jake Hawkins	1951	87	99	D	14	60	39	Qtu	8-14-52	56.90	54	T	30	Irr	500 gpm, L, C, 90A
22H1													T	15	Irr	
23B1	Walter Hansen		50		Dug								C	10	Irr	
23H1			50		Dug, D					8- 7-52	15.59		C		Irr	
23P1	F. W. Linser	1944	56	46	D	14				8- 7-52	29.97		C	15	Irr	800 gpm
24E1	H. G. Hiller	1945	55	48	D	16				8-11-52	[b] 18.23		T	20	Irr	70A
24G1	J. Giacomini		65		D	14				8-11-52	[a] 31.53		T	25	Irr	
24K1	Joe Sousa		55	29	D	24				8-11-52	[a] 13.20		C	20	Irr	
24R1	do	1952	58	39	D	12				8-11-52	[a] 16.08		C	10	Irr	
26C1	F. W. Linser	1916	52	57	D	14				8- 6-52	24.66		C	15	Irr	
26E1	Carl Renner	1942	60	53	D					8- 6-52	[a] 41.99		C	20	Irr	250 gpm
26L1	Van Harpen Lumber Co.		90		D	12				8- 6-52	[a] 49.0	58	T		Ind, Dom	C
26M1	Carl Renner	1932	60	41	D					8- 6-52	[a] 32.5		C	20	Irr	250 gpm
26Q1	Hunt		70	70	D									30	Irr	
35C1	John Cardoza		65	57	D	12	31	26	Qtu	8- 6-52	34.40		T	30	Irr	L
36F1	H. Bravo		70	45.5	D	23	0	50	do	8- 6-52	37.70				Un	L
36F2	Jensen	1950	70	56	D	12	50	6	do				T	10	Irr	250 gpm
36F3	do	1950	70	57	D	12	51	6	do				T	10	Irr	250 gpm
36H1	J. F. Voll	1952	80	60	D	10			do	8- 6-52	[a] 39.98	55	T	5	Ind, Dom	75 gpm, C

T. 2 N., R. 1 E.

2N/1E-16J1	D. N. Gould	1949	180	32.1	D, G	24			Qal	8- 7-52	[a] 24.73	54	T	20	Irr	600 gpm, 1 ft/dd, C
16J2	do	1916	180	33.5	D		30	10	do	8- 7-52	[a] 25.19		C	10	Irr	L
18R1	Tom Twohig	1951	360	360	D	10			QTwc	8-26-52	88.53		L		Dom	L
19K1	E. M. Genzoli	1950	70	48	Dug	D				8-11-52	[b] 18.22		C	10	Irr	9 ft/dd
19M1	J. Victoria, Jr	1927	75	42	D	14	0	42	Qal	8-11-52	[a] 19.83	55	T	20	Irr	1,400, C, open discharge
19R1	E. L. Fielden	1947	80	30	D		8	22	Qtu	8-11-52	16.60			10	Irr	400 gpm, 60A
21G1	Mantova	1933	120	49	D								T	7½	Irr	50A, 6A-in.
21K1	do	1931	120	51	D		11	40	Qal				T	7½	Irr	L, 50A, 6A-in.
22N1	Jake Matthiesen	1940	120	34	D								C	10	Irr	
22P1	Chase		125	54.6	D	12				8-27-52	8.97		C		Irr	
26D1	M. Machado		130	14.2	D	36				8-27-52	10.64		T	5	Irr	13A, 11A-in.
26K1			135	35.7	D	14				8-26-52	12.63		C	7½	Irr	
27C1	Jake Matthiesen	1946	115	31.6			6	34	Qal	8-26-52	[a] 9.10		C	20	Irr	3 ft/dd, 40A, 20A-in.

See footnotes at end of table.

TABLE 6.—*Descriptions of water wells in the Eureka area, Humboldt County, Calif.*—Continued

Well	Owner or user	Year completed	Altitude of land-surface datum (feet above sea level)	Depth of well (feet)	Type of well	Diameter of casing (inches)	Water-bearing material: Depth to top (feet)	Water-bearing material: Thickness (feet)	Water-bearing material: Geologic formation	Water level: Date measured	Water level: Depth below land-surface datum (feet)	Temperature of water (° F)	Pump: Type	Pump: Horsepower	Use	Remarks
T. 2 N., R. 1 E.—Continued																
2N/1E-27D1	Wiggin	1938	115	35	D	14				8-26-52	5.29		C	15	Irr	20A
29B1	Harville	1949	85	56	D	12	10	25	Qal	8-11-52	8.25		T	15	Irr	300 gpm, 12 ft/dd, L, 40A
30A1	D. W. Rakestraw		70	15	D	24				8-11-52	[b] 7.39	55	C	5	Irr	25A
30B1	do		70	30	D	14				8-11-52	[b] 7.02		C	5	Irr	25A
31F1	Silvio Mozzeti	1951	95	82	D	12	68	14	Qtu	9-15-52	[a] 61.00		Ts	15	Irr	150 gpm, L, 50A
31M1	J. J. Rovai		94												PS	Rio Dell
31M2	do		95												PS	Rio Dell
T. 3 N., R. 2 W.																
3N/2W-2A1	J. V. Toste, Jr.	1946	−2.5	19.3	D	8	18		Qh	6-8-51	[a] 5.78	56	C	7½	Irr, O	300 gpm, 9 ft/dd, Cp, L
2A2	do	1946	−2.0	16	D	8	16		Qh	6-8-51	[d] 1.41		C	5	Irr, O	185 gpm, 16 ft/dd, Cp, L
13D1	Andrew Flocchini		10		D	2½							L		S	Cp
13J1	E. Tanferani	1947	10	38	D	14	30	8	Qal	8-19-52	8.75	53	C	15	Irr	400 gpm, 7 ft/dd, L, C, 70A, 3A-in.
14L1	McClosky Ranch		5												S	C
15K1	Albert Pedrazzini		9	16	Dr	1½							L		Dom, S	Cp
16A1	W. P. Newhous	1951	5	11.1	Dug	36				8-4-52	5.73				Dom, S	
16H1	do		5	20	Dug	42				6-8-52	9.80				Un	Cp
23K1	Irven Thompsen	1948	10	30	D	22				8-19-52	12.37		C	(e)	Irr	20A
23K2	do		10		Dr	2							L		S	Cp
24E1	do	1950	10	60	D	12	44	16	Qal	8-19-52	[a] 18.56		C	25	Irr	C, L, 60A
25K1	Delmo Ambrosini & Son.	1946	20	49	D	14				8-20-52	16.45		T	20	Irr	95A, 16A-in.
25L1	do	1948	19	63	D	14	20	43	Qal	8-20-52	15.72		T	20	Irr	80A
25M1	Louis DeMello	1949	17	68	D	14				8-20-52	13.50		T	15	Irr	C, 80A, 9A-in.
25P1	Jack Halley	1951	20		D	14							T	10	Irr	40-60A
26G1			12	34.4	D	14				8-20-52	10.67		C	(e)	Irr	

3N/2W-26K1	John Byker	1952	15	52	D	14				8-21-52	[a] 15.58	54	C	10	Irr	Cp, 40A, 12A-in.
26L1	Dayton Titus	1947	8	38	D	14				8-21-52	10.40		C	25	Irr	80A, 9A-in.
26N1	Manuel G. Silva		11	45	D	12				8-21-52	[b] 9.83		T	15	Irr	C, 80A, 12A-in.
26P1	A. C. Enos	1946	14	28	D	14	11	17	Qal	8-20-52	11.75	53½	C	5	Irr	Cp, 2.2 ft/dd, 30A, 8A-in.
26R1	Ross Goble		12	29.6	D	14				6- 9-52	11.23		C	5	Irr, O	30A, 12A-in.
26R2	do		20	25	Dr	2							L		Dom, S	Cp
26R3	Pete Soatini	1947	11	25	D	20				8-21-52	[a] 13.53	54	C	7½	Irr	Cp, 30A, 8A-in.
27G1	P. M. Christiansen	1948	9	45.3	D	14				8-21-52	[a] 11.67	54	C	15	Irr	C, 100A, 10A-in.
27H1	Carl Lorenzen	1949	14	46	D	14				8-21-52	9.08	54	C	10	Irr	Cp, 60A, 9A-in.
32N1	Russ Connick: Well 2	1950	4	283	D	12	230	35	QTwc	9-30-52	(e)		T	25	Irr	1,200 gpm, 12 ft/dd, L, C
32Q1	Well 1	1950	5	268	D	12				9-30-52	(e)	54	T	25	Irr	1,200 gpm, 12 ft/dd, C
34K1	Boynton & Boynton	1942	12	20	D	14				8-21-52	12.55		J	1	Dom, S	Cp
34L1	Joe Mendes		11	75	D	4				8-21-52	9.10				Un	Seismic hole
35B1	Arthur L. Kercheval	1946	17	60	D	14	6	54	Qal	8-21-52	12.83		T	10	Irr	Cp, 40A, 10A-in.
35C1	A. C. Enos		12	30	D	24				8-20-52	12.39	54	T	20	Irr	Cp, 80A, 8A-in.
35G1	H. Bertelsen	1947	22	34	D	18				8-21-52	19.00	54	C	7½	Irr	Cp, 50A, 12A-in.
35H1	Francis Godinho	1948	19	32	D, G	18				8-22-52	14.87		C	5	Irr	24A, 12A-in.
35M1	P. C. Lorenzen	1947	13	42	D	14	30	12	Qal	8-22-52	[a] 20.77	54			Irr	650 gpm, 22 ft/dd, C, L, 80A, 9A-in.
36A1	Wm. Trutalli	1951	8	27	D	14	14	13	Qal	8-20-52	8.37		C	15	Irr	60A
36B1	Oscar Larsen		23	55	D	12	20	35	Qal	8-20-52	[a] 19.21		C	15	Irr, Dom	80A, 12A-in.
36D1	Tony M. Rocha	1951	17	50	D	14				8-20-52	13.06		C	20	Irr	60A, 9A-in.
36E1	J. N. Rocha	1947	20	30	D									10	Irr	40A
36F1	Tony M. Rocha	1951	22	30	D	12				8-20-52	[a] 18.50		C	10	Irr	40A
26G1	A. Tunzini	1947	27		D	14				8-20-52	[a] 22.00		T	7½	Irr	35A, 12A-in.
36J1	F. Rocha	1952	30	60	D	12	50	10	Qal				T	15	Irr	L, 60A
36K1			20	35	D	14				8-21-52	[a] 21.36		T	10	Irr	
36M1	Rocha & Rocha		26	37	D	24				8-22-52	[a] 23.99		T	7½	Irr	75A, 6A-in.
36R1	H. Anderson	1950	25	55	D	12				8-19-52	25.92		T	10	Irr	300 gpm, 20A

