UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Water Resources Division

HYDROLOGIC RECONNAISSANCE OF POINT REYES NATIONAL SEASHORE AREA, CALIFORNIA

Prepared in cooperation with the
National Park Service
U.S. Department of the Interior

OPEN-FILE REPORT

Menlo Park, California
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By

R. H. Dale and S. E. Rantz

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HYDROLOGIC RECONNAISSANCE OF

POINT REYES NATIONAL SEASHORE AREA, CALIFORNIA

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ABSTRACT

This report summarizes the results of a hydrologic reconnaissance of the Point Reyes National Seashore area, the primary purpose of which was to appraise potential sources of water supply at park sites where visitor accommodations are proposed.

Point Reyes National Seashore is a peninsular area on the California coast about 50 miles north of San Francisco. Inverness Ridge, with peaks about 1,400 feet above sea level, forms the eastern boundary of the seashore. Marine terraces, extending from sea level to altitudes of about 400 feet, form the remainder of the area.

The general climate is strongly influenced by the proximity of the Pacific Ocean, but marked local differences in temperature, wind velocity, and precipitation result from the topography of the peninsula. Precipitation is distinctly seasonal and more than 75 percent of the annual (October 1 through September 30) total occurs in the 5 months, November through March. Mean annual precipitation over the peninsula ranges from 20 to 40 inches, whereas mean annual runoff is estimated to range from 6 to 16 inches. About 90 percent of the annual runoff occurs in the 5 months, December through April, when water-supply requirements are minimum.

A streamflow reconnaissance of the area, consisting of a series of low-flow discharge measurements at each of nine streams, was made in 1964 and 1965. From these measurements, the low-flow characteristics of the streams were derived and an evaluation was made of their adequacy as sources of surface-water supply for sites where visitor accommodations are proposed in the national seashore. Results of the study showed that summer streamflow generally is inadequate at beach sites north of the latitude of the western tip of the peninsula. The development of a surface-water supply is feasible at the other proposed park sites.

The principal geologic features, with reference to a ground-water supply, consist of a basement complex overlain by marine sandstone and by shale and mudstone, which, in turn, are overlain by terrace and dune sand, alluvial sand and gravel, and tidal-marsh clay and silt. Wells completed in basement complex, shale and mudstone, and clay and silt yield about 1 gpm (gallon per minute); in sandstone and in terrace and dune sand, about 10 gpm; and in sand and gravel up to 60 gpm. Small quantities of water (less than 5 gpm) may be developed at most of the sites proposed for visitor accommodations, but quantities in excess of 25 gpm will be very difficult to develop.

Except for the iron content, the water quality of potential sources of supply generally appears to be satisfactory, according to U.S. Public Health Service standards. Analysis for iron was not made but field evidence suggests that a high-iron content in the water will be a problem throughout the seashore area.

Because this investigation was of the reconnaissance type, the quantitative results obtained are estimates. However, they provide a basis for the preliminary planning of park developments. Detailed studies are in progress (1965) to define hydrologic conditions more adequately at proposed park sites.

INTRODUCTION

In accordance with a July 1963 agreement between the U.S. Geological Survey and the National Park Service, the Geological Survey made a hydrologic reconnaissance directed toward the development of water supplies for proposed park sites in the Point Reyes National Seashore area. According to present (1965) plans, the national seashore will ultimately occupy about 33,000 acres of the 64,000-acre Point Reyes peninsula.

Purpose and Scope

The purpose of this report is to summarize the hydrologic features of the peninsula. The scope of the study included: (1) A geologic classification of the rocks, based in part on their water-bearing characteristics; (2) surface-water discharge measurements, analyzed to determine the low-flow characteristics of streams in the area; and (3) the results of chemical analyses of water samples to determine the suitability of the water for domestic use.

Also included is a brief appraisal of the potential water supply for nine proposed park sites. Each site that is to be developed may require more detailed evaluation than was possible in this reconnaissance-type study.

Acknowledgments

The geologic features of the area are described in an unpublished report by Mr. Alan J. Galloway of the California Academy of Sciences. Modifications were made to correlate the geologic features to the ground-water potential. The authors of this report gratefully acknowledge the assistance of Mr. Galloway.

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[illegible]

Numbering System for Springs and Wells

The numbering system used in California by the Geological Survey is based on the rectangular system for the subdivision of public land into township, range, and section. In an area such as Point Reyes, where the land has not been surveyed for such subdivision, the rectangular system is projected from outside the area. The sections are subdivided into a quarter of a quarter section and numbered as in the accompanying diagram.

An example best describes the system. Citizens Utilities owns a well in Inverness. It is located, according to this projected system, in the SW¼ of the SW¼ of sec. 16, T. 3 N., R. 9 W. of Mount Diablo base line and meridian. The assigned well number is 3N/9W-16N1. The 3N, 9W, and 16 correspond to the projected township, range, and section, respectively. The letter corresponds to the appropriate quarter of the quarter section, and the final digit denotes that it was the first well canvassed in the N plot. Available data not field verified are described in the same manner except that the final digit is not shown.

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

LOCATION AND GEOMORPHIC FEATURES

The Point Reyes National Seashore (fig. 1) is a peninsular area on the California coast about 50 miles north of San Francisco. It is triangular in shape and has a base about 30 miles long, extending from Bolinas Bay to Bodega Bay along the San Andreas Rift Zone. The apex of the triangle is at Point Reyes lighthouse.

Inverness Ridge lies parallel to and about a mile west of the base of the triangle. Section A-A' (fig. 2) approximately coincides with the crest of the ridge. The southern part of the ridge, designated as the upland, consists of three distinct peaks; each has an altitude of about 1,400 feet above sea level. Figure 3 shows the topography of the upland, viewed from an altitude of 800 feet at the saddle between Point Reyes Hill and Mount Wittenberg (fig. 1). The northern part of the ridge (figs. 2 and 4), designated as the high terrace, is a wave-cut terrace whose altitude ranges from 200 to 400 feet above sea level.

The low terrace on the west has an approximately triangular shape, formed by the Kehoe Ranch on the north, Laguna Ranch on the southeast, and Point Reyes School on the southwest. At some sites this terrace rises gradually from sea level to a maximum altitude of 300 feet, and at other sites sea cliffs rise abruptly to altitudes of 200 feet. In general, the average altitude is about 200 feet (section B-B', fig. 2). This low terrace is terminated by an east-west trending ridge at Point Reyes.

CLIMATE

The general climate is strongly influenced by the proximity of the Pacific Ocean, but distinct local differences in temperature, wind velocity, and precipitation result from the topography of the peninsula. The climate along the coast is marked by moderate and equable temperatures, heavy and recurrent fogs, and strong prevailing northwest winds. At Point Reyes lighthouse the mean annual temperature is 53°F; the mean temperature for January, the coldest month, is 50°F; the mean temperature for September, the warmest month, is 57°F. The difference between the long-term average maximum and average minimum temperatures for any month of the year is only 10°F. Inland, temperatures have a wider range, fog is lighter and less frequent, and winds are more moderate.

Precipitation is highly seasonal, there being negligible rainfall during the summer months. More than 75 percent of the annual (October 1 through September 30) precipitation, virtually all of it in the form of rain, occurs during the 5 months, November through March. The only long-term precipitation record available is that for the lighthouse weather station where the average annual rainfall is about 20 inches. This record indicates that there is great variability in precipitation from year to year, and during the period 1879-1943 annual precipitation ranged from a high of 45.91 inches in 1890 to a low of 9.56 inches in 1924. A study of precipitation records for nearby stations outside the peninsula shows that the rainfall is orographically influenced and that average annual precipitation may be as much as 40 inches at the higher altitudes in the southeastern part of the national seashore area (fig. 5).

SURFACE WATER

The areal distribution of precipitation is reflected in the areal pattern of runoff, values of which range from 6 to 16 inches. The isopleths of mean annual runoff shown on figure 6 are based on the rainfall distribution shown on figure 5 and on a rainfall-runoff relation for the surrounding area. There are no stream-gaging stations in the study area, but on the basis of streamflow records for nearby areas, it is estimated that about 90 percent of the annual runoff occurs during the 5 months, December through April.

A streamflow reconnaissance was made during the summers of 1964 and 1965 to estimate the low-flow characteristics of potential sources of surface-water supply and to evaluate the adequacy of these sources. The reconnaissance included the nine sites, shown on figure 7, where visitor accommodations are proposed. The only summer flow in the vicinity of four of these sites--Gallagher, Drakes, Point Reyes, and Tomales Beaches--occurs in small seeps and these sites, therefore, were eliminated from the surface-water investigation. Nine streams in the vicinity of the other five proposed park-development sites were selected for study. The observations at each stream consisted of a series of measurements of discharge and water temperature. The locations of the nine measurement sites are shown on figure 1; the discharge and temperature data are given in table 1.

Table 1.--Measured discharge and water temperature of streams

[Q = discharge in gallons per minute; T = water temperature in °F]

Date	Pine Gulch area		Double Point area		National Park Service Headquarters area						Limantour Beach area						McClures Beach area	
	Pine Gulch Creek (site 1)		Alamea Creek (site 2)		Bear Valley Creek tributary 1 (site 3)		Bear Valley Creek tributary 2 (site 4)		Bear Valley Creek upstream from tributary 2 (site 5)		Laguna Creek (site 6)		Muddy Hollow Creek (site 7)		Glenbrook Creek (site 8)		McClure Creek (site 9)	
	Q	T	Q	T	Q	T	Q	T	Q	T	Q	T	Q	T	Q	T	Q	T
1964																		
June 15					37	56	37	55	140	55	97	-	125	-	85	53	68	58
July 1					-	-	33	53	125	53	73	54	85	55	58	53	49	60
31					-	-	27	53	97	54	45	57	24	56	49	58	43	62
Sept. 1					21	-	19	-	73	-	7.3	-	0	-	13	-	46	-
15					-	-	16	-	68	-	7.3	-	0	-	-	-	-	-
Oct. 22					14	55	16	54	65	51	21	56	0	-	21	54	-	-
1965																		
May 25	1,160	59	947	57					422	50								
July 7	624	54	503	54					215	51								
Aug. 6	364	59	361	54					141	55								
Sept. 3	274	55	361	53					104	53								
20	193	51	334	51					79	49								
Oct. 1	212	54	308	53					91	52								

Correlation of the measured discharges in table 1 with concurrent discharges of gaged streams outside the study area elicited the low-flow information shown in table 2. The heading "Q0.60" in table 2 refers to the discharge that is exceeded, on the average, 60 percent of the time; the heading "Q0.90" refers to the discharge that is exceeded, on the average, 90 percent of the time. The heading "firm yield" requires more detailed explanation. After park facilities for the public are developed, the most critical period each year, from the standpoint of water supply, will be the Labor Day weekend. At that time water usage by visitors will be at a peak and streamflow almost at a minimum. (Consequently, a firm surface-water yield is one that will meet the demands of the critical Labor Day periods.) Long-term rainfall and runoff records indicate that the severest droughts during the past 50 years were those of 1924 and 1931. (From a consideration of these long records, firm surface-water yield has been defined arbitrarily for this study as the discharge that was equaled or exceeded in early September of each of the past 50 years, with the exception of 1924 and 1931.) By this definition, firm yield is a discharge of such magnitude that on only one Labor Day in 25 years, on the average, will it fail to be attained.

