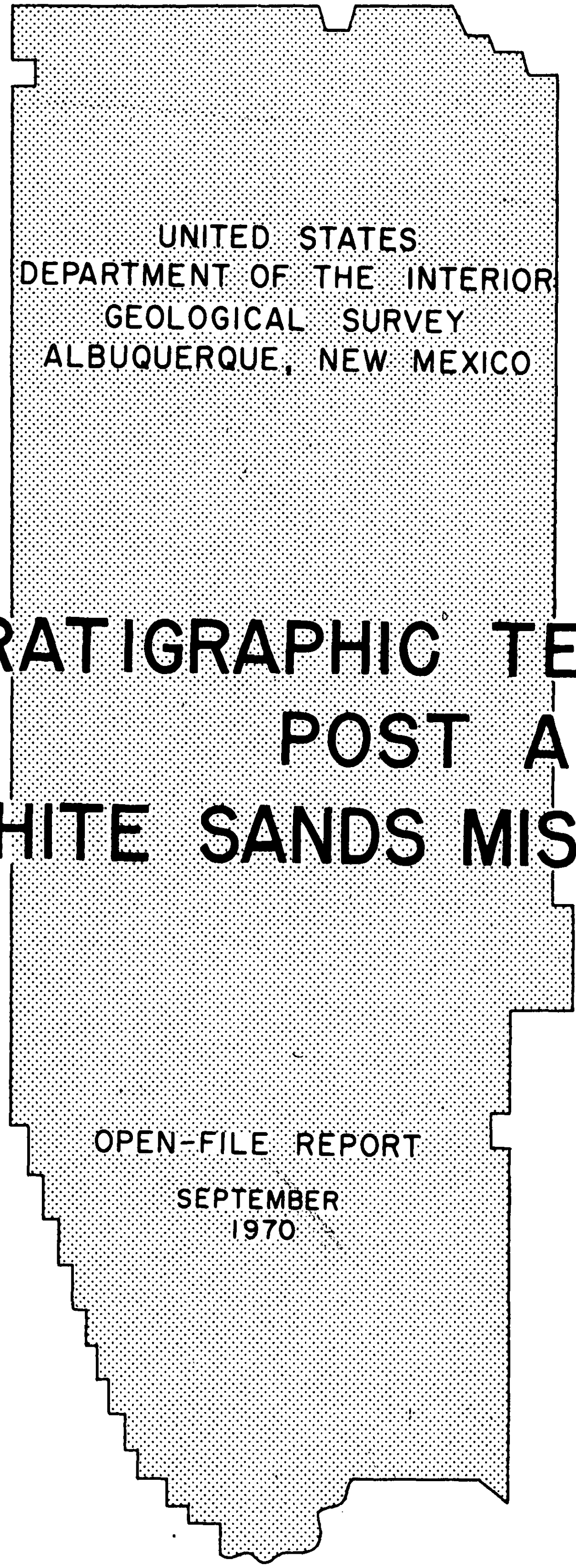


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
ALBUQUERQUE, NEW MEXICO

STRATIGRAPHIC TEST WELL T-14
POST AREA
WHITE SANDS MISSILE RANGE

By

Gene C. Doty

and

James B. Cooper

OPEN-FILE REPORT

SEPTEMBER
1970

Prepared in cooperation with the Department of the Army, White Sands Missile Range, New Mexico

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Albuquerque, New Mexico

Stratigraphic test well T-14, Post Area, White Sands Missile Range, Dona Ana County, New Mexico

By

Gene C. Doty and James B. Cooper

Open-file report

Prepared in cooperation with the Department of the Army,
White Sands Missile Range, New Mexico

September 1970

Contents

Illustrations

Tables

Stratigraphic test well T-14, Post Area, White Sands Missile Range, Dona Ana County, New Mexico

By

Gene C. Doty and James B. Cooper

Introduction

The Post Area of White Sands Missile Range is located at the edge of a reentrant in the mountains bordering the Tularosa Basin on the west. The Post Area is bounded on the south and southwest by the Organ Mountains, on the northwest by the San Augustin Mountains, and on the north by the San Andres Mountains (fig. 1). The total relief of the area is nearly 5,000 feet.