T. 3 N., R. 1 W.

3N/1W-7A1	Clough & Swain	1949	305	312	D	12							Ts	5	Irr	
17N1	Clarence Bertsch		150	56	D	12	31	22	Qh	9-27-52	[a] 35.42		T	5	PS	L
18D1	Orlen Christensen	1900	20	24	Dug	72				6- 8-52	3.07				Un, O	
18D2	do	1900	22	75	D	8				6- 8-52	[b] 8.00		J	1	Dom, S, O	Cp
18K1	Golden State Co. Ltd.: Well 5	1950	55	572	D	16			QTwc	9- -50	62		T	40	Ind	640 gpm, 132 ft/dd, L, C
18K2	Well 1		60	95	D	10					60	57	T		Ind	
18K3	Well 2	1952	60	173	D				Qh				T		Ind	260 gpm, L
18 [illegible]4	Golden State Co. Ltd.		30	147	D	14	64	27	Qh	[illegible]-28-52	65.86				Un	L
18M1	A. S. Tanferani		18	49	D	14				8-20-52	9.73	53	C	15	Irr	C, 40A
18N1	J. Genzoli	1950	19	42	D	12				8-19-52	[a] 16.50	53	T	15	Irr	300 gpm, C, 60A
19G1	Fred Bennett	1950	15	58	D	12				8-19-52	18.43		C	(f)	Irr	700 gpm, 40A
19R1	J. J. Hansen	1949	15	27	D	20					[a] 15.0	53	C	(f)	Irr	C, 40A

See footnotes at end of table.

TABLE 6.—*Descriptions of water wells in the Eureka area, Humboldt County, Calif.*—Continued

Well	Owner or user	Year completed	Altitude of land-surface datum (feet above sea level)	Depth of well (feet)	Type of well	Diameter of casing (inches)	Water-bearing material: Depth to top (feet)	Water-bearing material: Thickness (feet)	Water-bearing material: Geologic formation	Water level: Date measured	Water level: Depth below land-surface datum (feet)	Temperature of water (° F)	Pump: Type	Pump: Horsepower	Use	Remarks
T 3 N., R. 1 W.—Continued																
3N/1W-29F1	J. J. Hansen		25	28.5	D	36				8-27-52	[a] 22.26		C	15	Irr	60A
29G1	Humboldt Creamery Assoc.: Well 1.	1950	35	126	D	12			Qh				T	20	Ind	500 gpm, L
29G2	Well 2	1950	35	126	D	12			Qh				T	20	Ind	500 gpm
29N1	Bert Bonnikson	1922	20	30	D	18				8-13-52	15.35		C	10	Irr	5 ft/dd
29N2	J. J. Johnson	1930	16	40	D	14				8-18-52	[a] 18.00		T	15	Irr	60A
29P1	J. Lenardo	1952	25	42	D	12							T	10	Irr	28A
30N1	Fred Tedsen	1946	19	48	D	14	3	45	Qal	8-20-52	[a] 18.49	54	T	25	Irr, Dom	C, 60A, 9A-in.
30Q1	J. J. Johnson	1948	21	55	D	14				8-18-52	[a] 19.88	54	T	10	Irr	60A
31C1	Fred Tedsen		21		D	14				8-19-52	[a] 22.98		T	10	Irr	
31D1	Wm. Trutalli	1948	15	45	D	14				8-20-52	[a] 15.62		T	10	Irr	50A
31E1	do	1946	28	52	D	14	18	32	Qal	8-20-52	21.16	54	T	15	Irr	C, 70A, 9A-in.
31F1	Ralph Jacobsen		25	40	D	14				8-20-52	[a] 24.16		T	10	Irr	40A
31G1	Wendell Clausen	1948	20	55	D	14	15	40	Qal	8-18-52	19.35		T	15	Irr, Dom	90A
31H1	do	1930	25	40									C	10	Irr	25A
31J1	J. Godinho	1948	27	60	D	14	30	30	Qal	8-18-52	[a] 16.11	54	T	20	Irr	C, 90A
31L1	Otto Knaus		30		D					8-18-52	23.12	54	T	10	Irr	C, 40A
31P1	Ed Giacamini	1949	29	70	D	12				8-18-52	17.98		C	10	Irr	300 gpm, 40A
31Q1	Dick H. Zwick	1951	26	60	D	12				8-15-52	16.65		C	10	Irr	40A
32C1	Fred Bahnsen	1943	32	47	D					6-9-51	19.44		T	10	Irr, O	300 gpm, 2 ft/dd
32E1	Bert Bonnikson	1946	27	50	D					8-13-52	[b] 19.40		T	10	Irr	2.5 ft/dd, 100A
32F1	Fred Bahnsen	1943	30	35	D	8									Dom, S	Cp
32L1	C. Goble		30		D								T	20	Irr	65A
32M1	Fred Tedsen		22	35	D	24				8-20-52	15.10		T	10	Irr	40A, 16A-in.
32R1	J. Martin		31		D	14				8-12-52	25.35		T	20	Irr	80A
33E1	Emil Hansen		25	50									C	15	Irr	
33N1	E. Christensen		29	50	D					8-12-52	24.15		T	20	Irr	80A
34J1	City of Fortuna	1949	47	496	D	12			QTwc	6-8-51	34.29				Un, O	400 gpm, 72 ft/dd, L
34J2	do		25	25	D										Un	
34J3	Dr. Comfort		51	45	Dug	48				6-8-51	19.23		L	1	Dom	
35R1	Bruce McLeod	1942	55	60	D	14	45	15	Qtu	8-25-52	16.39		T	15	Irr	L, 18A, 15A-in.

T. 4 N., R. 1 W.

4N/1W-4A1	Pine Hill Trailer Court	1949	95	105	D	10	97	8	Qh				J	1	Dom	L
8J1	Dr. Stone	1950	40	360	D	12			QTwc	8-28-52	31.48		J	3	Dom	30 gpm, 20 ft/dd, L
8M1			45	55	D	12				8-27-52	[b] 32.38		J	3	Dom	
16A1	John H. Giacomini		10	160	D	14	130	8	Qh	8-25-52	1.23		T	10	Irr	L
T. 5 N., R. 1 W.																
5N/1W-16	Hammond Lumber Co.				Dr				Qs						Ind, PS	C; supply from numerous sand points connected to a central distribution system
28B1	P. G. & E. Station B		5		D										Un	L
28H1	City of Eureka	1927	8	56	D	36				4-29-53	7.15				Un	
28H2	do	1927	8	95	D	36				4-29-53	6.09		T	15	Un	For emergency supply
28H3	do	1927	8	102	D	36				4-29-53	6.15		T	15	Un	
28H4	do	1927	8	108	D	36				4-29-53	6.62				Un	
T. 5 N., R. 1 E.																
5N/1E-3N1	Carl May	1951	30	72	D	12	60	6	Qh	9-18-52	(e)			7½	S	L, 22A, insufficient for irrigation
3N2	do		23	21.5	Dug	48				9-18-52	3.60				Un	
4H1	A. C. Arnold	1951	30	19	Dug	24				6-7-52	12.08		J	½	Dom, O	Cp
4H2	V. Emerson	1952	125	65	D	8	50	15	Qh	9-17-52	50.40				Dom	L
8J1	Humboldt Dry Kiln	1952	5	210	D	8	154	56	Qh	8-5-52	(e)	60			Ind	30 gpm, 60 ft/dd, L, C
18Q1	Arcata Redwood Co.	1950	4	370	D	12	345	30	Qh	9-26-52	(e)				Ind, Dom	30 gpm, L
20Q1	L. L. Spinney	1949	22	157	D	8	146	11	Qh	6-7-51	(e)	54			Dom, S, O	L, Cp
30P1	P. G. & E	1952	164	83	D	8	50	20	Qh							L
T. 6 N., R. 1 W.																
6N/1W-1P1	Tom Bear	1947	10	13.9	D					9-11-52	6.81				Dom, S	C
12A1	R. L. Blankenship	1951	3	30	D	12	5	25	Qal	9-17-52	8.49		C	7½	Irr	200 gpm, L, 40A, 6A-in.
12C1	Tom Bear	1944	10	24.7	D	26				9-11-52	4.64				Un	400 gpm, 7 ft/dd
12F1	do	1951	10	6.3	D	12	6	24	Qal	9-11-52	3.10				S	L
26R1	Brightwood Lumber Co.	1949	3	165	D	10				9-8-52	[a] 0.07	55	C	3	Ind, Dom	C
36C1	Isaac Dias	1951	2	168	D	9	156	8	Qh?	9-24-52	(e)				Dom, S	L

