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Water Resources Division

PROGRESS REPORT ON INVESTIGATION OF THE WATER RESOURCES OF THE NORTH VANDENBERG AREA, VANDENBERG AIR FORCE BASE, SANTA BARBARA COUNTY, CALIFORNIA

By

Stanley ✓ 1939-

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SUMMARY

This report summarizes the status of the water-resources investigation at the North Vandenberg area, Vandenberg Air Force Base, Calif., and is intended to keep the Department of the Air Force advised of the progress of the investigation.

The North Vandenberg area of the Vandenberg Air Force Base covers about 100 square miles along the Pacific Coast in Santa Barbara County, Calif. The climate is mild with daily temperatures ranging from 40° to 60°F in the winter and 60° to 70°F in the summer.

The geologic formations can be grouped into two categories: Consolidated rocks and unconsolidated deposits. The consolidated rocks consist of igneous, metamorphic, and sedimentary rocks which yield some water to wells from fractures. The unconsolidated deposits, composed of gravel, sand, silt, and clay, are moderately permeable and, where saturated, will yield water to wells. Most of the ground water used on the base is pumped from the alluvial deposits in the Santa Ynez and San Antonio Valleys.

A geologic map has been completed, and a water-level monitoring and sampling program is being organized.

Four possible sources for irrigation water near the Marshallia Ranch area are suggested. These sources are: (1) A deep well near the ranch, (2) a shallow well in San Antonio Valley, (3) a surface-water reservoir in San Antonio Valley, and (4) a pipeline connecting the ranch with the water-treatment plant in San Antonio Valley.

Other investigations now in progress are: (1) The development of a water supply in the Point Sal area, (2) the location of a test-well site in San Antonio Valley, and (3) the feasibility of returning effluent from a sewage-treatment plant to the ground-water supply to help prevent sea-water intrusion in the Santa Ynez Valley.

INTRODUCTION

Purpose and Scope of the Investigation

This report summarizes the status of the water-resources investigation at the North Vandenberg area, Vandenberg Air Force Base, Calif. The investigation is being made by the U.S. Geological Survey, Water Resources Division, under the immediate supervision of L. C. Dutcher, chief of the Garden Grove subdistrict office, and under the general supervision of Walter Hofmann, district chief in charge of water-resources investigations in California.

The purpose of this report is to keep the Department of the Air Force advised on the progress of the water-resources investigation at Vandenberg Air Force Base. The scope of this investigation includes the following:

1. The preparation of a map showing the geology, location of supply and observation wells, water- and sewage-treatment plants, storage facilities, and the principal pipeline systems.

2. The collection and tabulation of all chemical analyses, drillers' logs, water-level measurements, and ground-water pumpage.

3. The semiannual collection of water samples from wells for chemical analysis to detect any deterioration in ground-water quality, with specific reference to sea-water intrusion.

4. The periodic measurement of water levels in wells in the Santa Ynez and San Antonio Valleys to determine the effect of local pumping on the ground-water supply. Water-level measurements in the Santa Ynez Valley will also be useful in determining whether or not hydrologic conditions exist which may permit sea-water intrusion in the western part of the valley.

5. The investigation of the geologic and hydrologic conditions in the western part of the Santa Ynez Valley to determine if a threat of sea-water intrusion could be alleviated by returning treated-sewage effluent to the ground-water body.

6. The investigation of the geologic and hydrologic conditions in the Marshallia Ranch area to determine if an adequate water supply can be made available to meet local irrigation needs.

7. The selection of a test-well site in San Antonio Valley.

8. The investigation of the geologic and hydrologic conditions in the Point Sal area to determine if a ground-water supply can be developed.

9. The continuance of the U.S. Geological Survey as technical adviser to the Air Force on matters pertaining to the water resources of the base.