The western edge of the main part of the Tularosa Basin approximately parallels the access road from U.S. Highways 70 and 82 to the Post Area. The Tularosa Basin is an elongated north-south valley more than 200 miles long and 24 to 60 miles wide.

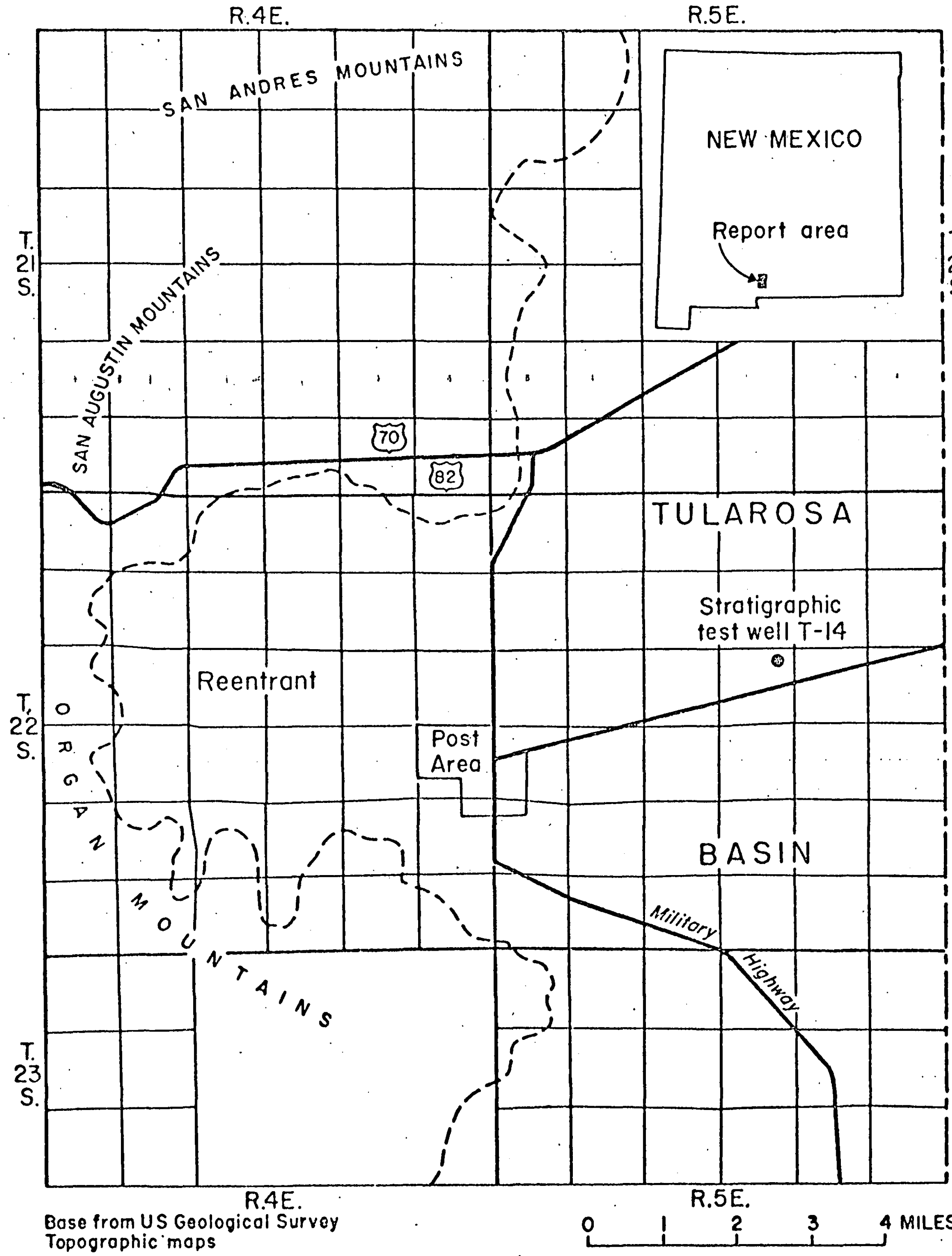


Figure 1.--Post Area, White Sands Missile Range, showing location of stratigraphic test well T-14.