See footnotes at end of table.

TABLE 6.—*Descriptions of water wells in the Eureka area, Humboldt County, Calif.*—Continued

Well	Owner or user	Year completed	Altitude of land-surface datum (feet above sea level)	Depth of well (feet)	Type of well	Diameter of casing (inches)	Water-bearing material: Depth to top (feet)	Water-bearing material: Thickness (feet)	Water-bearing material: Geologic formation	Water level: Date measured	Water level: Depth below land-surface datum (feet)	Temperature of water (° F)	Pump: Type	Pump: Horsepower	Use	Remarks
							T. 6 N., R. 1 E.									
6N/1E-6H1	Washington School		151	27.4	D	16				6- 7-51	8.46				Un, O	
6N1	R. L. Blankenship	1950	2	34.3	Dug	24				9-17-52	3.80		T	7½	Irr	450 gpm, 80A, 6A-in.
6N2	Blankenship & Baldwin.	1948	50	24.5	Dug	30				9-17-52	18.02		J	1	Dom, S	
7B1	Catherine M. Turner	1948	7	30	D	12				9-15-52	[a] 19.00	54	T	10	Irr	C
7E1	Earl Kjer		14	31	D	12				9-11-52	9.69		C	(f)	Irr	20A
7H1			11	17	D	24				9-12-52	[a] 13.63		C	7½	Irr	Cp
7J1	Joe E. Silva	1947	8	27.3	D	12				9-12-52	15.33	53	C	10	Irr, S	5 ft/dd, C, 60A
7K1	Ed Letter	1942	8	22.3	D	24				9-12-52	15.43		T	5	Irr, Dom	Cp, 30A, 36A-in.
7M1	Carl Spetz	1948	11	20	D	10				9-11-52	8.88		C	7½	Irr, Dom	250 gpm, C, 18A, 4A-in.
7Q1	Joe Bugenig	1947	20	90	D	12	72	18	Qal	9-11-52	[a] 32.51		T	10	Irr, Dom	250 gpm, 45 ft/dd, L, Cp, 30A, 6A-in.
8E1	H. Hunt Ranch		9	25.7	D	12				9-15-52	16.45		T	7½	Irr	
8L1	C. Clivelli		16	33.3	D					9-12-52	18.96		C	10	Irr	20A
8Q1	Wm. Tonini	1944	23	27.4	D	24				9-15-52	16.21		C	10	Irr	30A
13N1	Cannon Ball Lumber Co.	1949	80	70	D		14	2	Qtu				J		Ind	10 gpm, L
15C1			50	31.7	D	36				9-15-52	[b] 13.64		C	7½	Irr	
16E1	City of Arcata: Well 1		20	30											PS	
16E2	Well 2		20	40											PS	
16M1	N. T. Peugh		32	32.6	D	12	5	28	Qal	9-12-52	[a] 17.67		C	(e)	Irr, S	10A
16N1	do		27	30	D	12				9-12-52	[a] 11.46	54	C	10	Irr	C, 70A, 5A-in.
16P1					D										S	
17D1	Mrs. Iversen		16	45.7	D	12				9-11-52	[a] 21.57	52	C	15	Irr	Cp, 80A, 4A-in.
17E1	William Parton		18	24.7	D					9-10-52	11.50		J		Dom, S	
17E2	do	1952	18	30	D	12	14	16	Qal	9-29-52	13.68	53½	T	7½	Irr	400 gpm, 3.5 ft/dd, L, C
17K1	N. T. Peugh		21	18.7	D	12	0	18	do	9-17-52	6.98		C		Irr	
17N1	Chris. Strong		26	37.3	D					9-10-52	14.04	54	C	10	Irr	Cp, 46A, 18A-in.
17Q1	J. Ghisetti	1952	33	46	D					9-10-52	17.88		T	10	Irr	44A

18H1	Chester Hunt		16	24.3	D	14				9-11-52	6.51				Un, O	
18J1	do	1947	16	42.3	D	24				9-11-52	[a] 16.03	54	C	10	Irr, Dom	Cp, 85A, 6A-in.
18K1	Gerald Nicholson	1948	12	36.7	D	12	20	18	Qal	9-11-52	5.90		C	10	Irr, S	Cp, 30A, 3A-in.
18M1	Walter Lorenzen	1940	2	41	D	14				9-11-52	[b] 3.63	54	T	15	Irr	13.0 ft/dd, C, 50A, flood
18R1	E. E. Lancaster	1948	19	40	D	12	28	12	Qal	9-11-52	9.02		C	10	Irr	L, 45A, 8A-in.
19B1	Mrs. C. Iversen	1950	14	34.7	D	12				9-11-52	[b] 10.98		C	15	Irr	2.5 ft/dd, C
19B2	L. W. Siesser		16	37.3	D	12				9-10-52	[a] 10.44	54	C	10	Irr	
19D1			8	87.7	D	12				9-11-52	5.15		C	7½	Irr	
19H1	Matthew Martin		23	24.7	D	24				9-10-52	9.66		C	5	Irr, S	70A
19Q1	N. Holgersen	1950	19	108	D	8			Qal	6- 7-51	9.33		J	¼	Dom, S, O	L, Cp
20A1	J. Gallacci		33	29.7	D	20				9-17-52	[a] 23.37		T	5	Irr	
20C1	Janes School District		30	21.8	Dug	24				6- 7-51	11.53				PS, O	Cp
20C2	Tonini		30	40	D	18				9-10-52	14.15		C	10	Irr	
20D1	A. Christiansen	1941	27	23.7	D	24	12	12	Qal	9-10-52	11.93		C	5	Irr	15A
20J1	E. St. Louis	1948	30	25.7	D	24				9-12-52	14.65	54	C	7½	Irr	C, 20A
20L1	J. C. Souza	1943	28	22	Dug	48	2	20	Qal	9-10-52	13.81		C	10	Irr, Dom	Cp, 48A, 6A-in.
20L2	Mrs. Simes		26	17.4	Dug	48				9-10-52	10.65		T	5	Irr	15A
20M1	Fred Bullwinkeo	1943	24	24.3	D	24	17	8	Qal	9-10-52	[a] 14.86	55	T	5	Irr	2 ft/dd, L, Cp, 15A, 15A-in.
20Q1			30	23.6	Dug	48				9-10-52	10.39		C	7½	Irr, S	
23M1	E. Sullivan	1949	150	70	D	12				9-16-52	43.84		T	15	Irr	30A
24A1	Scotts Dairy	1910	55	13.7	Dug	30				9-17-52	4.84		J	¼	Dom, S	
24R1	do	1945	60	22.7	D	24				9-17-52	10.27		C	10	Irr	30A
25H1	J. R. Harris	1948	65	28.3	D	12	0	30	Qal	9-16-52	[b] 11.06	54	C	15	Irr	L, C, 70A, 7A-in.
29L1	R. Gilardoni	1942	17	24.7	D	24	7	18	do	9-12-52	[a] 14.56	55	C	10	Irr, S	500 gpm, C, 50A, 18A-in.
29N1			11	25	D	24				9- 9-52	8.05		C	5	Irr	
29P1	Golden State Co. Ltd.		15	46.1	D					6- 7-51	[a] 45.0		T	25	Ind	
30B1	Manuel Barcelles	1943	23	19	D	24	7	13	Qal	9- 9-52	[a] 12.58	54	T	7	Irr, Dom, S	2ft/dd, Cp, 46A
30E1	L. A. Moxon		9	22.6	D	12				9- 9-52	[a] 12.28		T	10	Irr	C
30F1	C. H. Moxon	1945	11	7.6	Dug	48				9- 9-52	3.82		C	5	Irr	40A
30G1	John Avila	1950	16	26	D	14	16	10	Qal	9- 9-52	11.41	54	C	7½	Irr	C, 30A
30H1	J. Gilardoni	1946	20	27	D	24				9-12-52	8.79		J		Dom	
30N1	Albert Simmons		12	37	D	14				6- 7-51	[a] 20.48		J	½	Dom, S, O	Cp
30R1	Fred Svinth Lumber Co.		14	40	D								T	40	Ind, Dom	
32B1	Pacific Fir Sales	1910	5	90.7	D	8				9-23-52	3.63		J	1½	Irr	
32F1	Arcata Plywood Co.	1951	3	640	D	10	605	35	Qh?	9-23-52	(g)	59			Ind	2 gpm, C
32F2	Durable Fir Lumber Co.	1951	3	75	D	12				9-23-52	11.44		T	30	Ind	500 gpm, 15A, 6-8 ft deep
32F3	do	1950	3	260	D						10.60				Un	
32G1	Humboldt Lumber Handlers.		3	130	D	10	113	17	Qal?				T	15	Ind	60 gpm, 0 ft/dd
33E1	Bill Moxom		10	17.3		48				9-18-52	4.57				Un	

See footnotes at end of table.