Table 2.--Low-flow characteristics of streams

Proposed park-development site	Stream-measurement site: Number on hydrologic-data map (fig. 1)	Stream-measurement site: Name of stream	Drainage area upstream from measurement site (sq mi)	$Q_{0.60}$ (gpm)	$Q_{0.90}$ (gpm)	Firm yield (gpm)
Pine Gulch	1	Pine Gulch Creek	3.91	410	190	60
Double Point	2	Alamea Creek	2.26	420	270	180
National Park Service Headquarters	3	Bear Valley Creek tributary 1	.31	40	20	8
	4	Bear Valley Creek tributary 2	.24	40	20	8
	5	Bear Valley Creek upstream from tributary 2	1.31	153	75	30
Limantour Beach	6	Laguna Creek	1.38	116	18	0
	7	Muddy Hollow Creek	2.32	164	0	0
	8	Glenbrook Creek	1.41	103	18	0
McClures Beach	9	McClure Creek	.17	66	40	25

Another low-flow characteristic deduced from the streamflow data was the base-flow recession curve for each of the nine streams. This recession curve is a discharge hydrograph for periods of no rain, when all the flow is derived from natural ground-water discharge into the stream channel (base flow). Factors that influence the recession curve are transmissibility of the ground-water aquifer or aquifers, water-table gradient, and volume of ground-water storage available for effluent discharge to the stream. It is customary to plot recession curves on semilogarithmic graph paper, using the logarithmic ordinate for the discharge scale and the rectangular abscissa for the time scale, usually expressed in days. The use of semilogarithmic plotting tends to linearize the recession curve. "Zero" on the time scale corresponds to an arbitrarily selected value of base flow; "1" on the time scale represents the discharge 1 day later; "2" on the time scale represents the discharge 2 days later; and so on. To permit visual comparison of the characteristics of the nine base-flow recession curves, they have all been plotted on the same graph (fig. 8), using discharge in gallons per minute per square mile as the ordinate. To obtain the actual discharge for any stream, the unit discharge values indicated on figure 8 are multiplied by the drainage area of the stream.

The initial discharges on figure 8, corresponding to 0 on the time scale, are the $Q_{0.60}$ values for the streams. The graphs show that in the absence of rain, $Q_{0.90}$ occurs 90 days after $Q_{0.60}$, and firm yield occurs 150 days after $Q_{0.60}$. The discharges corresponding to firm yield are exceeded, on the average, at least 99 percent of the time.

The slope of a recession curve indicates the degree to which base flow is sustained; the flatter the recession curve, the better sustained is the flow. Also, the higher a recession curve is on the scale of discharge per square mile, the greater is the available supply per unit of drainage area. Figure 8 shows that the base flow of 6 of the streams is fairly well sustained; that of the 3 streams in the Limantour Beach area is not.

The water-temperature data in table 1 indicate that summer temperatures are generally about 55°F, but reach 62°F in McClure Creek.

GEOLOGIC FEATURES AND GROUND-WATER POTENTIAL

In general, a basement complex of pre-Tertiary age, is overlain by marine sandstone and marine shale mudstone of Tertiary age. These, in turn, are overlain by terrace and dune sand, alluvial sand and gravel, and tidal-marsh clay and silt, all of Quaternary age.

Geologic section B-B' (fig. 9) shows the relative thickness of each of these units, and the geohydrologic map (fig. 10) shows their areal distribution. Table 3 summarizes the water-bearing properties for each of the geohydrologic units. Table 4 lists data for wells and springs that are mentioned in the following discussion of geohydrologic units.

Basement complex.--The basement complex forms Inverness Ridge from Mount Wittenberg north to Tomales Point. West and south of the ridge, it underlies a low terrace and crops out to form Point Reyes at the southwestern corner of the area.

The basement complex, consisting principally of granodiorite, is weathered and decomposed in surface exposures. Several domestic wells, yielding less than 1 gpm, have been completed in the weathered basement complex. A public-supply well (3N/9W-16N2), drilled to a depth of 303 feet in both the weathered and unweathered basement complex yielded 10 gpm.

Table 3.--Generalized geologic column and ground-water potential

System	Geologic unit	Ground-water potential	
Quaternary	Clay and silt	Unsatisfactory	Yield less than 2 gpm
	Sand and gravel	Best	Yield up to 60 gpm
	Sand	Good	Yields 10 gpm
Tertiary	Shale and mudstone	Unsatisfactory	Yield less than 1 gpm
	Sandstone	Probably good	Field examination suggests that, if saturated, this unit should yield 10 gpm.
Pre-Tertiary	Basement complex	Generally poor	Domestic wells yield less than 1 gpm. Large public supply wells yield 10 gpm.

Sandstone.--A sandstone unconformably overlies the basement complex. In general, it crops out discontinuously along the west flank of Inverness Ridge and may extend for a short distance at depth below the low-terrace area.

Near the Kehoe Ranch, the sandstone consists of a well-sorted, slightly cemented medium sand and is moderately porous and permeable. None of the wells canvassed were completed in this unit; however, field examination of the sandstone suggests that wells drilled in this unit probably will yield 10 gpm.

Shale and mudstone.--Shale forms Inverness Ridge from Mount Wittenberg south to Bolinas. Mudstone crops out along the west flank of Inverness Ridge from Mount Wittenberg north to the Kehoe Ranch and underlies the low terrace to the west at shallow depths. The thickness of the shale is unknown. Oil-well data indicate the mudstone lies directly on the basement complex and is 1,200 feet thick near the D Ranch west of Mount Wittenberg.

The shale is siliceous and well fractured, and small amounts of water might be pumped from this unit. The mudstone is a slightly lithified mud with some small fractures, but for the most part is dense and impermeable. Three wells, completed in the mudstone, were canvassed. Well 2N/10W-8A1 yielded 1 gpm; domestic well 3N/10W-14N2 was unused because of its small yield; and well 3N/10W-22C1, whose yield is unknown, was unused because of high-iron content in the water.

Sand.--Thin discontinuous beds of terrace sand overlie the mudstone in the low-terrace area and dune sand overlies the terrace sand along Point Reyes Beach. These two units are shown on figure 9 but are not differentiated on figure 10 or elsewhere in this report. The sand, undifferentiated, is thickest near Point Reyes Beach where it may be as much as 100 feet thick; it thins and becomes discontinuous to the east. Directly south of Bolinas, in the southeastern part of the area, the sand is about 100 feet thick. At McClures Beach, in the northwestern part of the area, the deposit is principally dune sand of unknown thickness.

The water-yielding characteristics of the sand vary considerably, and, in general, the permeability decreases with depth. Many small springs, yielding less than 1 gpm, were noted at horizons of permeability change. These include 2N/10W-8M1 and 3N/10W-23B1. Well 3N/10W-14N1 reportedly supplies enough water from the sand to run a dairy ranch. Reportedly, several wells were drilled in the Bolinas area, but no record of the yield was made. At McClures Beach, the entire flow of McClure Creek is ground-water discharge from the dune sand (spring 4N/10W-16R1).

Sand and gravel.--This unit occurs in significant amounts in the stream valleys of the low-terrace area (fig. 11). It also occurs in discontinuous patches along the San Andreas Rift Zone. Extremely small amounts also occur in the stream valleys on the east side of Inverness Ridge in and north of the town of Inverness (fig. 12).

The yield of wells varies with the thickness of the sand and gravel body. In Muddy Hollow, wells 2N/9W-5Q1 and 5Q2 reportedly were test pumped at 60 gpm. Well 3N/10W-25D1, just north of Home Ranch, yielded 19 gpm. Along the rift zone, well 1N/8W-24G1 yielded 8 gpm. These wells are in areas where the sand and gravel probably is more than 50 feet thick. In the small alluvial valleys north of Inverness, the sand and gravel is thin, probably less than 20 feet thick, and wells probably will yield less than 5 gpm. For example, well 4N/10W 36G1 yielded less than 1 gpm.

Clay and silt.--In the lower reaches of the alluvial valleys, the alluvial sand and gravel grades laterally into the fine sand, silt, and clay typical of tidal-flat deposit. The contact between the sand and gravel unit and the clay and silt unit (fig. 10) is placed at an abrupt change in stream gradient. Immediately upstream from the tidal flats gradients average 80 feet per mile, while in the tidal-flat area the gradient is only a few feet per mile. In Muddy Hollow drainage in the south-central part of the area, the lithologic-topographic correlation was apparent, but all other contacts were inferred.

The only well canvassed in this unit is a flowing well, 2N/9W-8B1, which yields less than 2 gpm.

WATER QUALITY

In all, 19 analyses of water samples were studied to determine the general chemical quality of the surface and ground water in the seashore area. Table 5 shows that the quality of the water, except the water from Drakes Beach (2N/10W-9), is satisfactory for domestic use. Sampling sites are shown on the water-quality map (fig. 13).

The water contains, on the average, about equal amounts of calcium, magnesium, and sodium cations. The anions are predominantly bicarbonate. The average sum of determined constituents (dissolved solids is 116 ppm (parts per million) for surface water and 280 ppm for ground water.

Samples were not collected specifically for analysis for iron, although evidence suggests iron in the water is a problem throughout the entire seashore. The owner of well 1N/8W-24G1 reported iron in the water. The water from spring 2N/10W-8M1 indicated a considerable amount of iron precipitate. Water from well 3N/10W-22C2 is treated to remove iron, and well 3N/9W-17G1 is unused because of the large amount of iron in the water.

Samples were not collected for bacteriological analysis, but, on the basis of nitrate content, the water from two wells probably contains organic matter. Analyses of water from wells 1N/8W-13M and 1N/8W-24F indicate 34 and 18 ppm. The U.S. "Public Health Service Drinking Water Standards, 1962," indicates that nitrates in water supplies should not be in excess of 45 ppm.

Ground water.--On the basis of the sum of determined constituents, the ground-water analyses can be divided into two distinct groups--one averaging about 390 ppm and the other, about 190 ppm. Wells in the sand and gravel or the silt and clay units yield water containing the greater concentrations of dissolved solids. Wells in the other geohydrologic units (fig. 10) yield water containing the lesser concentrations. Therefore, wells in the sand and gravel and in the silt and clay units will probably yield water of a somewhat poorer quality than wells in the other geohydrologic units. Also, wells drilled below sea level may yield salt water.