10. The preparation of annual reports advising the Air Force of any significant changes in the ground-water supply.

Previous Investigations

Reports by Dibblee (1950), Muir (1964), Upson and Thomasson (1951), and Woodring and Bramlette (1950) that describe the geology of the North Vandenberg area were used in compiling the geologic map for this report (fig. 2). Other reports on geologic investigations in the area include those of Evenson and Miller (1963) and Wilson (1959). Streamflow records for the San Antonio Creek and the Santa Ynez River are published by the U.S. Geological Survey.

Location and Extent of the Area

Vandenberg Air Force Base occupies about 150 square miles in the northwestern part of Santa Barbara County, Calif. (fig. 1). The base is about 15 miles south of Santa Maria and about 5 miles west of Lompoc.

The North Vandenberg area occupies about 100 square miles of the base and is bounded on the south by the Santa Ynez River and on the west by the Pacific Ocean (fig. 2). The eastern boundary extends to the northeast from the Santa Ynez River to a point about 3 miles south of Orcutt. From there the boundary extends northwestward to the Pacific Ocean near Point Sal.

The U.S. Disciplinary Barracks Military Reservation at the southeast edge of the base boundary is not part of the base, but its boundaries are shown in figure 2 because there are several supply wells for the base on the reservation.

Geography

The North Vandenberg area can be divided into two topographic regions. The Point Sal area, the Casmalia Hills, and the Purisima Hills make up the first region; Burton Mesa and San Antonio Terrace make up the second.

The first topographic region is mountainous with few buildings or improved roads in the area. The terrane ranges in altitude from about 600 to 1,650 feet above sea level and is covered with a profuse growth.

The majority of the base buildings and facilities are on Burton Mesa and San Antonio Terrace. This region ranges in altitude from sea level to about 600 feet above sea level and slopes gently toward the coast. The windblown sand that covers parts of San Antonio Terrace supports very little vegetation. However, most of the region is covered with grass and small brush. Although the base is not densely covered with trees, many large phreatophytes (plants that depend upon ground water for their supply) grow in parts of the Santa Ynez and San Antonio stream channels.

Climate

Temperatures in coastal Santa Barbara County are moderated by the onshore northwesterly wind. Daily temperatures average between 60° and 70°F in the summer and between 40° and 60°F in the winter. Temperatures seldom reach 100°F or fall below freezing.

The rainfall pattern is fairly uniform over most of the base. Of the 14 inches of mean annual precipitation, approximately 95 percent falls between November and May. The fog, which is common the year round, is the main source of moisture during the remainder of the year.

Well-Numbering System

The well-numbering system used for this investigation conforms to that used by the U.S. Geological Survey in California since 1940. It has been adopted as official by the California Department of Water Resources and by the California Water Pollution Control Board.

Wells are assigned numbers according to their location in the rectangular system for the subdivision of public land. For example, in the number 7N/34W-19J3, assigned to supply well 10, the part of the number preceding the slash indicates the township (T. 7 N.); the part between the slash and the hyphen is the range (R. 34 W.), with both township and range measured from the San Bernardino meridian and base line; the number between the hyphen and the letter indicates the section (sec. 19); and the letter indicates the 40-acre subdivision of the section shown in the following diagram.

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

Within each 40-acre tract the wells are numbered serially as indicated by the final digit. Thus, well 7N/34W-19J3 is the third well to be listed in the NE¼SE¼ sec. 19.

GEOLOGIC UNITS AND THEIR WATER-BEARING PROPERTIES

The geologic units in the North Vandenberg area, as shown in figure 2, can be grouped into two categories: Consolidated rocks and unconsolidated deposits. The consolidated rocks consist of igneous and metamorphic and sedimentary rocks, all of pre-Tertiary age. These rocks contain small quantities of ground water. The unconsolidated deposits consist of the Careaga Sand of late Pliocene age, the Paso Robles Formation of Pliocene and Pleistocene(?) age, the Orcutt Sand and terrace deposits of late Pleistocene age, and alluvium, landslides, and windblown sand of Recent age. These unconsolidated sedimentary deposits contain most of the ground water present in the North Vandenberg area.