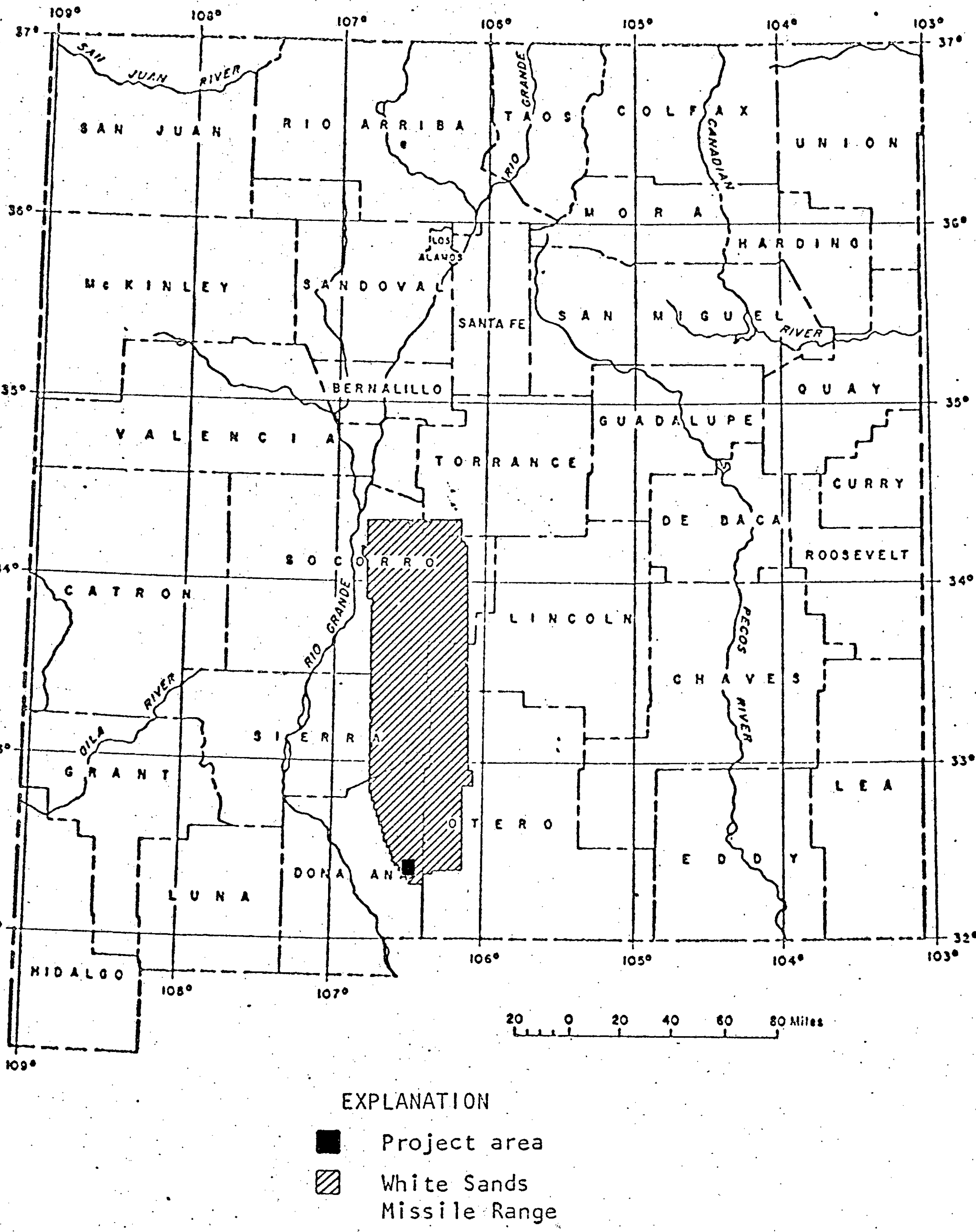