Surface water.--The results of analysis of most of the samples of surface water in the area indicate water of good quality. Two exceptions are noted: (1) Pine Gulch Creek (1N/8W-24J) where the sum of determined constituents was greater than that for the other streams, but the water is satisfactory for domestic use; and (2) Drakes Beach (2N/10W-9) where the chloride content is in excess of that allowed by the U.S. Public Health Service drinking-water standards (table 5).

BRIEF APPRAISAL OF SPECIFIC SITES

Nine sites were selected by the Park Service as potential park-development sites (fig. 7). Each requires an examination beyond the scope of this report to adequately define the water conditions. The following appraisal of these sites gives only the general hydrologic conditions. In this appraisal the term "firm yield" is used to describe the potential of a stream as a source of water supply. The term was defined earlier in this report as a discharge of such magnitude that only on one Labor Day in 25 years, on the average, will it fail to be attained. The Labor Day weekend is the most critical period each year because at that time a high water demand and a low water supply coincide.

1. Pine Gulch.--This site probably is unfavorable for the development of a ground-water supply. A potential source of surface-water supply is Pine Gulch Creek, which has an estimated firm yield of about 60 gpm.

2. Double Point.--This site probably is unfavorable for the development of a ground-water supply. A potential source of surface-water supply is Alamea Creek, which has an estimated firm yield of 180 gpm.

3. NPS Headquarters.--Two wells have been completed in the alluvial sand and gravel near park headquarters; one yields 35 gpm and the other 60 gpm. A potential source of surface-water supply is Bear Valley Creek and two unnamed tributaries, which have an estimated total firm yield of about 45 gpm.

4. Limantour Beach.--The summer discharge of each of two existing wells in the Muddy Hollow Creek watershed is about 55 gpm. None of the three streams in the area--Muddy Hollow, Glenbrook, and Laguna Creeks--has an adequate summer flow.

5. Gallagher Beach.--The primary source of a local water supply probably would be shallow wells drilled to the blue clay along a line that parallels the beach. The yield of these wells is speculative and will depend on whether or not a system of joints or cracks is encountered. For example, test hole 2 (fig. 14), which penetrated a system of cracks or joints, indicates a probable yield of about 5 gpm. Test hole 3 (fig. 14), however, did not penetrate any such system and indicates a probable yield of less than 1 gpm. The only summer surface flow occurs in small seeps at several geologic contacts (fig. 14).

6. Drakes Beach.--The flow of several small seeps is impounded behind a dam about 800 feet inland from the beach. There is no practical way to measure the rate of inflow to the small lake thus formed, but regardless of inflow rate, the lake water is not potable. The primary source of a local water supply would probably be wells drilled to the blue clay underlying the swampy areas tributary to the lake. The estimated yield of such wells is speculative, depending as it does on the presence or absence of a system of cracks or joints at the well site. One test hole, 100 feet deep, at the intersection of Drakes Beach road and the access road to D Ranch (fig. 1), indicated a probable yield of less than 1 gpm.

7. <u>Point Reyes Beach.</u>--Conditions here are similar to those at Gallagher Beach and prospecting for a local ground-water supply is therefore highly speculative. The only summer surface flow occurs in small seeps.

8. <u>McClures Beach.</u>--McClure Creek is probably the most feasible source of water. Its estimated firm yield is 25 gpm.

9. <u>Tomales Beach (Marshall property)</u>.--The alluvial sand and gravel is thin at this site. A well in the second alluvial valley north of Laird's Landing (figs. 10 and 12), about 20 feet above sea level, may yield about 5 gpm. If additional water is required, a well could be drilled in the marine sandstone about three-fourths of a mile southwest of the beach. There is no summer surface flow at Tomales Beach.

Table 4.--Data on water wells and springs

USGS number: The number assigned to the well or spring and described in the text in the section on well numbering.

Date of observation: Date well was canvassed by U.S. Geological Survey.

Owner or user: The name given is that of the owner or user on the date indicated.

Year completed: The completion date was obtained from the driller's log, or reported by the owner or others.

Depth: Depth of well was obtained from the driller's log or was reported by the owner or user.

Perforated interval: The perforated interval is the slotted part of the well casing. The top and bottom of the interval are given in feet below land-surface datum.

Type, diameter: The type of well construction is indicated by the symbols: C cable tool; Dg dug; Dr drilled; R rotary. The number following the letter is the diameter of the casing or pit, in inches. A spring is indicated as such.

Pump type and power: The type of pump or method of lift is indicated by the symbols: C centrifugal; J jet; P piston; S submersible; T turbine. The type of power is indicated by the symbol: W wind. The number is the rated horsepower of an electric motor.

Use: D domestic; In industrial; Ir irrigation; Ps public supply; S stock; U unused.

Discharge/drawdown: The discharge of the well is given in gallons per minute (gpm); the drawdown (pumping water level minus standing water level) is given in feet.

Altitude of lsd: Altitude is the elevation, in feet, of land-surface datum above mean sea level. Land-surface datum is an arbitrary plane that closely approximates land surface at the time of the first measurement and is the fixed plane of reference for all subsequent measurements. Altitudes were interpolated from U.S. Geological Survey topographic maps, having a contour interval of 40 feet.

Water level: Depths to water below land-surface datum, given in feet and tenths, were measured by the Geological Survey. Depths given in feet only were obtained from drillers' logs. A flowing well is so indicated.

Other data: Other data available are indicated by the symbols: C chemical analysis (table 5) and L driller's log and P pumping test (in the files of the Geological Survey).

USGS number	Date of observation	Owner or user	Well data: Year completed	Depth (feet)	Perforated interval: Top	Bottom	Type diameter (in.)	Pump type and power	Use	Discharge (gpm)/ drawdown (ft)	Altitude of lsd (feet)	Water level: Depth below lsd (feet)	Other data
1N/[illegible]-11G1	10----65	A. F. Tiexira	1956	56			3		U	33/	150	9.8	
24G1	3-23-64	Hamilton	1958	73			Dg 48	C 1	D	8/	120		L
2N/8W- 6N1	9-17-65	National Park Service (NPS)	1965	40	20		R 10		D	36/30.5	75	10.3	C,L
8M1	9-29-65	Olema Cemetery		39	18		C 12	P ½	Ir	20/14	130	8.2	L
21N1	9----65	W. Pinkerton		30			7	C 1½	Ir		160	8.0	C
29M1	9----65	NPS		79			8		U		1,260	59.9	
34F1	9-28-65	Don Brown		85			8	P W	U		360	6.5	
34K1	9-28-65	Don Brown		73			12	C ½	D	13/	370	5.0	
34K2	9-28-65	Don Brown					8		U		330		
34R1	9-28-65	Don Brown							U		420		
2N/9W- 1J1	10-22-65	NPS		72			R		U		85	Dry	L,P
1K1	9-30-65	NPS	1965	27	13		R 10		D	60/17.9	35	6.0	C,L
1K2	10-22-65	NPS		60			R		U		100	Dry	L,P
4Q1	10- 6-65	Marshall		110	75		8	J 1½	D		180		C
5Q1	10- 6-65	Citizens Utilities	1960	75	55		C 8	T 10	D	60/	60		L
5Q2	4-30-63	Citizens Utilities		100+			R 8	T 10	Ps	60/	60		L
5R1	4-30-63						10	W	U		300	28.3	
	9-17-63											48.3	
5R2	10- 6-65	Citizens Utilities	1960	160	55		C 8	T 10	D	60/50	60		L
8A1	9----65	Drakes Bay Development Co.		125			8	P W	U		300	50	
8B1	10- 6-65	Drakes Bay Development Co.		98			8		U	1.5/	20	+1.5 (above lsd)	C
8J1	10- 6-65	Marshall	194?	65			12		U	.5/	20	Flowing	

USGS number	Date of observation	Owner or user	Well data: Year completed	Well data: Depth (feet)	Well data: Perforated interval: Top	Well data: Perforated interval: Bottom	Well data: Type	Well data: diameter (in.)	Well data: Pump type	Well data: Pump power	Use	Discharge (gpm)/drawdown (ft)	Altitude of lsd (feet)	Water level: Depth below lsd (feet)	Other data
2N/10W- 1C1	10- 1-65	Home Ranch		[illegible]				[illegible]	P	[illegible]	S		240	18	
4M1	3-24-64	Nunes		5			Dg	12[illegible]			[illegible]		280		
5Q1	8-17-65	NPS	1965	46	10	24		10			Ps	6.0/15.7	70	4.3	C,L
8A1	10- 1-65	Spaletta	1960	157	40		C	8		3/4	D	1/	110	64	L
8M1	3-31-64	Mendoza					Spring		P		D,S	1/2/	40		
11A1	10- 1-65	Home Ranch						6	P	W	U		160		
17P1	10-22-65			16			Dg	72	C	3/4	S		75	1.8	
2N/11W-25A1	10-1-65	U.S.Coast Guard	1943	395			C	6	S	1	D	2.5/348	520		
3N/9W-16N1	3-27-64	Citizens Utilities		300	17	293	R	12	S		Ps		20		L
16N2	3-27-64	Citizens Utilities		303	203	303	R	8	S		Ps	10/292	20		L
17G1	3-27-64	I. W. Matthews	1955	132			C	8	J	3/4	D	3/4/	270	60	
17K1	3-27-64	I. W. Matthews	1962	158			Dr	3/4	J	1	D	1/2/	200	Flowing	
17K2	3-27-64	I. W. Matthews					Spring					1/2/	200	Flowing	
3N/10W-1F1	9-30-65	L. Ranch Co.		15			Dg	60	C	1	S	5/	310	8.6	
3F1	9-30-65	McClures	1956	110			C	8		1½	D	7-8/	130	41.0	
3F2	9-29-65	McClures	Pre-1956	117			C	8		1½	U		130	35.0	
11K1	9-30-65	R. Grossi		128				8	S	1/3	S	5/	210		
11Q1	9-30-65	R. Grossi		100				8	S	1/3	D	5/	170		
12G1	9-30-65	E. Ghisletta		18			C	8	C	½	D	8-9/	320	5	
13B1	9-30-65	D. Grossi		120				8	S	1	D	1[illegible]/	180	62.5	
14N1	10- 1-65	Lunny (RCA)	1961	24	10			36	P	½	U	7-8/	100	5.[illegible]	L
14N2	10- 1-65	Lunny (RCA)	1960	225			C	6			U	3-4/	100	5.2	L
22C1	10- 1-65	Radio Corp. of America (RCA)	1930	90				6	J	1	Ir		90		C
22C2	10- 1-65	RCA	1956	160	13[illegible]		C	[illegible]	J	1	D	1[illegible]/95	90	23.5	L
22E1	4- 8-65	American Telephone & Telegraph Co.	1930	100			C	8			D	13/40	80		