TABLE 6.—*Descriptions of water wells in the Eureka area, Humboldt County, Calif.*—Continued

Well	Owner or user	Year completed	Altitude of land-surface datum (feet above sea level)	Depth of well (feet)	Type of well	Diameter of casing (inches)	Water-bearing material			Water level		Temperature of water (° F)	Pump		Use	Remarks
							Depth to top (feet)	Thickness (feet)	Geologic formation	Date measured	Depth below land-surface datum (feet)		Type	Horsepower		
T. 6 N., R. 2 E.																
6N/2E-29E1	Domingo Silva			44.7	Dug	36				9-16-52	42.93	53	L		Dom	C
30B1	Broderick	1952		100	D	14				9-15-52	9.53		T	40	PS	Blue Lake water supply
30H1	Domingo Silva			19.5	Dug	24				9-16-52	[a] 14.48		C	10	Irr	300 gpm, C, 100A
30P1	J. L. Newhart			14	Dug	24				9-16-52	7.60		T	7½	Irr, Dom	50A
31C1	do	1948		86	D	12				9-16-52	[a] 19.5	55	C	20	Irr	C, 60A
32C1	A. Caprile	1946		25.3	Dug	48	5	20	Qal	9-16-52	[a] 21.79		C	5	Irr	C, 25A
T. 7 N., R. 1 E.																
7N/1E-8M1	Dr. S. M. Moose	1950	155	115	D	14	20	7	Qh				J		Dom	L
20L1	Dows Prairie Grange	1950	208	47.4	Dug	24				6-7-51	19.33		J		Dom, O	
31D1	J. W. Holt	1950	88	50	D	48	30	20	Qh	6-7-51	25.78		J	½	Dom	Cp

[a] Pumping.
[b] Pumped recently.
[c] Pumping nearby.
[d] Measurement, in feet, above land-surface datum.
[e] Tractor powered.
[f] Gas motor.
[g] Flowing.

TABLE 7.—*Periodic water-level measurements in wells in the Eureka area, Humboldt County, Calif.*

Water level: Water-level measurements are given in feet below or above (+) land-surface datum.

Source of records: Measurements from 1951 to 1954 were made by the Geological Survey; those in 1955 were made by the Bureau of Reclamation.

2N/2W-4K1. A. Hansen. About 1.75 miles west of Ferndale, 50 feet south of Centerville Road, 18 feet east of half-section fence. Domestic well; diameter, 24 inches; depth, 34 feet. Measuring point at top of casing on west side, 2.5 feet above land-surface datum, which is 28 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
June 8, 1951	20.30	Sept. 29, 1952	21.43	May 18, 1954	16.91
May 11, 1952	17.62	Nov. 11, 1952	21.37	Aug. 21, 1954	21.12
Aug. 4, 1952	20.93	Apr. 25, 1953	19.02	May 25, 1955	17.5
Sept. 5, 1952	21.35	Aug. 29, 1953	21.00	Aug. 24, 1955	21.2

2N/1W-8B1. J. Lourenzo. About 3 miles east of Ferndale, 10 feet west of board fence at rear of dwelling, 6 feet south of east-west wire fence. Irrigation well; diameter, 14 inches; depth, 40 feet. Measuring point at top of casing on north side, 1.0 foot above land-surface datum, which is 28 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
June 9, 1951	19.41	Sept. 29, 1952	23.59	May 18, 1954	16.69
May 11, 1952	16.83	Nov. 11, 1952	23.29	Aug. 21, 1954	24.01
Aug. 4, 1952	[a] 24.70	Apr. 25, 1953	16.34	May 25, 1955	18.0
Sept. 5, 1952	23.22	Aug. 28, 1953	23.91	Aug. 24, 1955	23.4

2N/1W-11G1 (City well 1). City of Fortuna. About 1.5 miles south of Fortuna, 110 feet east of Highway 101, in pump house. Public supply well; diameter, 14 inches; depth, 48 feet. Measuring point at plug in flange at top of casing, 12 feet below land-surface datum, which is 44 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
June 8, 1951	[b] 22.75	Sept. 27, 1952	24.40	May 19, 1954	21.51
Aug. 4, 1952	24.10	Nov. 11, 1952	[c] 24.11		

2N/1W-11G2 (City well 2). City of Fortuna. About 1.5 miles south of Fortuna, 190 feet east of Highway 101, 80 feet east and 60 feet south of 2N/1W-11G1. Public supply well; diameter, 14 inches; depth, 56 feet. Measuring point at hole in pump base on southeast side, 1.0 foot above land-surface datum, which is 38 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
June 8, 1951	16.54	Nov. 11, 1952	18.10	Aug. 21, 1954	23.50
Aug. 4, 1952	18.03	Apr. 26, 1953	[a] 17.23	Aug. 24, 1955	[a] 21.6
Sept. 27, 1952	[a] 19.6				

See footnotes at end of table.

TABLE 7.—*Periodic water-level measurements in wells in the Eureka area, Humboldt County, Calif.*—Continued

2N/1W–15C1. Lyle Taylor. About 4.5 miles east of Ferndale, 150 feet north of East Ferry Road, 100 feet east of Grizzly Bluff Road, 60 feet east of high hedge around school. Domestic well; diameter, 6 inches; depth unknown. Measuring point at top of casing on south side, 1.0 foot above land-surface datum, which is 49 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
June 9, 1951	26.7	Sept. 5, 1952	30.3	Apr. 25, 1953	23.66
May 11, 1952	23.86	Nov. 11, 1952	30.65	May 18, 1954	24.49

3N/2W–2A1. Joe V. Toste. About 3.5 miles northwest of Loleta, 0.24 mile west of Copenhagen Road, 200 feet south of eastward-trending fence. Irrigation well; diameter, 8 inches; depth, 19 feet. Measuring point at top of casing on south side, 1.5 feet above land-surface datum, which is 2.5 feet below sea level.

Date	Water level	Date	Water level	Date	Water level
June 8, 1951	[a] 5.78	Sept. 29, 1952	[c] +0.92	May 18, 1954	([f])
May 11, 1952	+1.45	Nov. 11, 1952	+1.15	Aug. 21, 1954	[a] 8.50
Aug. 4, 1952	[a] 6.56	Apr. 25, 1953	([f])	May 25, 1955	[b] 5.5
Sept. 5, 1952	[a] 8.04	Aug. 29, 1953	+.80	Aug. 24, 1955	[a] 6.46

3N/2W–2A2. J. V. Toste. About 3.5 miles northwest of Loleta, 0.15 mile west of Copenhagen Road, approximately 800 feet southeast of 3N/2W–2A1. Irrigation well; diameter, 6 inches; depth, 16 feet. Measuring point at top of casing on west side, 2.0 feet above land-surface datum, which is 2.0 feet below sea level.

Date	Water level	Date	Water level	Date	Water level
June 8, 1951	+1.41	Sept. 29, 1952	+1.09	May 18, 1954	([f])
May 11, 1952	([f])	Nov. 11, 1952	+1.30	Aug. 21, 1954	+0.90
Aug. 4, 1952	[a] 10.73	Apr. 25, 1953	([f])	May 25, 1955	[a] 8.4
Sept. 5, 1952	[a] 10.67	Aug. 29, 1953	+1.22	Aug. 24, 1955	[a] 10.14

3N/2W–16H1. W. P. Newhaus. About 4 miles west of Loleta, 0.23 mile north of Cannibal Island Road, 0.15 mile west of Senestraro Lane, 25 feet south and 10 feet west of southwest corner of dwelling. Unused well; diameter, 42 inches; depth, 20 feet. Measuring point at top of wood cover at land-surface datum, which is about 5 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
June 8, 1951	9.80	Aug. 4, 1952	4.45	Sept. 29, 1952	4.88
May 11, 1952	3.50	Sept. 5, 1952	4.70	Nov. 11, 1952	4.62

3N/2W–26R1. Ross Goble. About 1 mile north of Ferndale, 0.45 mile west of Fulmor Road, 425 feet north of Goble Lane, 25 feet west of north-south fence, 2 feet north of east-west fence. Irrigation well; diameter, 14 inches; depth, 30 feet. Measuring point at top edge of spoke on west side of wheel, used as pump support, at land-surface datum, which is 12 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
June 8, 1951	11.23	Sept. 29, 1952	12.43	May 18, 1954	9.74
May 11, 1952	9.94	Nov. 11, 1952	[a] 14.52	Aug. 21, 1954	12.34
Aug. 4, 1952	[a] 13.85	Apr. 25, 1953	9.47	May 25, 1955	8.5
Sept. 5, 1952	12.66	Aug. 29, 1953	12.23	Aug. 24, 1955	12.0

See footnotes at end of table.