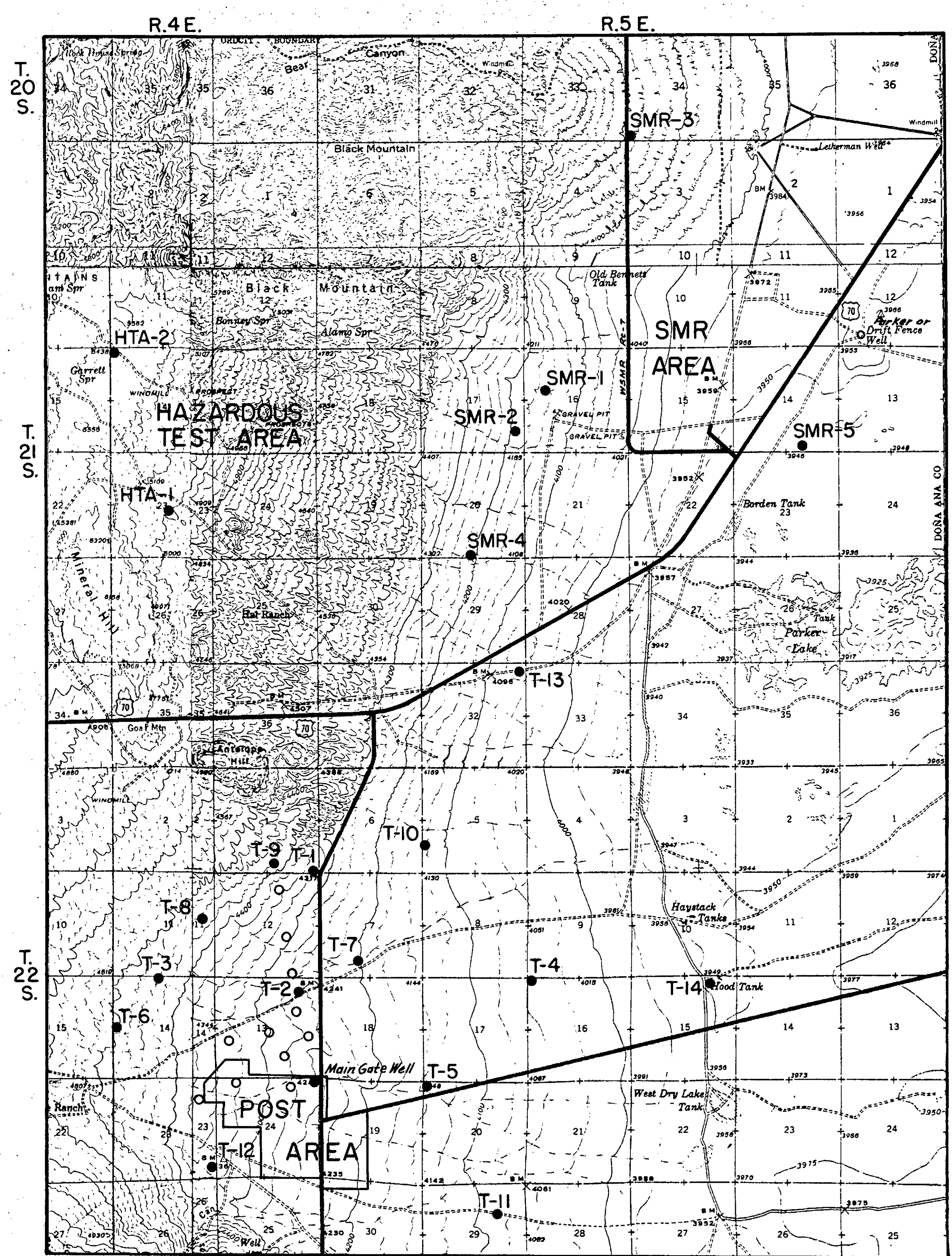