USGS number	Date of observation	Owner or user	Well data: Year completed	Depth (feet)	Perforated interval: Top	Perforated interval: Bottom	Type diameter (in.)	Pump type and power	Use	Discharge (gpm)/ drawdown (ft)	Altitude of lsd (feet)	Water level: Depth below lsd (feet)	Other data
3N/10W-23B1	3-27-64	RCA					Spring		D		40	Flowing	
24P1	10-22-65	NPS		Filled			6		U		80		
25J1	9-30-65	NPS		125			8	C 2	S	19/3	40		C
25Q1	10- 1-65	Home Ranch		43			12	C 5	D		20	23.[illegible]	C
26C1	9-30-65	Johnson Oyster Co.		36			8	S 1	In	>10/	15	20	C
26C2	10- 1-65	Johnson Oyster Co.		15			Dg 120		U		30	5.[illegible]	
28K1	9-14-65	NPS	1965	26	10	26	10		Ps	25/15	108	5.0	C,L
28K2	9- 1-65	NPS	1965	32	10	32	10		Ps	17.5/13.7	103	5.3	C,L
33G1	10- 5-65	Duck Club		12			Dg 60	C 1	D		50	0	
4N/10W-16R1	3-25-64	McClures					Spring	C	D,S	200/	160	Flowing	
27J1	9-29-65	Kehoe Ranch		112	50		C 8	C 2	D	7-9/	160		C
27J2	9-29-65	Kehoe Ranch		20			Dg 196	C	S		150	2.2	
35H1	10-20-65	R. Grossi		12			Dg 72		U		220	3.8	
35J1	9-30-65	L. Ranch Co.		15			8	P 1	D		260	4.0	
36B1	10- 5-65	Murray		14			48	C ½	D		50	5.7	
36C1	10- 5-65	F. Spengler	1962	10	8		R 27	J ½	D	¼/	20	6.0	L
36C2	10- 4-65	F. Spengler		20			8	J ½	D		30	7	
36R1	10- 5-65	L. Ranch Co.		26			8		U		40	2.3	
36R2	10- 5-65	L. Ranch Co.		26			30	C 2	D		40	3.4	

Laboratory and lab. number: GS U.S. Geological Survey; USPHS U.S. Public Health Service

Number above line indicates results in parts per million (ppm); number below line indicates results in equivalents per million (epm). Values are given as ppm / epm.

[illegible]	Date of collection	Estimated flow (cfs)	Water temperature (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids: Calculated (Sum of determined constituents)	Dissolved solids: Residue on evaporation at 180°C	Hardness as $CaCO_3$	Noncarbonate hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH	Laboratory and lab. number
U.S. Public Health Service drinking-water standards (196[illegible])					0.3							250	250	1.1	45		500	500						
1N/8W-13F	[illegible]		66	18		19 / 0.95	14 / 1.12	21 / 0.91	1.0 / 0.03	110 / 1.80	0 / 0.00	26 / 0.54	27 / [illegible]	[illegible]	[illegible]	0.03	[illegible]		104				[illegible]	GS-1[illegible]
13M	[illegible]		60	51		8.9 / [illegible]	4.0 / .33	41 / 1.78	.6 / .02	48 / .79	0 / .00	9.5 / .20	40 / 1.13	0 / .00	34 / .55	.00	[illegible]		[illegible]				7.[illegible]	GS-1[illegible]
[illegible]4F	[illegible]		6[illegible]	19		27 / 1.3[illegible]	23 / 1.8[illegible]	29 / 1.26	4.[illegible] / .12	[illegible]	7 / .23	[illegible] / .58	34 / [illegible]	.1 / [illegible]	18 / [illegible]	.07	[illegible]		161			45[illegible]	[illegible]	GS-1[illegible]
[illegible]L	[illegible]		57	[illegible]		9.7 / .48	13 / 1.05	156 / 6.7[illegible]	6.[illegible] / .17	361 / 5.9[illegible]	0 / .00	11 / [illegible]	68 / 1.92	[illegible] / .11	.6 / .01	[illegible]	[illegible]		[illegible]				[illegible]	GS-1[illegible]
2N/6W-4Q1	[illegible]		56	41		15 / .75	14 / 1.13	31 / 1.35	[illegible] / .07	116 / 1.[illegible]	0 / .0[illegible]	[illegible] / .46	35 / 1.[illegible]	[illegible]	1.9 / .03	[illegible]	[illegible]		[illegible]				[illegible]	GS-1[illegible]
8B1	[illegible]		[illegible]	[illegible]		9.2 / .46	[illegible]	[illegible]	[illegible]	1[illegible]	[illegible] / .19	60 / 1.[illegible]	36 / 1.[illegible]	[illegible]	[illegible]	.4	[illegible]	[illegible]	[illegible]					[illegible]
3N/6W-[illegible]	[illegible]		[illegible]	[illegible].1		[illegible]	4.0 / .33	21 / .9[illegible]	[illegible]	[illegible]	[illegible]	13 / [illegible]	27 / .7[illegible]	[illegible]	.7 / .01	[illegible]	[illegible]							GS-13[illegible]
17A	[illegible]		[illegible]	39		[illegible] / 1.10	39 / 3.20	[illegible]	1.4 / .04	[illegible]	[illegible]	[illegible]	27 / 1.[illegible]	[illegible] / .00	.1 / .00		[illegible]			[illegible]		[illegible]	[illegible]	GS-1[illegible]
[illegible]W-2[illegible]1	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	.6 / [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	GS-1[illegible]
[illegible]5D1	[illegible]		[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	11 / [illegible]	[illegible]	[illegible]	[illegible]	[illegible] / .01	[illegible]	[illegible]				[illegible]		[illegible]	[illegible]	GS-13[illegible]
[illegible]	[illegible]		[illegible]			3[illegible] / 1.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	41 / 1.1[illegible]	[illegible]	[illegible] / .04	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	GS-1[illegible]3[illegible]
[illegible]	1-1[illegible]-	[illegible]	[illegible]	[illegible]		[illegible] / 1.10	[illegible]	27 / 1.17	3.[illegible]	111 / 1.81	[illegible] / 0.00	[illegible]	[illegible]	[illegible]	.4 / [illegible]	[illegible]	201		[illegible]	13	[illegible]	[illegible]	7.[illegible]	[illegible]
[illegible]	2-17-64	[illegible]	[illegible]	[illegible]		6.6 / .33	3.8 / .31	7.8 / .34	[illegible] / .07	30 / .49	0 / .0[illegible]	6.3 / .13	[illegible]	.1 / [illegible]	2.4 / .04	.13	[illegible]		[illegible]		[illegible]	11[illegible]	7.[illegible]	
[illegible]	[illegible]-28-64				[illegible]							100	[illegible]5						[illegible]					[illegible]
[illegible]	[illegible]-28-64				0							17[illegible]	[illegible]5						100					[illegible]
[illegible]	[illegible]-28-[illegible]				0							17[illegible]	[illegible]						[illegible]					[illegible]
[illegible]	2-17-[illegible]	1[illegible]	[illegible]	1[illegible]		7.0 / .3[illegible]	5.2 / .4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] / .20	.1 / .00	[illegible]	[illegible]	[illegible]						[illegible]	[illegible]
[illegible]	[illegible]-28-64											[illegible]	[illegible]						10[illegible]					
[illegible]	[illegible]-17-[illegible]	[illegible]	56	13		[illegible]	[illegible]	[illegible]5 / 1.[illegible]	4.7 / .1[illegible]	[illegible]	[illegible]	1[illegible] / .25	[illegible] / 1.1[illegible]	.1 / [illegible]	1.4 / [illegible]	.[illegible]4	1[illegible]3		[illegible]	14	[illegible]	[illegible]27	7.[illegible]	[illegible]

APPENDIX

Subsequent to preparation of the main body of this report three wells, 2N/10W-5Q1 at access No. 1 and 3N/10W-28K1 and 28K2 at access No. 2, near Point Reyes Beach, have been successfully completed. In addition, all wells and springs in the Point Reyes peninsula, except at Bolinas, were visited, relocated, and described in greater detail.

New Wells

All new wells are completed in clayey sand overlying a massive blue mudstone. The sand aquifer is mixed with yellow silt or clay forming a slurry when saturated, and water obtained from the wells is extracted from this slurry. Each of the wells was constructed by drilling a hole 30 inches in diameter through the yellow clayey sand to a depth selected by the driller. Ten-inch-diameter casings having torch-cut perforations starting about 10 feet below land surface were installed, and pea gravel was packed in the annular space around the casings. Concrete sanitary seals were poured around the casings to a depth of 10 feet below land surface. Two 5-inch-diameter tubes were installed in each well, outside the 10-inch casing and extending below the concrete seal, to permit additions of gravel and to aid in washing the gravel pack in the future, if necessary.

None of these wells can be classified as fully developed. Because of the nature of the aquifer material, full development may be impossible. However, each well was bailed and airlifted with compressed air for about 8 hours, then test pumps were installed and the wells were pumped and surged for 24 to 40 hours. In the course of future use, these wells probably will continue to develop. Consequently, the side tubes at each well should be kept supplied with gravel to insure replacement if the gravel pack settles.

Greater development could be implemented, when electric pumps are installed, by using an automatic timer to turn the pumps on and off. A suggested pumping sequence would be to pump for 4 to 6 hours, then allow the water level to recover for a similar period of time and repeat the cycle. This sequence repeated for several days or weeks, with occasional checks to see that the side tubes are supplied with gravel, may result in some improvement in the yield of the wells.

Well 2N/10W-5Q1 (driller's number G-9) was drilled to a depth of 46 feet and, on August 17, 1965, had a static water level of 4.3 feet below the land surface (7.3 feet below top of casing). Test pumping on the same date indicated that this well had a specific capacity of about 0.4 gallon per minute per foot of drawdown (gpm/ft dd) for 15.7 feet of drawdown. It is suggested that this well be pumped at a rate not to exceed 5 gallons per minute (gpm).

A chemical analysis of the water (table 6) indicates that the chloride content is slightly more than is recommended by the U.S. Public Health Service and that the water is hard. Otherwise, it is chemically suitable for drinking purposes.

Well 3N/10W-28K1 (driller's number G-22) was drilled to a depth of 26 feet and, on September 14, 1965, had a static water level of 5.0 feet below the land surface (5.5 feet below top of casing). Test pumping on August 25, 1965, indicates that the well had a specific capacity of about 1.7 gpm/ft dd for 15 feet of drawdown. It is suggested that this well be pumped at a rate not to exceed 20 gpm.

According to U.S. Public Health Service standards water from this well is chemically suitable for drinking.