Consolidated Rocks

The oldest of the consolidated rocks are the igneous and metamorphic rocks of the Franciscan Formation of Jurassic and Cretaceous age and igneous rocks of probable Tertiary age. These rocks, exposed near Point Sal, underlie the younger formations and are not considered a good source of ground water. However, small quantities of ground water may be present in fractures and deeply weathered zones.

Consolidated sedimentary rocks of pre-Tertiary and Tertiary age are exposed over much of the North Vandenberg area. These sedimentary rocks consist of beds of conglomerate, sandstone, mudstone, siltstone, shale, and limestone. Various combinations of these beds make up the Foxen Mudstone, the Sisquoc Formation, the Monterey Shale, the Point Sal Formation, the Lompoc Formation, and the Knoxville Formation. Combined, these formations may have a maximum thickness of about 10,000 feet, but they are generally impermeable and yield only limited quantities of ground water from fractures.

Unconsolidated Deposits

Careaga Sand

The Careaga Sand is a fine to medium sand of late Pliocene age. It is loosely consolidated and contains some silt and an abundance of well-rounded pebbles in the upper parts of the formation. The main outcrop of the formation occurs north of the Purisima Hills, where it is about 1,400 feet thick. Though the Careaga Sand yields ample water to wells, few wells are perforated in it because the fine silt and sand occurring in the formation tend to enter the wells through the perforations. Properly constructed wells, however, should eliminate this sanding and produce sufficient quantities of water to meet most supply needs.

Paso Robles Formation

The Paso Robles Formation, of Pliocene and Pleistocene(?) age, is exposed near the east boundary of the base in San Antonio Valley. The formation in this area is about 2,000 feet thick and is composed of loosely consolidated beds of gravel, sand, silt, and clay, with occasional beds of fresh-water limestone in the lower part of the formation. The sand is usually crossbedded, poorly sorted, and includes stringers of coarse sand and gravel. The formation does not yield water to wells as readily as does the alluvium. Nevertheless, it can be a major source of ground water if a saturated zone of sufficient thickness is penetrated.

Orcutt Sand

The Orcutt Sand consists of unconsolidated sand, pebbles, and lenses of clay and silt. The sand is late Pleistocene in age and has a maximum thickness of about 150 feet. The formation is exposed throughout much of the North Vandenberg area and acts as a catchment for rain. Because the Orcutt Sand is moderately permeable, it holds sizable quantities of water. However, the clay and silt lenses within the formation restrict ground-water movement; thus, wells perforated in this formation yield only moderate quantities of water.

Terrace Deposits

Terrace deposits of marine origin are exposed in the North Vandenberg area. These deposits are of late Pleistocene age and are composed of moderately permeable, crossbedded gravel, sand, silt, and clay. The maximum thickness probably does not exceed 75 feet. Most of the terrace deposits are above the zone of saturation and are not a source of ground water.

Alluvium

Most of the valleys and their tributary canyons are underlain with alluvium of Recent age. The alluvium, ranging in thickness from 0 to about 200 feet, is made up of unconsolidated clay, silt, sand, and gravel. In most areas the alluvium, which yields water readily to wells, is one of the main water-bearing deposits.

In San Antonio Valley the alluvium averages about 80 feet in thickness, the lower two-thirds of which is saturated throughout most of the valley. The alluvium is completely saturated in the areas of rising ground water in Barka Slough. Logs from test wells 8N/35W-10J1, 15E3, and 16E1 indicate that the alluvium in the western end of San Antonio Valley contains large amounts of clay. Thus, wells perforated in this part of the alluvium will probably yield less water than wells that are perforated in the alluvium near Barka Slough.

The alluvial deposits in the Lompoc plain are the most productive source of water in the area. Near the base these deposits, which are about 200 feet thick, contain an upper and lower member (Wilson, 1959, p. 6). The upper member consists of clay and silt with some strata of sand; the lower member consists of cobbles, gravel, and sand. The lower member, about 100 feet thick, is the main water-bearing zone. The static water level in this member ranges from about 3 to 20 feet below land surface. Beds of clay in the upper member range from 10 to 60 feet in thickness and tend to prevent the downward movement of ground water.