Figure 1.--White Sands Missile Range and project area (SMR, HTA, and Post Areas), New Mexico.



Map from U.S. Geological Survey 1:62,500 topographic maps

0 1 2 MILES

Contour interval 25 feet
Datum is mean sea level

EXPLANATION

● SMR-4 Test Well

○ Other Well

Figure 2.--Wells in and near SMR, HTA, and Post Areas, White Sands Missile Range, Dona Ana County, New Mexico.

Stratigraphic test well T-14 was drilled in 1967 to a depth of 6,015 feet about 4 miles N. 70°E. of the Post Area, White Sands Missile Range (fig. 1). The geography and hydrology of the Post Area has been described by Herrick (1960), Hood (1968), and Davis and Busch (1968); the reader is referred to these sources for detailed descriptions of the area.

Test well T-14 was drilled as a part of the White Sands Missile Range Water Master Plan for exploration and development of water resources. Objectives of the drilling program included determining:

1. The quality of water in aquifers at greater depths than previously investigated in the area.
2. The presence or absence of large quantities of near-potable water.
3. The depth to bedrock and the thickness of the bolson fill.
4. The physical and lithological composition of the bolson fill.
5. The adequacy of newly developed geophysical logging and computer-processing techniques to interpret lithology, porosity, and formation-water salinity.

The contract drilling depth of the test well was based upon the results of geophysical surveys made in February and March 1966 by the U.S. Geological Survey. The preliminary results of a seismic-refraction survey along an east-west profile line 2 miles north of the location of test well T-14 indicated a major velocity increase near a depth of 5,400 feet (written communication, Robert Mattick, 1966). This increase was thought to mark the bedrock interface.

The U.S. Army Corps of Engineers administered the drilling contract and supervised drilling operations. The U.S. Geological Survey provided technical assistance in selecting the drill site, preparing the drilling specifications, collecting water samples, and gathering hydrologic data. Geological Survey personnel involved in field-data collection included F. E. Busch, H. E. Lobley, and G. C. Doty, supervised by J. B. Cooper, Hydrologist, and W. E. Hale, District Chief.

Drilling methods and procedures

The drilling and hydrologic testing program for test well T-14 was as follows:

1. Drill to 200 feet and cement in 12 3/4-inch outside diameter pipe.
2. Drill a 7 7/8-inch hole to 6,000 feet.
3. Run geophysical logs and select zones for water sampling and hydrologic testing.
4. Collect water samples by bailing fluid from a pipe connected to a hydraulically inflatable packer, starting with the lowermost zone, and successively plugging the hole with cement and resetting the packer at the next higher sample zone, until all zones are sampled.

Initial move-in of equipment and site preparation began on 31 January 1967. Drilling began 9 March, and 200 feet of 12 3/4-inch outside diameter surface casing was cemented in the borehole by 21 March 1967.

Drilling continued with some interruption for short "fishing jobs" until 2 June 1967 when the hole had been drilled to a depth of 4,264 feet. At this time the contractor asked for and received permission to install 400 feet of 10 3/4-inch outside diameter "temporary" casing. The "temporary" casing included 50 feet of torch-cut slots in the lower section (table 1) that were placed opposite permeable zones, selected by the driller, in the event that the "temporary" casing could not be removed from the well.

Drilling was resumed 7 June 1967 and on 19 July a depth of 6,005 feet was reached. Geophysical logging began 20 July. Logging was interrupted on 21 July, after two logs had been completed, because the logging line fouled during an attempt to drive the sonde through a "bridge" across the hole at a depth of about 5,410 feet. The drilling contractor then decided to go into the hole with coring tools to clean the hole and to collect a core sample from the bottom of the hole. The coring run was completed at a depth of 6,015 feet. The rate of penetration during coring was erratic; when the coring tool was brought to the surface, the cutters and rollers of the bit were completely worn away. The geophysical logging was then completed without further interruption on 22 July.

Computer readout of the geophysical logs was delayed by malfunctioning of the equipment. The computed logs were not obtained until 15 August 1967. Mr. Roy Vann of the Schlumberger Well Surveying Corporation personally brought a copy of the computed logs to the Albuquerque office of the Geological Survey and assisted Geological Survey personnel in the selection of aquifer zones from which to collect water samples.

The drilling contractor was informed of the depth intervals of the aquifer zones to be sampled. He then cleaned out the hole, thoroughly reconditioned the drilling fluid, and began water-sampling operations on 20 August 1967.