Well 3N/10W-28K2 (driller's number G-24) was drilled to a depth of 32 feet and, on September 1, 1965, had a static water level of 5.3 feet below the land surface (5.8 feet below top of casing). Test pumping September 12, 1965, indicated that this well had a specific capacity of about 1.3 gpm/ft dd for 13.7 feet of drawdown. It is recommended that this well be pumped at a rate not greater than 13 gpm.

Chemically, water from this well is suitable for drinking.

Table 7 lists the three wells, with information about construction, maximum yield, and suggested pumping rates to aid pump selection.

Table 6 --Chemical analyses of water from wells drilled in Point Reyes National Seashore area, 1965

(Analyses by U.S. Geological Survey)

Well number	2N/10W-5Q1	3N/10W-28K1	3N/10W-28K2
Date of collection	8-17-65	9-14-65	9-13-65
Temperature (°F)	-	75	75
Constituents in parts per million			
Silica (SiO_2)	23	16	21
Calcium (Ca)	31	11	9.8
Magnesium (Mg)	33	11	12
Sodium (Na)	152	66	82
Potassium (K)	2.7	1.7	1.1
Bicarbonate (HCO_3)	84	34	32
Carbonate (CO_3)	41	17	16
Sulfate (SO_4)	44	13	22
Chloride (Cl)	318	125	146
Fluoride (F)	.2	.1	.1
Nitrate (NO_3)	1.8	5.1	3.4
Boron (B)	.1	0	0
Dissolved solids			
Calculated	674	266	313
Hardness as $CaCO_3$	212	74	75
Noncarbonate hardness as $CaCO_3$	143	46	49
Percent sodium	61	65	70
Specific conductance (micromhos at 25°C)	1,190	522	594
pH	6.4	6.4	6.7
Laboratory number	50245	50340	50341

Table 7.--Data for three wells drilled in the Point Reyes National Seashore area in 1965

USGS well No.	Driller's well No.	Measured depth (feet below land surface)	Perforated interval (feet below land surface)	Static water level (feet below land surface)	Pumping water level (feet below land surface)	Discharge (gallons per minute)	Suggested rate of discharge (gallons per minute)
2N/10W- 5Q1	G-9	46	10-24	4.3	20	6	3-5
3N/10W-28K1	G-22	26	10-26	5.0	20	25	15-20
3N/10W-28K2	G-24	32	10-32	5.3	19	17.5	10-13

Well and Spring Canvass

Data from the canvass of the wells are listed in table 4, and the well locations are indicated in figure 1. The locations of numerous springs are also indicated; but the nature of the springs--mostly broad zones of seeps--made determination of yield more difficult than was warranted for this study. In many places the water from the seeps, or from ephemeral streamflow, is impounded behind small earthen dams, which are also shown in figure 1.

No attempt was made to determine the discharge of all streams in the area. However, the discharge was determined or estimated for 33 sites (table 8) on the principal and most accessible streams. These measurements were made in the dry part of year after a lengthy period of little or no rainfall. They thus have value in estimating low flow at the sites shown.

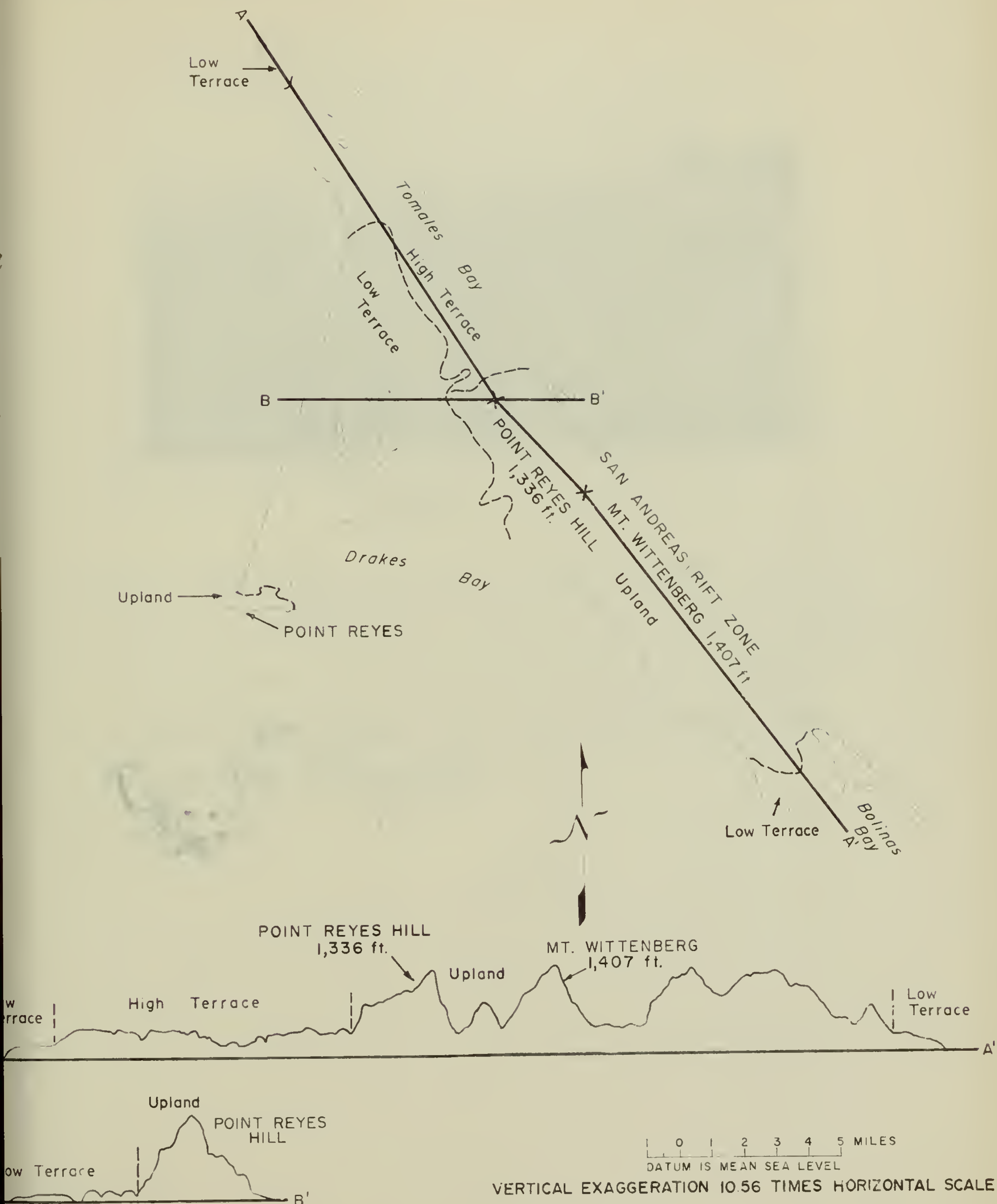
Table 8.--Streamflow at selected sites in the Point Reyes peninsular area

Date	Time (hours)	Discharge (gallons per minute)	Temperature (°F)		Methods of measurement
			Air	Water	
10/20/65	1130	15	72	52	Current meter
10/20/65	1200	½			Estimated
10/20/65	0930	63	68	53	Current meter
10/20/65	1000	12			Current meter
10/20/65	1400	77	76	53	Current meter
10/20/65	1430	10			Current meter
10/20/65	1530	2	72	52	Bucket
10/21/65	0900	10			Current meter
10/21/65	0930	5			Estimated
10/21/65	1030	60	70	54	Current meter
10/27/65	1100	16	73	55	Flume
10/27/65	1105	20	73	52	Flume
10/27/65	1030	34	66	52	Flume
10/27/65	1610	70	69	55	Flume
10/27/65	1625	53		54	Flume
10/27/65	1630	23		54	Flume
10/27/65	1700	25		54	Flume
10/28/65	1345	73	72	55	Flume
10/28/65	1415	56			Flume
10/28/65	1550	42	69	56	Flume
10/27/65	1710	1,300		55	Current meter
10/28/65	1615	33	59	57	Flume
10/27/65	1230	18			Flume
10/27/65	1245	200			Flume
10/27/65	1300	9			Flume
10/27/65	1330	14			Flume
10/27/65	1415	450	73	55	Estimated (> flume capacity)
10/28/65	1000	1.2			Bucket
10/28/65	0940	6	59	57	Flume
10/28/65	0915	53	57	55	Flume
10/28/65	1130	160	68	55	Current meter
10/28/65	1140	about 10			Estimated
10/28/65	1100	2,000			Estimated

[1]Sites are shown by numbered triangle in figure 1.
[2]Pine Gulch.

Test Holes

Twenty-eight test holes were drilled by the Park Service in 1965 preparatory to completing 3 production wells near Point Reyes Beach and the 2 production wells at the Park Headquarters at Bear Valley Ranch. The location of the test holes, except G-9, G-22, G-24, G-26, and G-28, now wells 2N/10W-5Q1, 3N/10W-28K1, 3N/10-28K2, 2N/8W-6N1, and 2N/9W-1K1, are shown in figures 15 and 16. Most of the holes not converted to production wells were filled in so that no trace of them remains. Consequently, Geological Survey numbers were not assigned to them; the numbers shown on figures 15 and 16 were assigned by the driller.

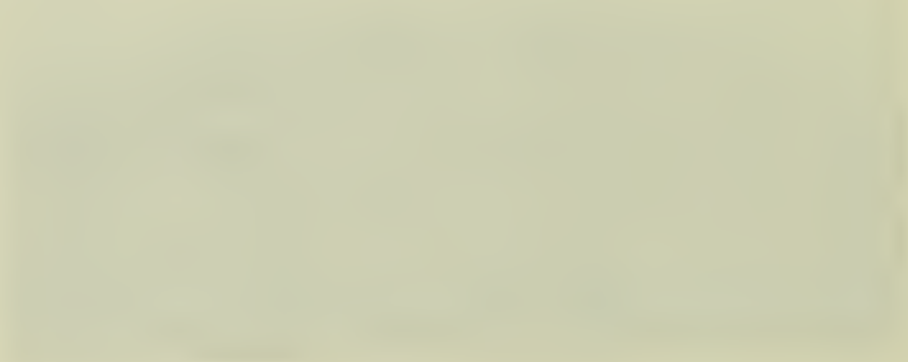


See fig. 9.

FIGURE 2.- GEOMORPHIC MAP

Figure 3.--View looking west from the summit of Drakes Summit Road (3N/9W-34). The upper basin of Laguna Creek is in the foreground; the low terrace is in the midground; and Point Reyes is in the background. This photo is taken in the saddle between Point Reyes Hill and Mount Wittenberg.

Figure 4.--View of Tomales Point looking northwest from BM 534 (4N/10W-15). The high wave-cut terrace is typical of the northern part of Inverness Ridge. Sand (Qs) lies on the basement complex (pTu) and forms the excellent reservoir that supplies McClure Creek. Trees in the midground mark the location of the Upper Pierce Ranch.