Windblown Sand

Windblown sand extends inland from the coast and covers parts of San Antonio Terrace, Burton Mesa, and the coastal area north of Point Sal. On San Antonio Terrace and Burton Mesa windblown sand has formed dunes of three different types--young, mature, and old, all of Recent age. The young dunes migrate and support little or no vegetation; the mature dunes are usually anchored by vegetation and are well preserved. The old dunes are also anchored by vegetation, but have lost their distinctive shape.

The sand has a maximum thickness of about 100 feet and, for the most part, lies above the zone of saturation. Thus, only small, perched water bodies within the sand could yield water to wells.

Landslides

Landslides are common in the Point Sal area. These deposits are of Recent age and are composed of rock debris which overlies the consolidated formations. Seeps and springs sometimes occur along the lower edge of the landslides, because the debris is more permeable than the underlying formations.

WATER RESOURCES

Ground Water

Ground water occurs in most of the unconsolidated deposits in the North Vandenberg area. The main water-bearing deposit is the alluvium, but the Paso Robles Formation, the Orcutt Sand, and the Careaga Sand also yield water to wells. The terrace deposits and the windblown sand are fairly permeable, but they are usually above the zone of saturation.

Recharge to the ground-water system is derived mainly from runoff that originates as precipitation on the higher elevations east of the base. Small quantities of recharge may occur directly from precipitation on the permeable deposits. Generally, the ground water moves from the east to the west through the Santa Ynez and San Antonio Valleys.

A syncline which underlies San Antonio Valley east of sec. 16, T. 8 N., R. 34 W., turns north at this point and forms a barrier to ground-water movement. This barrier forces some ground water to the surface where that which is not consumed by phreatophytes appears as surface flow. Part of the water used in the North Vandenberg area is pumped from the alluvium and from the Paso Robles Formation near this area of rising ground water.

Most of the water used in the North Vandenberg area is pumped from the alluvium in the lower Santa Ynez Valley. This alluvium contains ground water in an upper and a lower aquifer. The upper aquifer is semiperched and is the smaller of the two aquifers. The static water levels are about 10 feet below the land surface in the upper aquifer and about 15 feet below the land surface in the lower aquifer. Water levels in wells near the Santa Ynez River rise when the river flows, indicating that hydraulic continuity exists between the ground water and the surface water.

Ground water in Burton Mesa and San Antonio Terrace is probably limited to small, perched or semiperched water bodies. Although no wells are known to have been drilled in these areas, old records of springs and seeps substantiate the existence of these water bodies.

The alluvium in Schuman Canyon does not seem to contain an appreciable quantity of ground water. The alluvium is not extensive, and it is underlain by consolidated rocks.

Ground water in the Point Sal area may occur only in limited quantities. Most of the formations in the area are consolidated and will yield only small quantities of water from fractures and weathered zones. Small springs occur at the base of many of the landslides in this area. Development of these springs for a water supply to meet limited domestic needs may be possible. Small quantities of ground water may also be obtained from fault zones in the area.

Surface Water

The main sources of surface water on Vandenberg Air Force Base are San Antonio Creek and the Santa Ynez River. These two streams drain 1,030 square miles, about 55 square miles of which is within the base boundary. The remaining 45 square miles of the North Vandenberg area is drained by small ephemeral streams that flow directly into the ocean.

In San Antonio Creek, perennial flow past the gaging station near Casmalia has averaged 4,630 acre-feet per year for the 9 years of record (October 1955 to September 1964). The flow-duration table (table 1) shows the distribution of the average daily discharges for the period of record. An auxiliary gaging station has been installed on San Antonio Creek at the Lompoc-Casmalia bridge. The low-flow records from this station and those from the station near Casmalia are being used to determine if there is sufficient flow in San Antonio Creek to meet irrigation needs near the Marshallia Ranch.