TABLE 7.—*Periodic water-level measurements in wells in the Eureka area, Humboldt County, Calif.*—Continued

3N/1W-18D1. O. Christensen. About 0.5 mile northwest of Loleta, 75 feet southwest of Copenhagen Road, 35 feet southeast of Table Bluff Hill Road. Unused well; diameter, 72 inches; depth, 24 feet. Measuring point at top of brick curbing south side, 1.0 foot above land-surface datum, which is 20 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
June 8, 1951	3.07	Sept. 29, 1952	3.05	Aug. 20, 1954	3.00
May 11, 1952	2.1	Nov. 11, 1952	3.48	May 25, 1955	2.6
Aug. 4, 1952	2.52	Apr. 25, 1953	1.94	Aug. 23, 1955	3.1
Sept. 5, 1952	2.83	May 18, 1954	1.83		

3N/1W-18D2. O. Christensen. About 0.5 mile northwest of Loleta, 115 feet southeast of Table Bluff Hill Road, 60 feet southwest of Copenhagen Road, in southwest corner of garage part of long shed facing Copenhagen Road. Domestic well; diameter, 8 inches; depth, 75 feet. Measuring point at center top of wood casing cover, 1.5 feet above land-surface datum, which is 22 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
June 8, 1951	[a] 8.00	Sept. 29, 1952	8.84	Aug. 20, 1954	7.90
May 11, 1952	[a] 13.8	Nov. 11, 1952	8.72	May 25, 1955	[a] 14.7
Aug. 4, 1952	8.30	Apr. 25, 1953	7.51	Aug. 23, 1955	[a] 16.8
Sept. 5, 1952	8.74	May 18, 1954	[a] 14.62		

3N/1W-32C1. Fred Bahnsen. About 2.5 miles west of Fortuna, 130 feet north of Ferndale Road, 25 feet east of northward-trending fence. Irrigation well; diameter unknown; depth, 47 feet. Measuring point at hole in pump base on east side, 1.0 foot above land-surface datum, which is 32 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
June 9, 1951	19.44	Sept. 29, 1952	22.27	May 18, 1954	[a] 18.32
May 11, 1952	17.41	Nov. 11, 1952	22.04	Aug. 21, 1954	21.22
Aug. 4, 1952	[a] 20.37	Apr. 25, 1953	17.07	Aug. 23, 1955	19.0
Sept. 5, 1952	[a] 23.37	Aug. 29, 1953	[a] 22.53		

3N/1W-34J1. City of Fortuna. In Fortuna 70 feet east of 7th Street, 35 feet north of K Street, 10 feet south of large wood storage tank. Unused well; diameter, 12 inches; depth, 496 feet. Measuring point at ½-inch hole in casing cover, 1.0 foot above land-surface datum which is 47 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
June 8, 1951	34.29	Sept. 5, 1952	36.70	Apr. 26, 1953	32.82
May 11, 1952	32.66	Sept. 29, 1952	37.27	Aug. 29, 1953	35.70
Aug. 4, 1952	35.22	Nov. 8, 1952	37.45		

See footnotes at end of table.

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TABLE 7.—*Periodic water-level measurements in wells in the Eureka area, Humboldt County, Calif.*—Continued

5N/1E-4H1. A. C. Arnold. About 2 miles southeast of Arcata, 250 feet northwest of junction of Bayside golf course road and Old Arcata Road, 150 feet southwest of Old Arcata Road, 36 feet south of dwelling. Domestic well; diameter, 24 inches; depth, 19 feet. Measuring point at top of concrete curbing on north side, 1.0 foot above land-surface datum, which is 30 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
June 7, 1951	12.08	Sept. 29, 1952	11.48	May 18, 1954	[b] 13.85
May 10, 1952	10.05	Nov. 11, 1952	11.54	Aug. 20, 1954	13.78
Aug. 4, 1952	13.3	Apr. 27, 1953	7.85	May 25, 1955	11.6
Sept. 5, 1952	13.63	Aug. 28, 1953	11.85	Aug. 24, 1955	15.5

5N/1E-20Q1. L. L. Spinney. About 3 miles east of Eureka, approximately 400 feet northeast of dwelling, 200 feet west of Old Arcata Road, 125 feet north of access lane, in clump of Redwood trees. Domestic and stock well; diameter, 8 inches; depth, 157 feet. Observations made at end of ¾-inch discharge pipe in southeast end of milk barn. Altitude of land-surface datum at well is 22 feet above sea level.

June 7, 1951	([f])	Sept. 29, 1952	([f])	Aug. 20, 1954	([f])
May 10, 1952	([f])	Nov. 11, 1952	([f])	May 27, 1954	([f])
Aug. 4, 1952	([f])	Apr. 27, 1953	([f])	Aug. 24, 1954	([f])
Sept. 5, 1952	([f])	May 28, 1954	([f])		

6N/1E-6H1. Washington School. About 0.7 mile south of McKinleyville. 195 feet north of eastward-trending road, 185 feet west of Highway 101, in school yard 30 feet north of school building. Unused well; diameter, 16 inches; depth, 27 feet. Measuring point at top of casing on south side, 2.0 feet above land-surface datum, which is 151 feet above sea level.

June 7, 1951	8.46	Sept. 29, 1952	13.29	Aug. 20, 1954	12.46
May 10, 1952	3.60	Nov. 10, 1952	14.07	May 27, 1955	5.4
Aug. 5, 1952	10.46	Apr. 27, 1953	.80	Aug. 26, 1955	13.2
Sept. 6, 1952	12.13	May 18, 1954	5.45		

6N/1E-19Q1. N. Holgersen. About 1 mile northwest of Arcata, 0.25 mile north of Bay School, 0.10 mile west of road north from Bay School, 60 feet north of eastward-trending road. Domestic well; diameter, 8 inches; depth, 108 feet. Measuring point at top of casing on east side, 2.0 feet above land-surface datum, which is 19 feet above sea level.

June 7, 1951	9.33	Sept. 29, 1952	12.32	May 18, 1954	9.02
May 10, 1952	8.89	Nov. 11, 1952	11.61	Aug. 20, 1954	14.36
Aug. 5, 1952	10.40	Apr. 27, 1953	7.90	May 27, 1955	8.4
Sept. 6, 1952	11.56	Aug. 28, 1953	10.03	Aug. 26, 1955	12.8

See footnotes at end of table.

TABLE 7.—*Periodic water-level measurements in wells in the Eureka area, Humboldt County, Calif.*—Continued

6N/1E–20C1. Janes School. About 1 mile north of Arcata, 147 feet east of north-south road, 30 feet north of school house, 8 feet east and 6 feet north of northwest corner of tank house. Public supply well; diameter, 24 inches; depth, 22 feet. Measuring point at hole in center of concrete casing cover, 0.5 foot above land-surface datum, which is 30 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
June 7, 1951	11.53	Sept. 29, 1952	15.29	May 18, 1954	10.66
May 10, 1952	9.54	Nov. 10, 1952	15.52	Aug. 20, 1954	15.12
Aug. 5, 1952	13.67	Apr. 27, 1953	9.28	May 27, 1955	14.1
Sept. 6, 1952	14.95	Aug. 28, 1953	13.89		

6N/1E–29P1. Golden State Company, Ltd. In Arcata, 200 feet east of N Street, 120 feet south of 9th Street, 135 feet west and 75 feet south of southwest corner of plant building, at west side of parking area. Industrial well; depth, 46 feet. Measuring point at top of casing on east side, 2.0 feet above land-surface datum, which is 15 feet above sea level.

June 7, 1951	[a] 43.0	Sept. 29, 1952	18.37	May 18, 1954	21.99
May 10, 1952	20.85	Nov. 11, 1952	22.69	Aug. 20, 1954	23.19
Aug. 5, 1952	[c] 26.74	Apr. 27, 1953	[a] 29.40	May 27, 1955	13.6
Sept. 5, 1952	[d] 23.65	Aug. 28, 1953	27.95	Aug. 24, 1955	22.6

6N/1E–30N1. Albert Simmons. About 1 mile west of Arcata, 39 feet west and 21 feet northeast of northwest corner of tank house, at west side of pump house. Domestic and stock well; diameter, 14 inches; depth, 37 feet. Measuring point at top of casing on north side, 1.4 feet above land-surface datum, which is 12 feet above sea level.