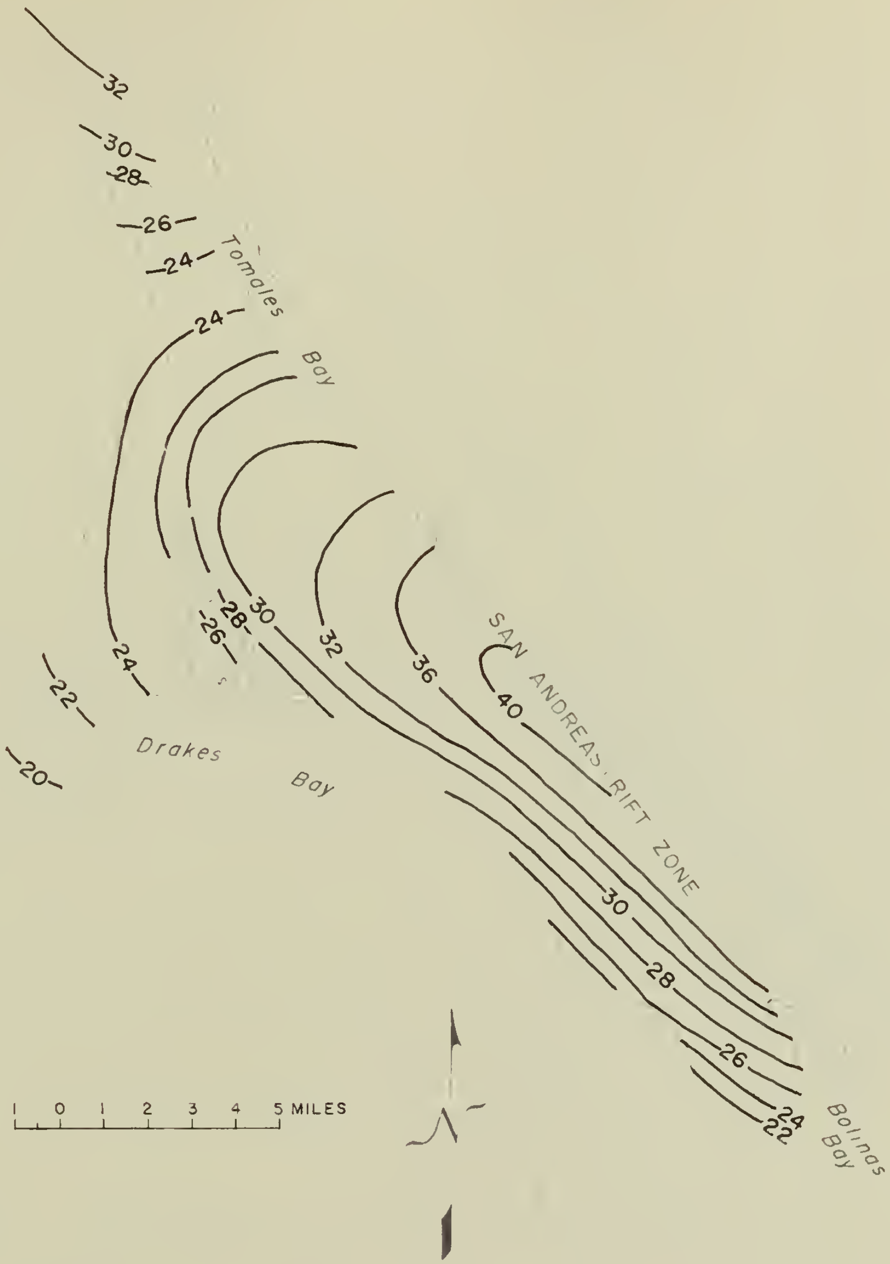


FIGURE 5.-PRECIPITATION MAP

CONTOURS ARE ISOHYETS OF AVERAGE ANNUAL RAINFALL, IN INCHES

FIGURE 6.–RUNOFF MAP

CONTOURS ARE ISOPLETHS OF AVERAGE ANNUAL RUNOFF, IN INCHES

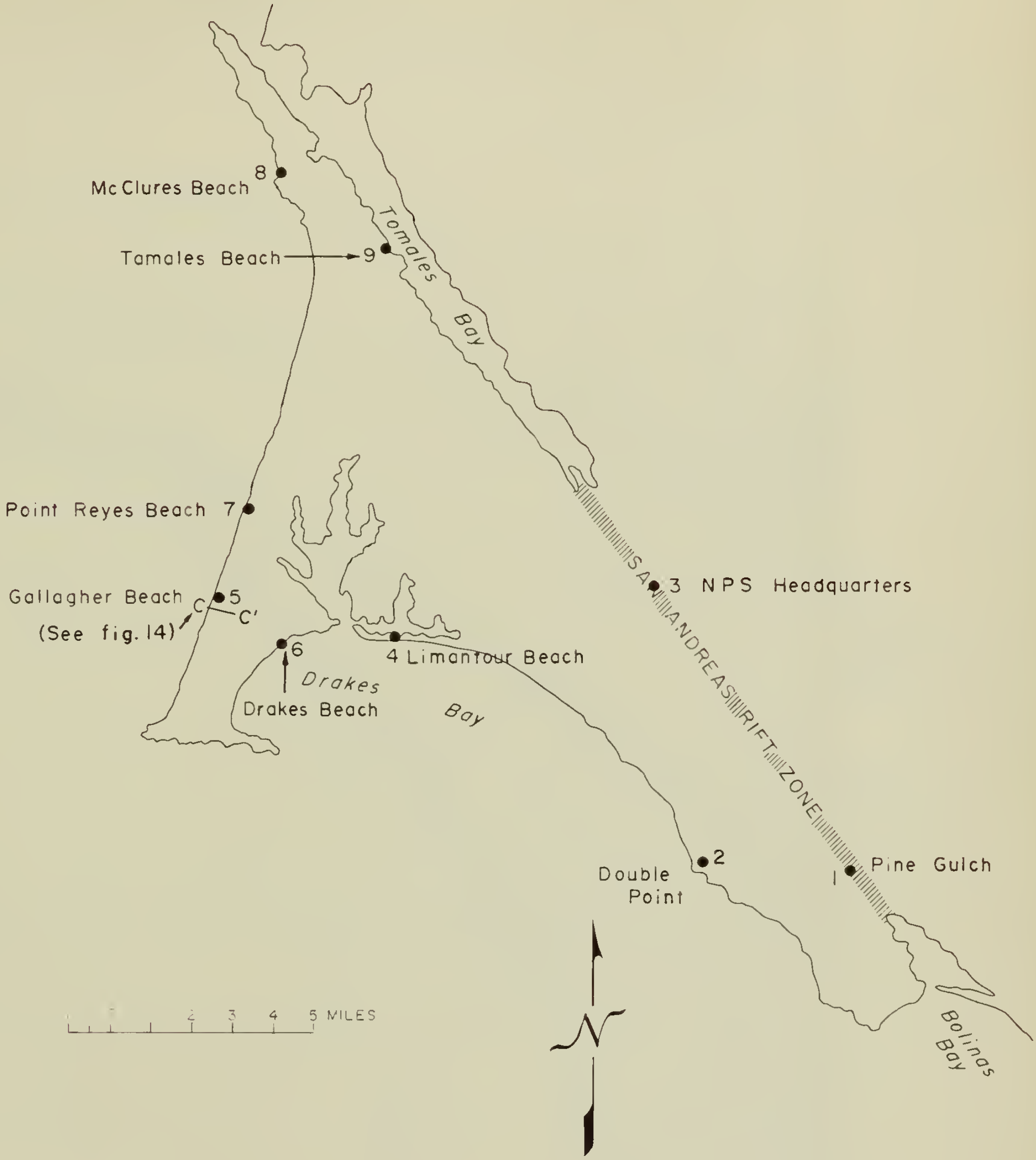


FIGURE 7.—PROPOSED DEVELOPMENT SITES

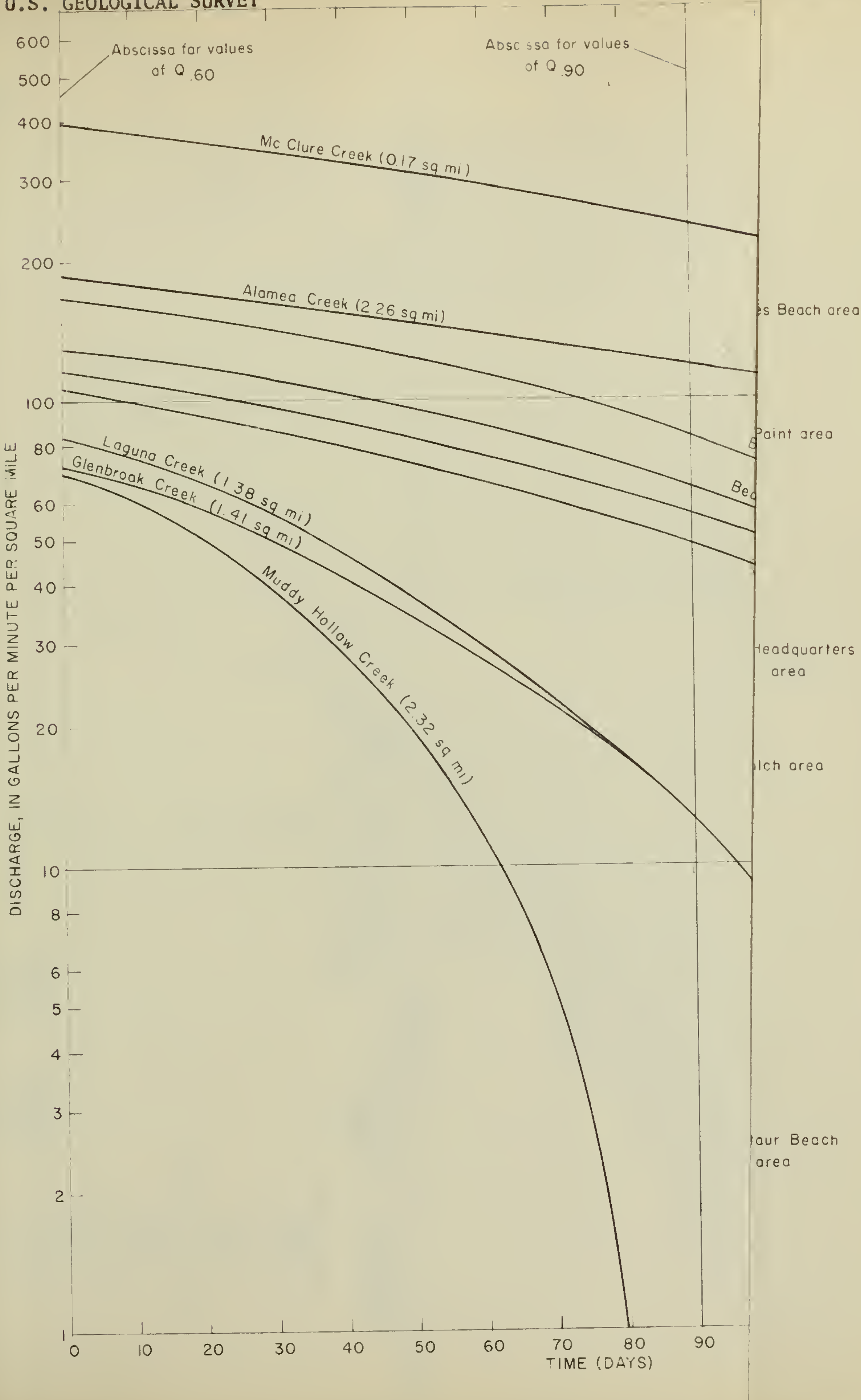


FIGURE 8.– BASE-FLOW RECESSION

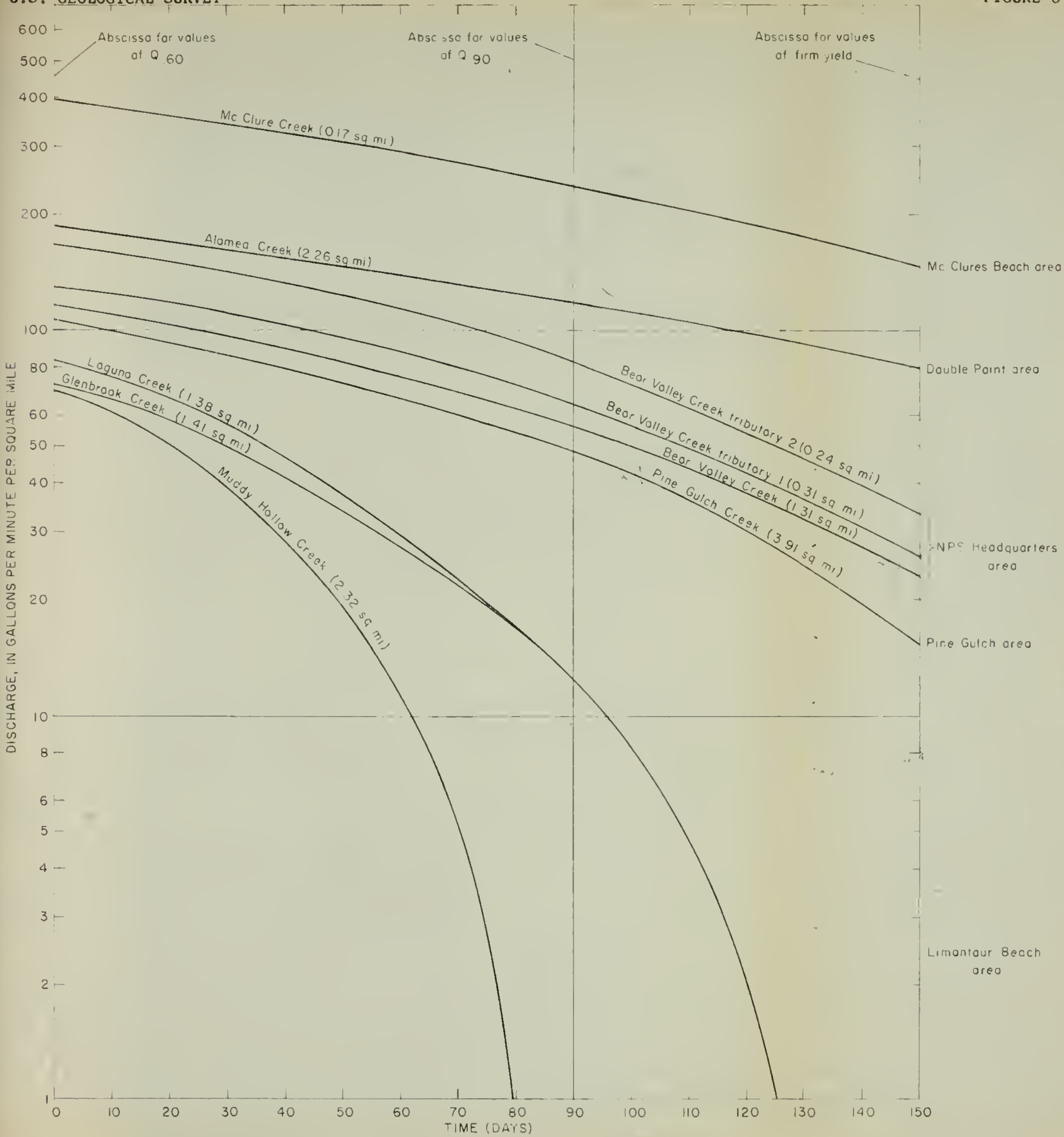


FIGURE 8.-BASE-FLOW RECESSION CURVES

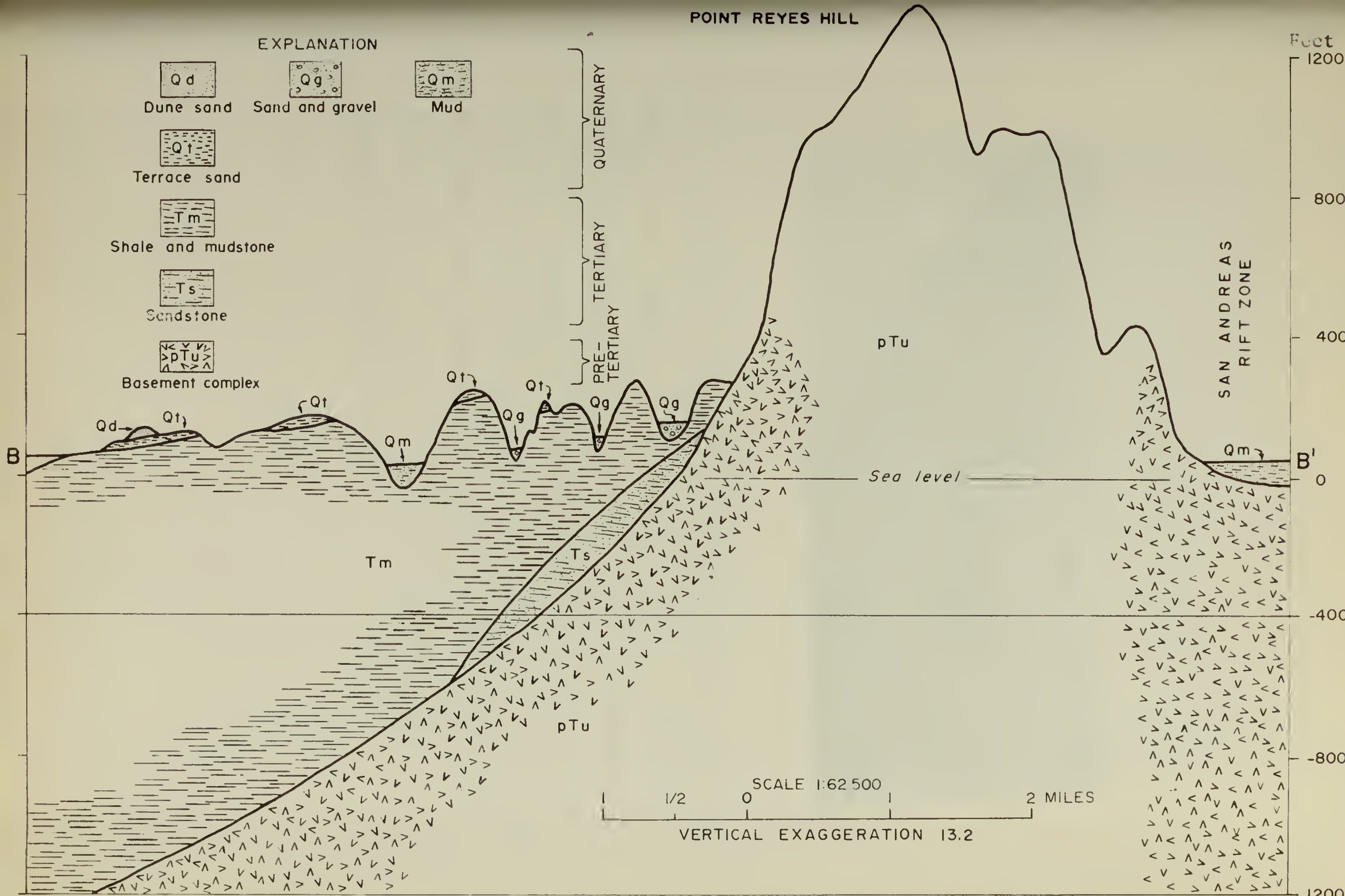


FIGURE 9.—GEOLOGIC SECTION B-B'.

Figure 11.--View from the Home Ranch road (3N/10W-24) toward well 3N/10W-25D1. The well is indicated by a circle. A destroyed well that previously supplied the ranch is in the foreground. Well 25D1 is about 80 feet above sea level and the low terrace (the flat-topped hills) is about 200 feet above sea level. Sand and gravel (Qg) at least 50 feet thick lies on mudstone (Tm). The stream flowing through this valley is typical of the Limantour Beach group of streams.

Figure 12.--The northernmost alluvial valley at Tomales Beach. The mouth of the valley is 120 feet wide. A well drilled at the location indicated by the circle probably will penetrate basement complex at less than 50 feet below land surface and probably will produce about 5 gpm. There is no perennial stream in this valley.