The Santa Ynez River flows intermittently at the gaging station at the salt-water barrier near Surf. This flow usually occurs during the months from November to May and is the result of precipitation runoff and the release of excess water from upstream reservoirs. The average annual discharge for the period of record (1947-64) is 32,800 acre-feet.

Numerous small stream channels extend from Burton Mesa and the Casmalia Hills to the ocean. These short, steep channels carry flow only during periods of precipitation, and the resulting runoff has little effect on the water supply of the base.

Table 1.--Flow-duration table for San Antonio Creek near Casmalia, Calif.

Discharge (cubic feet per second)	Number of days when discharge was equal to, or greater than, that shown in first column but less than that shown on next line of first column										Days	Percent of time
	1956	1957	1958	1959	1960	1961	1962	1963	1964	Total		
0.1		2								2	3,288	100.0
.2		3						2		5	3,286	99.9
.3		2	3					1		6	3,281	99.8
.4								1	4	5	3,275	99.6
.5		7				1		6	21	35	3,270	99.5
.6		16		4	7	14		7	40	88	3,235	98.4
.7		27	1	3	28	5		8	16	88	3,147	95.8
.8	7	13		36	16	46	3	13	11	145	3,059	93.1
.9	20	28	8	9	14	17	6	11	7	120	2,914	88.7
1.0	120	27	66	51	90	44	82	44	13	537	2,794	85.0
1.5	36	67	76	69	54	66	48	46	27	489	2,257	68.7
2.0	34	59	48	61	65	40	80	64	54	505	1,768	53.8
3.0	62	67	49	80	34	76	47	65	106	586	1,263	38.4
4.0	46	22	20	21	22	30	25	54	41	281	677	20.6
5.0	23	17	41	21	19	20	39	27	20	227	396	12.1
10	8	8	13	7	12	5	7	10	3	73	169	5.14
20	2		10	1	2	1	5	3	3	27	96	2.92
30	2		6	1	2		2	1		14	69	2.10
40			6	1			4	1		12	55	1.67
50	3		6				6	1		16	43	1.31
100	3		12		1		11			27	27	.82
	366	365	365	365	366	365	365	365	366	3,288		

Quality of Water

Water samples for chemical analysis were collected in the North Vandenberg area by the Geological Survey in 1959. These samples were collected from wells in the Santa Ynez and San Antonio Valleys. Preliminary work indicates that the water quality in the Santa Ynez and San Antonio Valleys has not changed significantly since 1959.

Two water samples were taken from San Antonio Creek near the Lompoc-Casmalia bridge and analyzed to determine if the chemical quality would be suitable for irrigation purposes. The samples were taken in April and August 1965, during periods of low flow. The analyses indicate that the quality of the water is poor for irrigation of most soils during these months.

STATUS OF THE INVESTIGATION

Work on the water-resources investigation in the North Vandenberg area began in 1964. Basic data are being collected and analyzed to aid in solving particular water-supply problems in the area. A map (fig. 2) has been compiled showing the geology and the location of base-supply wells, test wells, and observation wells measured by the Geological Survey. The sewage- and water-treatment plants, the main pipeline systems, and storage tanks are also shown. In addition, all known springs and previously unlocated wells in the area will be mapped.

A previously established water-level measuring and sampling program in the southern part of the Vandenberg Air Force Base area is being continued. The data obtained from this program will be combined with data from a supplemental measuring and sampling program that will be initiated in the northern part of Vandenberg Air Force Base. The new program will include periodic water-level measurements and semiannual sampling for water quality from key wells within the base boundaries. These data will be included in the current program of collection and tabulation of all chemical analyses, water-level measurements, drillers' logs, and pumpage.

A water supply suitable for irrigation use is needed near the Marshallia Ranch, in sec. 10, T. 8 N., R. 35 W. The quantity of water needed varies from a negligible amount in the winter to about 4 to 5 million gallons per month during May through September. Four possible methods of obtaining this water have been considered: (1) A deep well near the Marshallia Ranch, (2) a shallow well in San Antonio Valley, (3) a surface-water storage facility in San Antonio Valley, and (4) a pipeline between the Marshallia Ranch and the water-treatment plant in San Antonio Valley.