June 7, 1951	[a] 20.48	Sept. 29, 1952	11.00	May 18, 1954	3.52
May 10, 1952	[a] 8.58	Nov. 11, 1952	12.21	Aug. 20, 1954	12.62
Aug. 5, 1952	8.22	Apr. 27, 1953	16.74	May 27, 1955	5.3
Sept. 6, 1952	7.46	Aug. 28, 1953	6.11	Aug. 24, 1955	8.2

7N/1E–20L1. Dows Prairie Grange. About 2 miles north of McKinleyville, 0.5 mile east of Dows Prairie School, 135 feet east of north-south road, 3 feet north of projected center line of east-west road, in northeast corner of Grange yard at north side of frame pump house. Domestic well; diameter, 24 inches; depth, 47 feet. Measuring point at top inside edge of concrete casing on east side, at land-surface datum, which is 208 feet above sea level.

June 7, 1951	19.33	Sept. 29, 1952	25.66	May 19, 1954	18.55
May 10, 1952	16.82	Nov. 10, 1952	25.41	Aug. 20, 1954	21.85
Aug. 5, 1952	20.96	Apr. 27, 1953	17.60	May 27, 1955	28.3
Sept. 6, 1952	22.95	Aug. 28, 1953	20.66	Aug. 26, 1955	27.4

See footnotes at end of table.

TABLE 7.—*Periodic water-level measurements in wells in the Eureka area, Humboldt County, Calif.*—Continued

7N/1E-31D1. J. W. Holt. About 1 mile northwest of McKinleyville, 0.50 mile west of McKinleyville Avenue, 85 feet south of West Murray Road, 15 feet east of Humboldt Meridian fence line. Domestic well; diameter, 48 inches; depth, 50 feet. Measuring point at top plank well cover on north side of pump column, 2.0 feet above land-surface datum, which is 88 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
June 7, 1951	25.78	Sept. 29, 1952	28.98	May 18, 1954	25.25
May 10, 1952	24.48	Nov. 10, 1952	29.90	Aug. 20, 1954	28.36
Aug. 5, 1952	27.53	Apr. 27, 1953	25.34	May 27, 1955	38.0
Sept. 6, 1952	28.37	Aug. 28, 1953	27.29	Aug. 26, 1955	40.4

[a] Pumping.
[b] Pumping recently.
[c] Pump gone.
[d] Pump installed.
[e] Pumping nearby.
[f] Flowing.

TABLE 8.—*Chemical analyses of ground water in the Eureka area, Humboldt County, Calif.*

[Analyses by U. S. Geological Survey, except as indicated.]

Well	Date	Depth (feet)	Temperature (° F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Sum of determined constituents	Hardness as $CaCO_3$: Total	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25° C)	pH
								Parts per million													
Water from aquifers in dune sand																					
5N/1W-16-2 [a b]	10-30-51				0.0	9.2	14	45		70	9.6	69	0.0	[c] 0.5		235	80.5				7.9
16-3 [a b]	10-30-51				.4	14	20	53		88	7.7	94	.0	[c] .2		296	114.5				7.3
16-6 [a d]	10-30-51				.60	18	22	41		107	8.6	77	.0	[c] .1		291	138				8.1
16 [e f]	6- 1-51										32	145					116				7.2
Water from aquifers in alluvium																					
2N/1W-6J2	8-15-52	60	54		0.00	32	29	14	2.0	212		17			0.02		199	25	13	423	6.9
6Q1	8-15-52	35	56		2.5	22	25	21	1.2	188		26			.0		158	4	22	380	7.4
7B1 [g]	2- 1-51	50		17	[h] 4.4	26	26	7.7		189	0.8	23			.03	204	173				6.7
8D2	8-15-52	43	55		.01	31	27	15	2.0	200		18			.02		188	24	15	415	7.1
8M1	8-18-52	45	54		.96	18	22	15	1.5	156		18			.00		135	8	19	325	7.4
9A1	8-12-52	60	56		.03	36	14	11	1.3	164		7.5			.07		147	13	14	318	8.1
9C1	8-12-52	32	54		.00	57	20	13	1.3	240		12			.05		224	28	11	459	7.5
15C2	8-14-52	45	54		.00	58	17	9.2	1.3	234		7.0			.03		215	23	8	415	8.2
15G1	8-14-52	40	54		.00	59	17	9.6	1.3	234		7.5			.07		217	25	9	437	7.5
16E1	8-14-52	73	55		5.4	40	18	16	1.7	202		14			.02		174	8	17	386	7.7
17C1	8-15-52	32			.24	26	24	25	2.5	206		18			.03		164		25	413	7.1
17G1	8-15-52	40	52		.88	31	31	41	3.1	220		48			.04		205	24	30	560	6.9
17H1	8-15-52	32	55		.38	36	34	29	2.7	258		23			.04		230	18	21	559	7.0
2N/1E-13J1	3- 7-52	32.1	54		.00	5.2	20	12	1.0	118		9.0			.15		95		21	235	6.9
19M1	8-11-52	42	55		.00	47	8.4	9.2	1.0	176		6.0			.02		152	8	12	315	7.8
3N/2W-13J1	8-19-52	38	53		4.3	80	99	79	3.7	284		400			.02		606	374	22	1,590	7.3
14L1 [g]	9-22-50			18	[h] 3.2	33	40	326		485	44	362			.9	1,090	250				7.1
24E1	8-19-52	60			26	192	254	712	8.0	510		1,810			.08		1,520	1,110	50	5,880	7.4
25M1	8-20-52	68	53		.67	65	70	250	1.5	196		570			.06		450	290	55	2,150	8.3

See footnotes at end of table.

TABLE 8.—*Chemical analyses of ground water in the Eureka area, Humboldt County, Calif.*—Continued

[Analyses by U. S. Geological Survey, except as indicated.]

Well	Date	Depth (feet)	Temperature (° F)	Parts per million: Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Sum of determined constituents	Hardness as $CaCO_3$: Total	Noncarbonate	Percent sodium	Specific conductance (micromhos at 25° C)	pH
Water from aquifers in alluvium—Continued																					
3N/2W-26N1	8-21-52	45	—	—	.43	107	125	418	6.0	278	—	1,000	—	—	.06	—	781	553	54	3,520	8.1
27G1	8-21-52	45.3	54	—	1.0	78	120	295	15	284	—	765	—	—	.08	—	688	456	48	2,840	8.3
35M1	8-22-52	42	54	—	1.3	87	108	113	16	232	—	495	—	—	.04	—	661	471	28	1,940	7.5
3N/1W-18M1	8-20-52	49	53	—	9.1	30	40	23	1.5	238	—	47	—	—	.00	—	240	28	17	526	8.4
18N1	8-19-52	42	53	—	7.1	20	25	21	1.5	164	—	34	—	—	.01	—	153	18	23	391	7.1
19R1	8-27-52	27	53	—	.00	42	31	13	2.1	228	—	25	—	—	.04	—	232	46	11	478	8.0
30N1	8-20-52	48	54	—	.09	42	28	10	1.5	228	—	12	—	—	.04	—	220	33	9	434	8.2
—	8-21-54	48	62	17	.01	62	25	7.8	1.5	275	22	12	0.1	0.8	.06	291	256	30	6	501	8.0
31E1	9-25-52	52	54	15	.02	65	28	12	1.9	294	24	15	.0	11	.46	317	277	36	9	546	7.4
31J1	8-18-52	60	54	—	.20	53	26	11	1.2	274	—	10	—	—	.05	—	239	14	9	453	8.0
31L1	8-18-52	—	54	—	.00	64	27	12	1.3	294	—	15	—	—	.03	—	270	30	9	506	7.6
6N/1W-1P1	9-11-52	13.9	—	—	.08	22	18	442	54	318	—	528	—	—	.48	—	129	—	83	2,400	7.6
6N/1E-7B1	9-15-52	30	54	—	.03	21	9.1	16	1.3	98	—	26	—	—	.05	—	90	10	28	253	7.3
7J1	9-12-52	27.3	53	—	.05	54	19	10	5.9	240	—	16	—	—	.07	—	213	16	9	454	7.6
7M1	9-11-52	20	—	—	3.6	39	25	16	2.2	250	—	19	—	—	.11	—	200	—	15	436	7.2
—	8-20-54	20	—	17	.005	48	28	14	1.8	285	7.7	18	.2	.0	.11	275	234	0	11	479	7.7
16N1	9-15-52	30	54	—	.08	35	17	7.4	1.8	168	—	10	—	—	.05	—	157	20	9	327	7.6
17E2	9-29-52	30	54	35	6.5	34	25	11	1.4	226	4.4	12	.0	.6	.18	241	188	2	11	384	7.1
18M1	9-11-52	41	54	—	1.4	48	21	10	1.1	250	—	13	—	—	.06	—	206	1	9	419	7.7
19B1	9-10-52	34.7	—	—	3.5	23	17	9.4	1.1	152	—	13	—	—	.02	—	127	3	14	276	7.8
20J1	9-12-52	25.7	54	—	.52	12	13	12	.8	86	—	17	—	—	.03	—	83	13	24	219	7.1
25H1	9-16-52	28.3	54	—	.04	15	8.0	9.4	1.2	82	—	7.0	—	—	.03	—	70	3	22	168	7.5
29L1	9-12-52	24.7	55	—	3.6	18	16	11	1.1	116	—	13	—	—	.04	—	111	16	18	259	6.8
30E1	9-8-52	22.6	—	—	6.4	19	19	11	1.5	120	—	13	—	—	.03	—	126	27	16	287	7.6
30G1	9-25-52	26	54	24	.10	18	18	7.8	1.0	120	18	15	.3	.1	.07	161	119	21	12	271	7.2
30N1	8-20-54	—	60	45	.40	47	15	8.8	1.6	214	.2	12	.3	5.3	.18	240	178	3	10	361	7.3