Completion of the water-sampling program was delayed until 20 October 1967 because of difficulty in obtaining a tight-packer seal in the lowermost sample zone. A "fishing job" for the pipe string and packer after the first sample was obtained, and a ruptured packer envelope after the fourth sample had been obtained, also delayed the program.

The 400 feet of "temporary" 10 3/4-inch outside diameter casing installed by the contractor for his own use could not be removed and was retained as permanent casing. The formation opposite the slotted casing was then washed and bailed until free of drilling fluid, a concrete slab was constructed around the well head, and the well was retained to monitor changes in water level. Data pertinent to the completed well are included in table 1.

Table 1.--Summary record of test well T-14, Post Area, White Sands Missile Range, Dona Ana County, N. Mex.

LOCATION: NW¼NE¼NE¼ sec. 15, T. 22 S., R. 5 E. USGS NO. 22.5.15.221

LATITUDE: 32° 24' 01" LONGITUDE: 106° 24' 52" ALTITUDE: 3,950 feet

Depth: 6,015 feet (plugged back and completed at 370 feet)

DATE COMPLETED: October 1967 DRILLING METHOD: Hydraulic rotary

DRILLING CONTRACTOR: Boyd and Son Drilling Co., Las Cruces, N. Mex.

CASING AND HOLE RECORD: Twelve and three-quarter inch outer-diameter casing cemented in to 200 feet; 10 3/4-inch outer-diameter casing from 0 to 400 feet with 1/8 x 2 3/4-inch torch-cut slots from 210-230, 260-270, 290-300, and 350-360 feet; cement plug from 370 to 410 feet; 7 7/8-inch hole filled with mud and cement plugs, at intervals, from 6,015 to 370 feet.

YIELD: Not test pumped; bailed at 10 gallons per minute for 7 hours after completion at 370 feet.

NONPUMPING WATER LEVEL: 131.36 feet on 1-11-68 (completed well)

CHEMICAL QUALITY OF COMPLETED POTABLE ZONE:	Date	Depth interval (feet)	Specific conductance (micromhos at 25°C)	Sulfate (mg/l)	Chloride (mg/l)
	10/20/67	210-360	833	161	81

FORMATION LOGS: 1) Sample description; 2) dual induction-laterolog; 3) sidewall neutron porosity; 4) compensated formation density; 5) borehole compensated sonic 6) proximity log-microlog; 7) temperature; 8) computed logs.

GEOLOGIC SOURCE: Bolson fill

USE AND REMARKS: Observation well to monitor water-level changes and water quality. Depth-to-water measurements are made every 3 months. Drilled as a stratigraphic test well.

Geophysical logs

An extensive set of geophysical logs (figs. 2a-f, in pocket) was made in test well T-14. Data from these logs were used to determine the lithology, porosity, and salinity encountered in this borehole. A computer program developed by the Schlumberger Well Surveying Corporation was employed to process this information and make the thousands of calculations required. The several logs also provide the best means of preserving borehole data for future reference to the hydrology and geology of the area. Data from the logs were used by Geological Survey geophysicists as additional control for surface seismic and electrical resistivity studies of the subsurface conditions of the Post Area (Zohdy and others, 1969, p. 15).

The data traces were recorded on magnetic tape in addition to the conventional film required for data processing. The appropriate traces were then processed in a computer programmed to compute the parameter values needed for each foot of recorder log in order to determine the lithology, porosity, and salinity (figs. 3a-d, in pocket). The numerous computations required preclude similar detailed processing by manual methods.