A deep well near the ranch would probably penetrate about 30 feet of unsaturated terrace deposits before consolidated sediments are encountered. These sediments could be several thousand feet thick, and, if sufficient fractures are present, the sediments might yield some water to a deep well. A well 300 to 800 feet deep might produce a sufficient quantity of water to meet the irrigation requirements.

A shallow well perforated in the alluvium in San Antonio Valley might also yield sufficient ground water for irrigation use. Seven test wells have been drilled in this alluvium. Five of the wells penetrated a sand layer, about 10 feet thick, 60 feet below the land surface. This sand may yield enough water to a well to meet the irrigation requirements near the ranch. The quality of the water will be poor, but it may be suitable for irrigation on sandy soils. The best site for this well is near the Lompoc-Casmalia bridge, about a mile south of the ranch. To transport this water to the ranch would require about a mile of pipeline and possibly a small reservoir.

Approximately this same distribution system would be needed if the water supply were to be obtained from surface flow in San Antonio Creek. The flow-duration table (table 1) indicates that 99.5 percent of the time at least 0.5 cfs (cubic feet per second) of the flow passes the gaging station on San Antonio Creek near Casmalia. This minimal discharge of 0.5 cfs is equivalent to 9.7 million gallons per month, which would be adequate to meet the maximum irrigation requirement of about 5 million gallons per month. However, preliminary low-flow records from the auxiliary gaging station at the Lompoc-Casmalia bridge indicate that there is insufficient flow at the gage to meet the irrigation requirements of 5 million gallons per month. Thus, a diversion works and a small reservoir would be feasible only near the upstream station (about 1.5 miles from the ranch). This assumes that the streamflow will not be reduced by changes in upstream channel conditions.

Samples of surface water from San Antonio Creek were collected in April and August 1965 to determine their chemical constituents. The results are plotted in figure 3. This figure was developed in part by the French investigator Schoeller (1935), with modifications suggested by Edwin Berkaloff of the Bureau for the Inventory of Hydrologic Resources of Tunisia. As shown in the figure, the point where the projection of the line joining the total-hardness and sodium (Na) scales crosses the alkalinity scale determines the suitability of the water for irrigation. Figure 3 shows that the water quality is poor for irrigation use on most soils. However, the sandy soils near the ranch are probably sufficiently permeable to prevent salt buildup, thus this water probably is suitable for local irrigation.

The fourth source of irrigation water is the water-treatment plant in San Antonio Valley. A pipeline approximately 6 inches in diameter and about 3 miles long, extending from the plant intake to the Marshallia Ranch, could supply the quantity and quality of water required for irrigation near the ranch.

An investigation is in progress to determine if an adequate domestic water supply can be found in the Point Sal area. Two possible sources are being investigated: (1) Springs along the base of the landslides and (2) ground water in fractures and along fault zones in the consolidated rocks.

The development of springs as a source of water will require mapping the spring locations and determining the quantity and quality of the ground-water discharge. The investigation in the faulted areas will require precise mapping of the faults and a detailed investigation of the geology in the immediate area. Several test-hole sites will be selected, and the results of drilling will determine if a water supply can be developed.

A test well in San Antonio Valley should be drilled to determine the stratigraphic sequence and the water-bearing properties of the formations.

The investigation of sea-water intrusion in the Santa Ynez Valley will begin when more basic data are collected. Present data indicate that very little intrusion is occurring at this time. The feasibility of injecting treated waste water in the ground-water body to alleviate the threat of sea-water intrusion will be studied as part of the sea-water intrusion investigation.