6N/2E-29E1	9-16-52	44.7	53		.18	4.4	3.2	5.8	3.8	18		8.0			.02		24	9	30	84.7	6.3
30H1	9-16-52	19.5			.05	20	2.4	5.0	.9	74		4.0			.02		60		15	140	7.8
31C1	9-16-52	86	55		.02	37	5.9	5.8	1.2	132		4.0			.06		117	8	10	244	7.9
32C1	9-16-52	25.3			.15	28	4.9	5.4	1.4	98		5.0			.03		90	10	11	184	7.8
Water from aquifers in terrace deposits																					
2N/1W-22C1	9-30-52	99	54	19	0.15	33	15	14	1.6	154	28	16	0.1	2.0	0.06	205	144	18	17	341	7.3
26L1	8-6-52		58		.01	37	21	19	1.1	220		20			.07		179		19	404	8.4
36H1	8-6-52	60	55		.00	44	12	28	1.6	208		20			.05		159		27	410	7.0
Water from aquifers probably in the Hookton formation of Ogle (1953)																					
3N/2W-2A2	8-21-54	16	57	18	0.02	54	55	135	2.0	54	25	418	0.1	5.2	0.01	739	361	317	45	1,520	7.1
3N/1W-18D2	8-21-54	75		30	.005	5.2	8.9	14	.6	67	2.3	16	.2	1.4	.05	112	49	0	38	163	7.6
5N/1E -8J1	8-5-52	210	60		.32	15	12	29	1.5	154		16			.01		87		42	273	8.2
6N/1W-26R1	9-8-52	165	55		.54	60	15	14	2.0	268		11			.06		211		12	446	7.8
6N/1E -32F1	9-29-52	640	59		.94	15	15	159	8.5	210		138			.47		99		76	761	8.0
Water from aquifers probably in the Carlotta formation of Ogle (1953)																					
2N/2W-12F1	9-27-52	180	58	25	0.51	25	26	38	5.4	214	42	24	0.1	0.2	0.26	292	170		32	490	7.7
2N/1W-12D1	8-27-52	114			.09	15	12	20	.9	122		12			.00		87		33	231	8.0
3N/2W-32N1 [i]	7-17-50	283		17	.08	31	32	[j] 151		212	23	240		2.2		636	210				7
32Q1	9-30-52	268	54	24	.14	28	30	146	4.4	226	22	220	.3	.0	.08	586	194	8	62	1,080	7.4
3N/1W-34J1 [i k]	9-17-50	496			1.03							48					290			696	7.3

[a] Analyzed by California State Department of Public Health.
[b] Contains 0.0 ppm manganese.
[c] Reported as nitrogen.
[d] Contains 0.08 ppm manganese.
[e] Analyzed by Pacific Engineering Laboratory.
[f] Composite sample from drive-point wells; contains 40 ppm phosphate.
[g] Twining Laboratories, Fresno.
[h] Includes aluminum.
[i] Analyzed by Brown and Caldwell.
[j] Includes potassium.
[k] Contains 1.24 ppm manganese.

TABLE 9.—*Partial chemical analyses of ground water in the Eureka area, Humboldt County, Calif.*

[Analyses by Quality of Water Branch, U. S. Geological Survey.]

Well	Aquifer [a]	Date	Depth (feet)	Temperature (° F)	Parts per million		Specific conductance (micromhos at 25°C)	pH
					Chloride (Cl)	Total hardness as $CaCO_3$		
2N/1W-8A1	Qal	6- 9-51	25		19	211	439	
11G1	Qal	6- 8-51	48	55	11	93	235	
15C1	Qal	6- 9-51			12	205	424	
16E2	Qal	9-11-52	63		16		384	8.5
3N/2W-2A1	Qh	6- 8-51	18	56	19	32	132	
2A2	Qh	6- 8-51	16		508	445	1,830	
		8-29-53			455	385	1,560	
13D1	Qal	6- 8-51	20		408	310	1,530	
15K1	Qal	6- 8-51	16		101	258	809	
16H1	Qal	6- 8-51	20		2,040	880	7,200	
23K2	Qal	8-19-52			192		1,160	8.2
25M1	Qal	8-29-53			590	555	2,290	
26K1	Qal	8-21-52	52	54	162		902	7.3
26N1	Qal	8-29-53			1,020	750	3,610	
26P1	Qal	8-20-52	28	54	130		778	8.6
26R2	Qal	6- 9-51	25		86	260	733	
26R3	Qal	8-21-52	25	54	142		803	8.3
27G1	Qal	8-29-53			1,060	840	3,670	
27H1	Qal	8-22-52	46	54	274		1,280	8.5
34K1	Qal	8-21-52	20.0		66		606	7.9
35B1	Qal	8-21-52	60		278		1,210	8.3
35C1	Qal	8-20-52	30.0	54	136		820	8.2
35G1	Qal	8-22-52	34	54	435		1,930	7.2
35M1	Qal	8-29-53			450	615	1,760	
3N/1W-18D2	Qh	6- 8-51	75		20	42	169	
32F1	Qal	6- 9-51	35		27	264	616	
34J2 [b]	Qal	6-17-31	25		28	212		
5N/1E-4H1	Qtu	6- 7-51	19.0		11	78	194	
20Q1	Qh	6- 7-51	157	54	28	82	271	
6N/1E-7H1	Qal	9-12-52	17.0		14		373	7.5
7K1	Qal	9-12-52	22.3		10		382	7.4
7Q1	Qal	9-11-52	90		9.0		443	7.2
17D1	Qal	9-11-52	45.7	52	12		383	7.1
17N1	Qal	9-10-52	37.3	54	11		294	7.2
18J1	Qal	9-11-52	42.3	54	12		412	7.8
18K1	Qal	9-11-52	36.7		10		374	8.1
19Q1	Qal	6- 7-51	110		15	130	398	
20C1	Qal	6- 7-51	21.8		10	88	214	
20L1	Qal	9-10-52	22.0		12		252	7.1
6N/1W-20M1	Qal	9-10-52	24.3	55	9.0		246	7.4
30B1	Qal	9- 9-52	19.0	54	20		285	7.7
30N1	Qal	6- 7-51	37.0		13	155	356	
7N/1E-31D1	Qh	6- 7-51	50		34	47	213	

[a] See table 1 for aquifer description and symbol.
[b] Analyzed by Brown and Caldwell.

Table 10.—*Chemical analyses of surface water in the Eureka area, Humboldt County, Calif.*

[Analyses by Quality of Water Branch, U. S. Geological Survey]