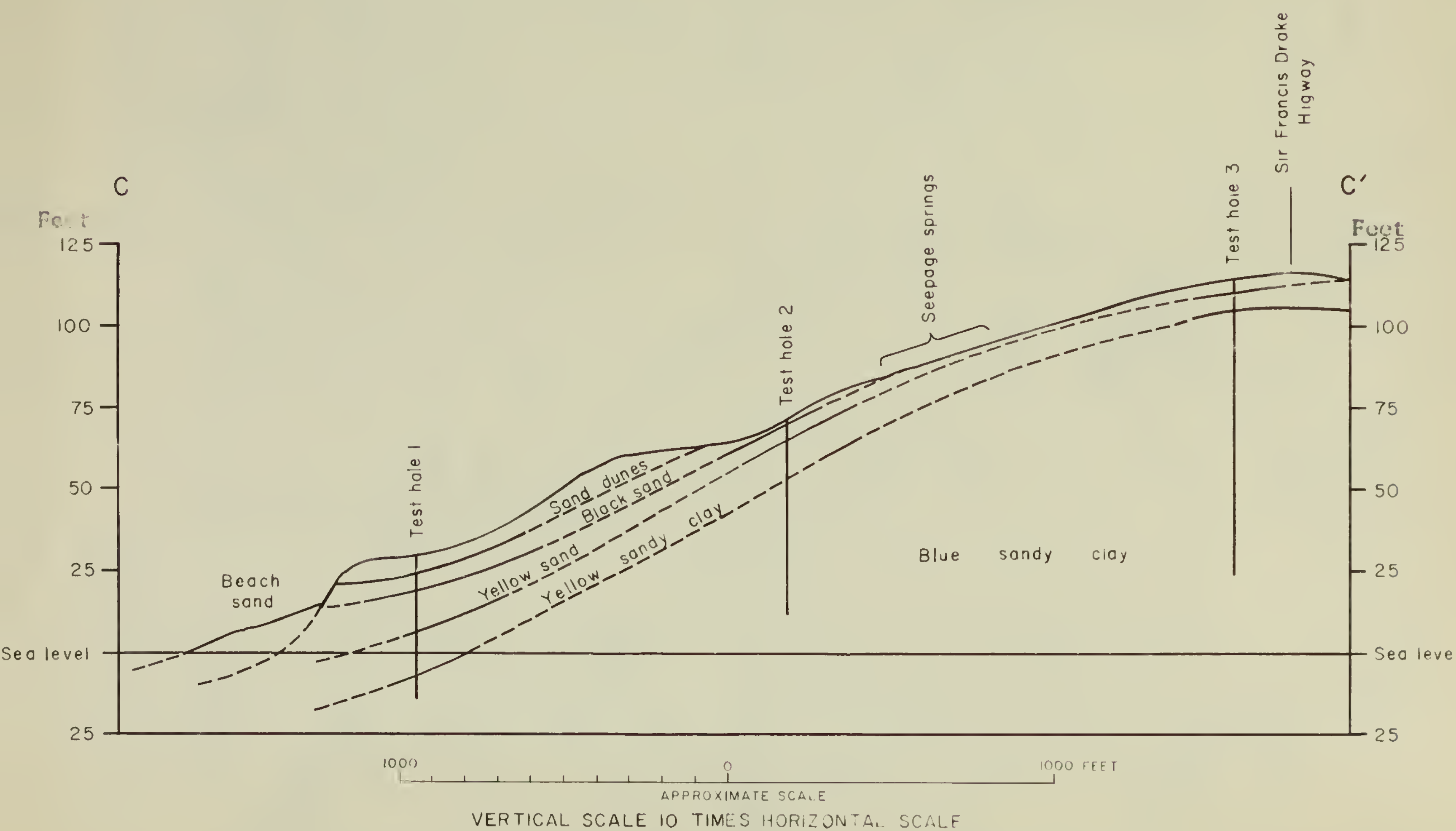
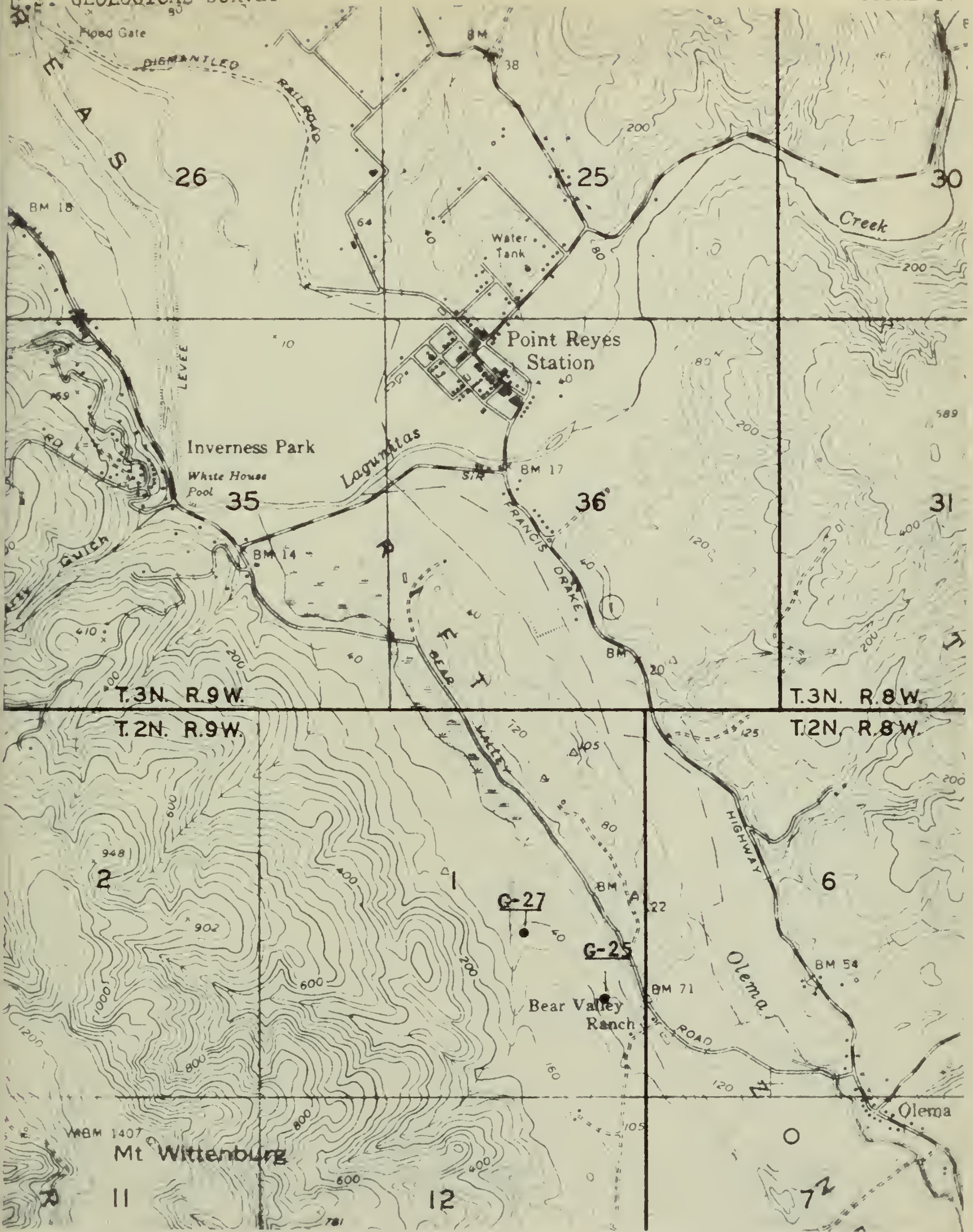


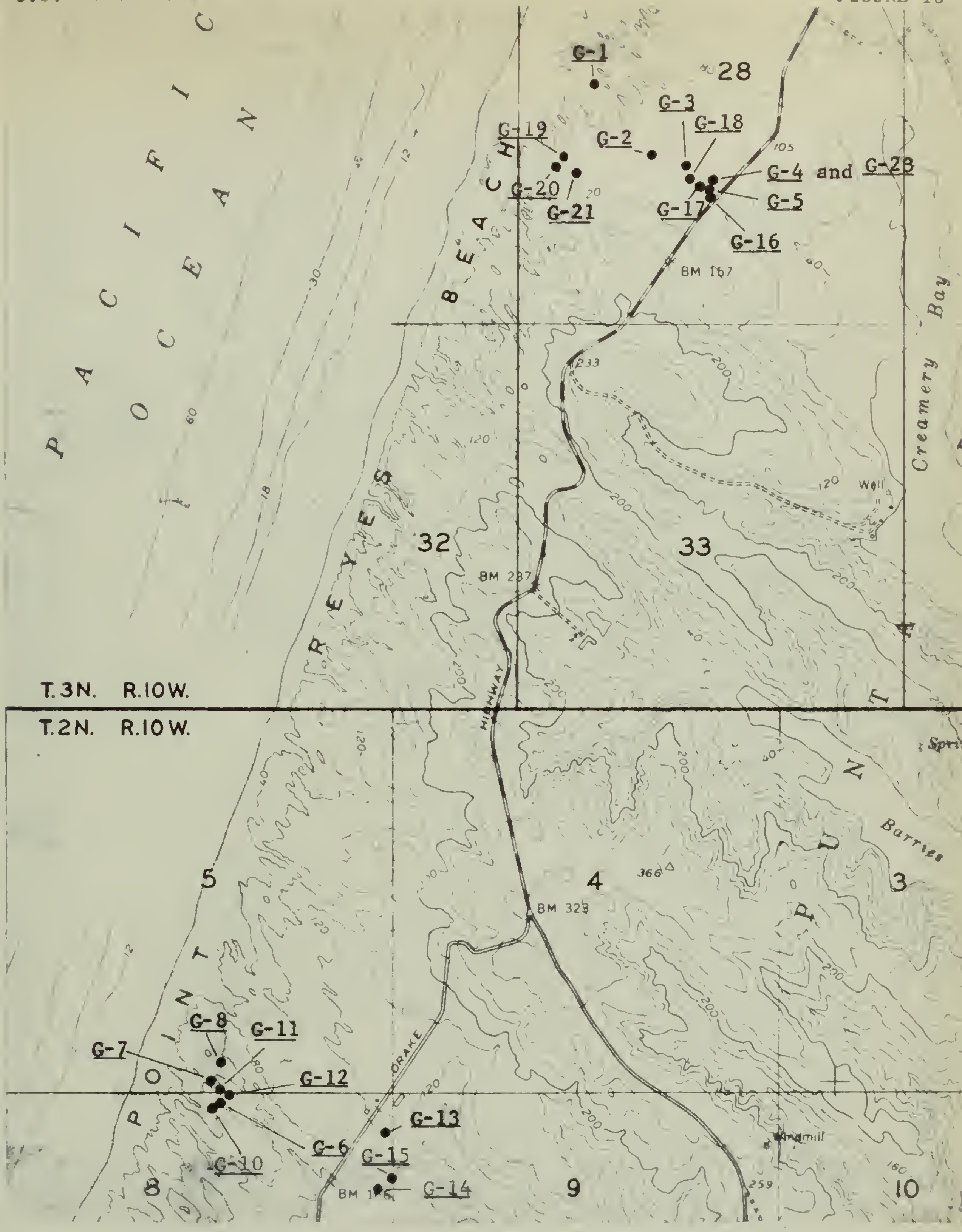
FIGURE 14.-SKETCH CROSS SECTION NEAR GALLAGHER BEACH



Base from U.S. Geological Survey topographic quadrangle: Inverness, scale 1:24,000

Test-hole locations by National Park Service. Numbers assigned by driller

FIGURE 15.--Map showing location of unused or destroyed test holes at Point Reyes National Seashore Headquarters, Bear Valley Ranch.



Base from U.S. Geological Survey topographic quadrangle: Drakes Bay, scale 1:24,000

Test-hole locations by National Park Service. Numbers assigned by driller

FIGURE 16.--Map showing location of unused or destroyed test holes in Point Reyes beach area.