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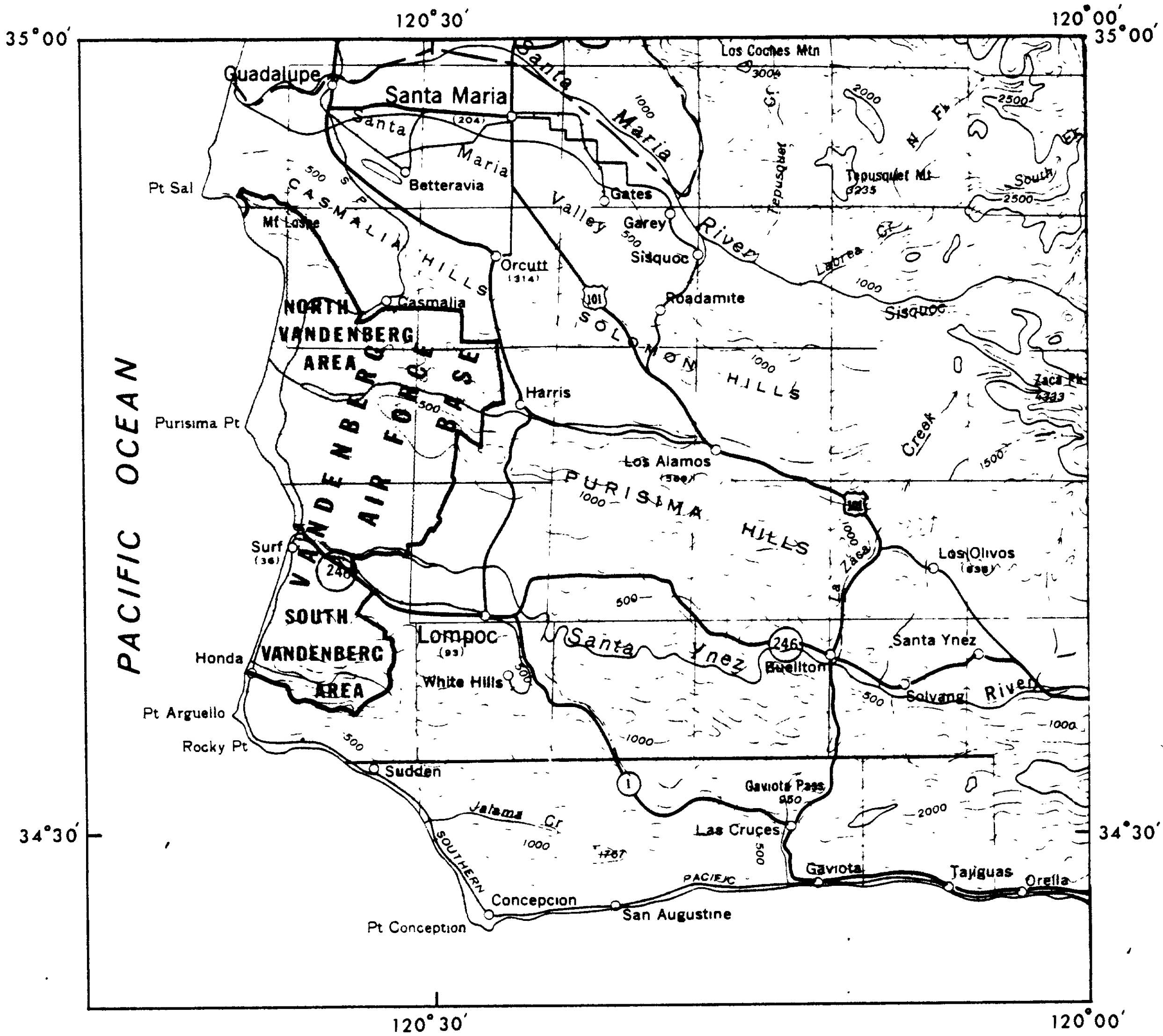
U.S. GEOLOGICAL SURVEY - PREPARED IN COOPERATION WITH THE DEPARTMENT OF THE AIR FORCE