Location [a]	Stream name	Date collected	Temperature (°F)	Parts per million: Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Sum of determined constituents	Hardness as $CaCO_3$: Total	Noncarbonate	Percent sodium	Specific conductance (micromhos at 25°C)	pH
1N/1E-5N	Eel River	10-20-52	60	8.9	37	10	12	1.5	158	11	9.0	0.1	0.8	0.05	168	133	4	16	291	7.8
		4-28-53	----	11	15	3.2	4.0	1.7	61	5.1	2.5	.5	.7	.09	74	51	1	14	113	7.4
1N/3E-14A	Van Duzen River	10-19-52	59.5	8.5	29	7.3	8.2	0.7	115	13	6.2	.0	1.4	.07	131	102	8	15	223	7.9
2N/2W-4M	Russ Creek	10-20-52	54	20	56	50	41	6.8	311	91	56	.3	1.2	.02	476	345	90	20	804	7.4
12L	Williams Creek	10-20-52	54	19	28	26	24	3.4	203	13	34	.2	1.4	.00	249	177	10	22	433	7.4
2N/1W-27H	Price Creek	10-20-52	58	8.8	60	13	41	2.6	196	58	49	.2	.6	.23	330	203	42	30	571	7.8
23Q	Van Duzen River	10-20-52	58	10	40	10	9.2	1.0	161	14	9.0	.1	.6	.00	173	141	9	12	299	7.8
		4-26-53	----	14	19	4.6	5.0	.9	78	7.2	4.0	.1	.1	.06	93	66	2	14	146	7.7
2N/1E-10H	Yager Creek	10-20-52	59	9.6	37	7.3	12	1.3	146	12	12	.1	.6	.02	164	122	3	17	282	8.0
3N/2W-24C	Eel River	9-30-52	59	----	----	----	----	----	159	----	8,200	----	----	----	----	----	----	----	23,500	7.6
3N/1W-9F	Salmon Creek	10-20-52	53	12	28	18	50	4.2	144	17	85	.2	1.3	.37	287	144	26	26	538	7.4
9P	Little Salmon Creek	10-20-52	54	19	9.9	14	16	4.4	97	2.6	22	.1	4.1	.00	140	82	3	28	235	7.0
4N/1W-26E	Elk River	10-21-52	49	16	11	9.7	22	2.3	77	9.1	29	.1	1.8	.03	139	67	4	40	236	7.1
4N/1E-4A	Freshwater Creek	10-21-52	51	11	19	12	18	2.1	114	15	16	.1	1.1	.03	150	97	3	28	256	7.3
5N/1E-10H	Jacoby Creek	10-21-52	54	14	21	11	10	1.4	112	8.7	11	.1	.5	.00	133	98	6	18	224	7.5
6N/1E-7D	Mad River	9-29-52	62	----	----	----	----	----	115	----	170	----	----	----	----	----	----	----	798	8.2
14K	Lindsay Creek	10-21-52	52	16	3.0	2.8	7.4	1.1	26	1.4	8.5	.1	1.5	.04	55	19	0	44	78.4	7.4
16A	Mad River	10-21-52	58	10	31	5.0	6.1	1.3	115	8.0	5.5	0	.3	.26	124	98	4	12	213	7.4
		4-29-53	----	8.9	13	1.9	3.4	1.3	46	5.5	3.0	.3	.3	.17	60	40	3	15	91.3	7.4
6N/2E-28A	N. Fork Mad River	10-21-52	53	6.3	17	4.7	6.1	1.3	73	6.6	5.0	0	.3	.02	83	62	2	17	146	7.6
31R	Mad River	10-21-52	62	10	37	7.0	7.4	1.1	136	19	5.2	0	.7	.07	154	121	10	12	265	8.0

[a] Number indicates nearest 40-acre location of sampling point, on same basis as well location numbers.

TABLE 11.—*Selected drillers' logs of wells in the Eureka area, Humboldt County, Calif.*

[Correlations of the deposits by R. E. Evenson, U. S. Geological Survey]

2N/1W-22C1. Herb Russ. Drilled by Barnes Tractor and Equipment Co. Altitude, 87 feet.

Material	Thickness (feet)	Depth (feet)
Quaternary (Recent and Pleistocene):		
Terrace deposits:		
Soil	6	6
Sand	12	18
Hillside gravel	42	60
Water gravel	39	99

2N/1E-16J2. D. N. Gould. Altitude, 180 feet.

Material	Thickness (feet)	Depth (feet)
Quaternary (Recent):		
Alluvium:		
Soil	30	30
Rock and gravel (boulders at bottom larger than 4 ft in diameter)	10	40

2N/1E-31B1. Harville. Drilled by A. H. Word and Son. Altitude, 85 feet.

Material	Thickness (feet)	Depth (feet)
Quaternary (Recent):		
Alluvium:		
Silt	8	8
Gravel	2	10
Cemented gravel	10	20
Free gravel	15	35

2N/1E-31F1. Silvio Mozzetti. Drilled by Olsen Implement Co. Altitude, 95 feet.

Material	Thickness (feet)	Depth (feet)
Quaternary (Recent and Pleistocene):		
Terrace deposits:		
Soil and clay	18	18
Cemented gravel	22	40
Clay and some gravel	21	61
Cemented gravel, dry	7	68
Clay, some gravel	4	72
Free gravel, water	10	82

3N/2W-32N1. Russ Connick. Drilled by C. Dougherty. Altitude, 4 feet.

Material	Thickness (feet)	Depth (feet)
Quaternary (Recent):		
Alluvium:		
Soil	10	10
Heavy blue clay	4	14
Undetermined	16	30
Water carrying sand	5	35
Gray sandy clay	5	40
Gravel, salt water	23	63
Gray sand	20	80
Gravel	8	88
Quaternary and Tertiary (Pleistocene and Pliocene):		
Carlotta formation of Ogle (1953):		
Gray sand	54	142
Blue sandy mudlike clay, claystone, siltstone	60	202
Gray sand	33	235
Cemented gravel, fresh artesian water to the surface	35	265

TABLE 11.—*Selected drillers' logs of wells in the Eureka area, Humboldt County, Calif.*—Continued

3N/1W–18K1. Golden State Co., Ltd. Drilled by John N. Pitcher Co. Altitude, 55 feet.

Material	Thickness (feet)	Depth (feet)
Quaternary and Tertiary (Pliestocene and Pliocene):		
Carlotta formation of Ogle (1953):		
Yellow clay	16	16
Sand and gravel	5	21
Blue clay	7	28
Sand and gravel, dry	10	38
Yellow clay	4	42
Blue clay	17	59
Brown clay and gravel, hard	28	87
Yellow sand	21	108
Blue clay	69	177
Fine gravel, sandy	5	182
Coarse gravel	16	198
Hard blue clay, some drift wood	26	224
Sediment, clay	48	272
Coarse gravel	18	290
Blue sand	33	323
Gravel	21	344
Blue clay and sand	2	346
Blue sand	27	373
Gravel and shell	8	381
Hard blue clay	23	404
Coarse cemented sand	26	430
Coarse gravel	6	436
Fine sand	13	449
Cemented gravel	3	452
Hard blue clay	50	502
Gray sand	6	508
Coarse gravel	29	537
Blue sand	14	551
Coarse gravel	8	559
Blue sand	13	572

5N/1W–28B1. Pacific Gas and Electric Co., Station B. Altitude, 5 feet.

Material	Thickness (feet)	Depth (feet)
Quaternary (Recent):		
Alluvium:		
Blue clay	39	39
Heavy gravel	31	70
Sand	10	80
Sandy clay	3	83
Sand	40	123
Blue clay	10	133
Quaternary and Tertiary (Pleistocene and Pliocene):		
Carlotta formation of Ogle (1953):		
Sandy clay	16	149
Clay and gravel	33	182
Heavy gravel	10	192
Fine gravel	13	205
Hard sand and gravel	88	293
Hard sand	12	305
Sand cement and shells, wood, and gravel	230	535
Sticky gravel	10	545
Sand	5	550
Blue clay	------------	----------

5N/1E–8J1. Humboldt Dry Kiln. Drilled by C. Hensley. Altitude, 5 feet.

Material	Thickness (feet)	Depth (feet)
Quaternary (Recent):		
Alluvium:		
Blue clay or mud (some gas from 1948 to 1955)	55	55
Gravel	2	57
Blue clay or mud	97	154
Red-brown sand (flowing)	56	210

TABLE 11.—*Selected drillers' logs of wells in the Eureka area, Humboldt County, Calif.*—Continued

5N/1E-18Q1. Arcata Redwood Co. Drilled by Claude Dougherty. Altitude, 4 feet.

Material	Thickness (feet)	Depth (feet)
Quaternary (Recent):		
Alluvium:		
Blue mud	165	165
Mud and gravel	5	170
Bay mud, vegetation and gas	160	330
Blue coarse sand	15	345
Gravel	30	375

6N/1W-36C1. Isaac Dias. Drilled by A. H. Word and Son. Altitude, 2 feet.

Material	Thickness (feet)	Depth (feet)
Quaternary (Recent):		
Alluvium:		
Top soil	4	4
Blue clay	16	20
Black salt, decomposed marsh, water-bearing	30	50
Blue clay	20	70
Beach sand, salt water	3	73
Blue clay	83	156
Gravel (½×1½ in.), water	8	164

6N/1E-7Q1. Anna Kjer. Drilled by C. Hensley. Altitude, 20 feet.

Material	Thickness (feet)	Depth (feet)
Quaternary (Recent):		
Alluvium:		
Blue mud	72	72
Gravel	18	90

6N/E-13N1. Cannon Ball Lumber Co. Drilled by Barnes Tractor and Equipment Co. Altitude, 80 feet.

Material	Thickness (feet)	Depth (feet)
Quaternary (Recent and Pleistocene):		
Terrace deposits:		
Soil	14	14
Gravel	2	16
Shale	16	32
Shale and sandstone	38	70

6N/1E-17E2. W. Parton. Drilled by C. Hensley. Altitude, 18 feet.

Material	Thickness (feet)	Depth (feet)
Quaternary (Recent):		
Alluvium:		
Soil and Silt	13	13
Blue mud	1	14
Sand, fine to coarse, blue, and gravel as much as 3 in. in diameter	16	30

6N/1E-25H1. J. R. Harris. Drilled by C. Hensley. Altitude, 65 feet.

Material	Thickness (feet)	Depth (feet)
Quaternary (Recent):		
Alluvium:		
River gravel	30	30
Blue clay with some gravel	17	47

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