FIGURE 1



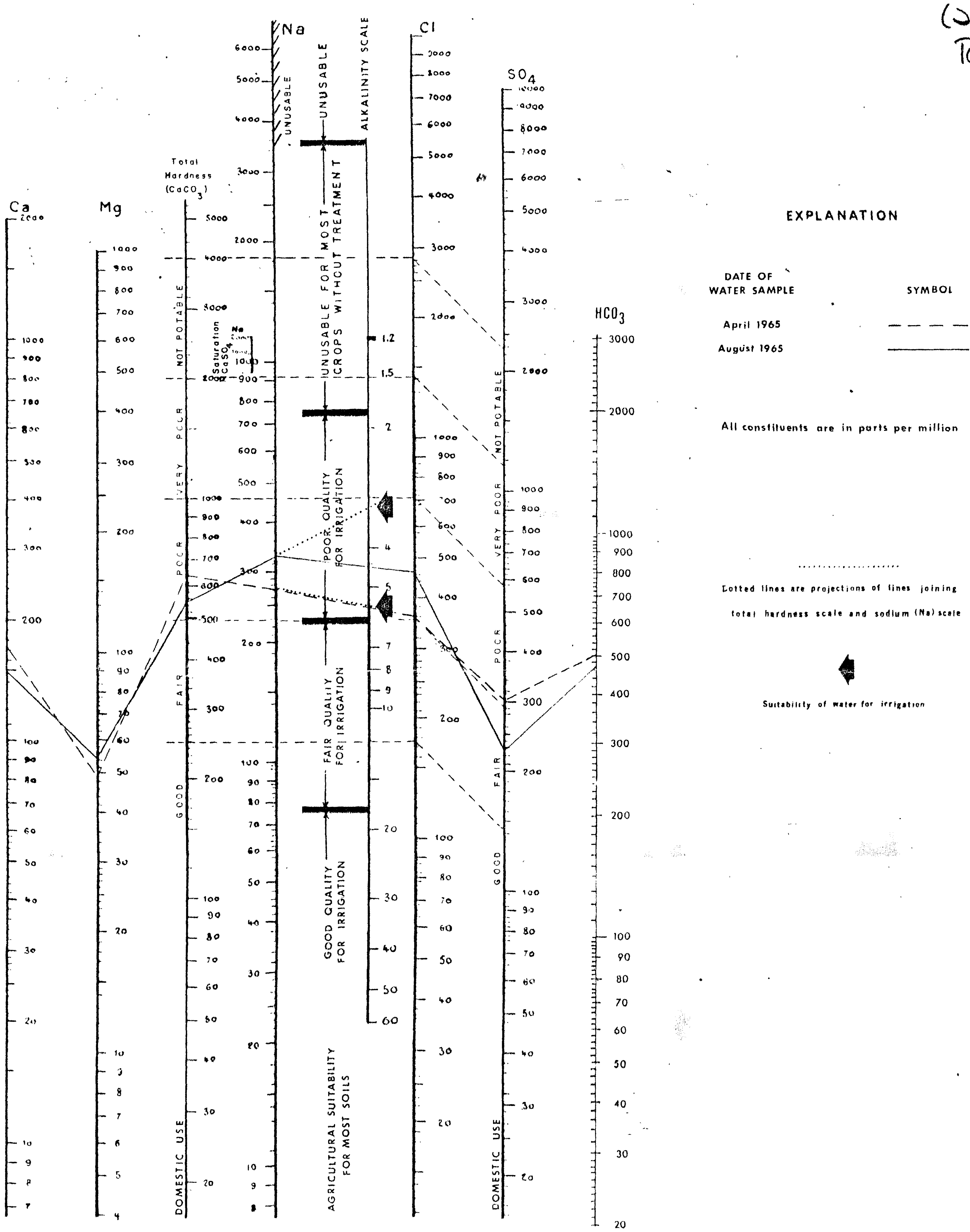
Map of part of Santa Barbara County, California, showing area described in this report

0 5 10 Miles

Scale

66-116

(200)
R576p



NOMOGRAPH SHOWING SUITABILITY OF WATER FROM SAN ANTONIO CREEK FOR DOMESTIC AND AGRICULTURAL PURPOSES