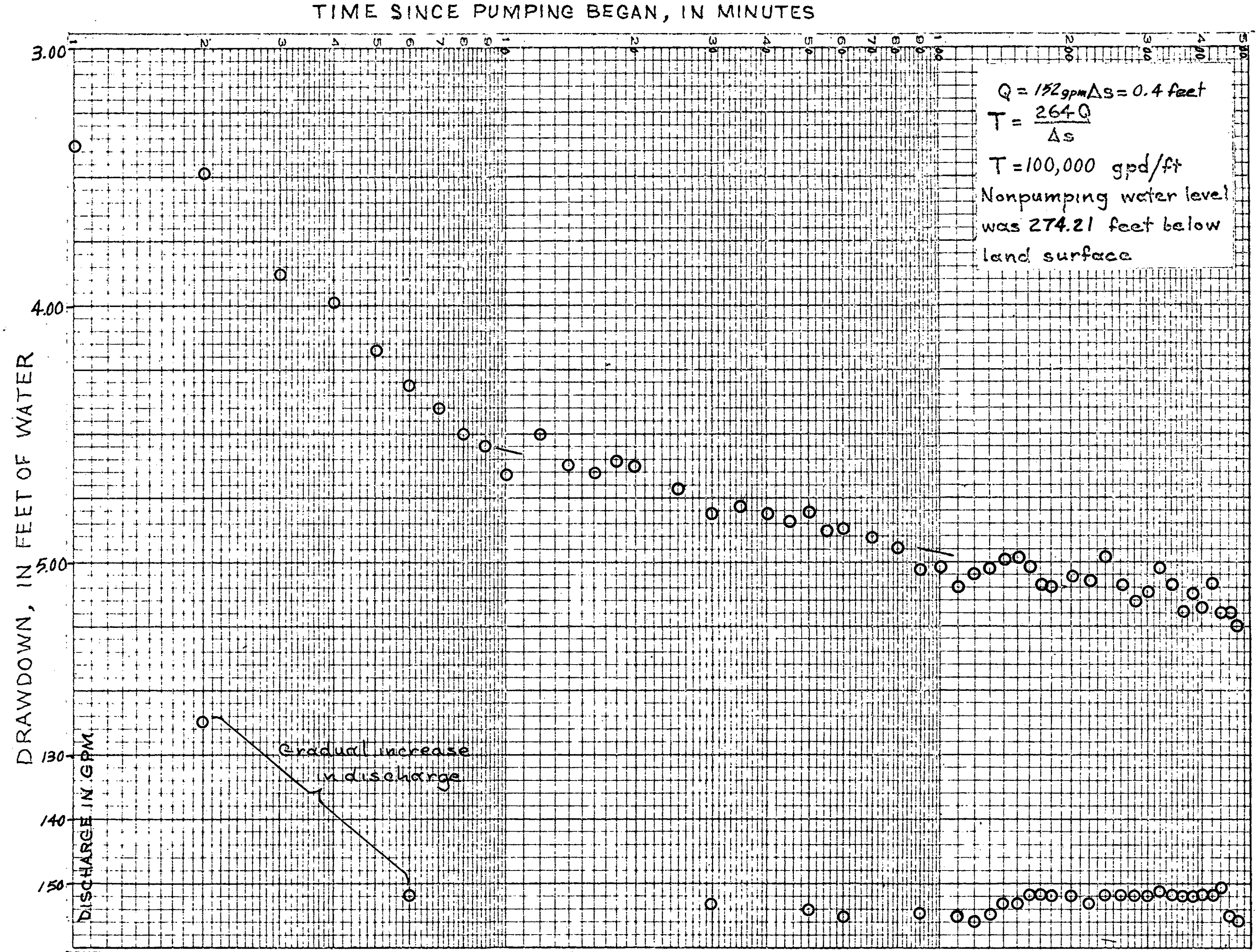


Figure 4.--Drawdown in test well SMR-4, December 29, 1967, White Sands Missile Range, Dona Ana County, N. Mex.

Careful control of the borehole conditions, especially hole configuration, drilling-mud consistency, and mudcake thickness on the sidewall, is necessary to obtain optimum quality input data for either manual or computer processing of geophysical logs. Borehole conditions in test well T-14 were not ideal and data needed for lithology and porosity computations between 2,750 and 4,650 feet were unreliable. The mudcake was too thick for proper formation contact of pad-type sensing equipment, possibly as a result of the long time required to drill the hole, or possibly because of the effect of filtrate water on the formation clays.

The porous beds penetrated by test well T-14 were, in most cases, relatively thin. The logging equipment probably was not capable of defining or measuring the closely-spaced changes in bed characteristics encountered in this borehole. Presumably slight changes in density as the result of compaction or cementation also affected the accuracy of the logs.

Formation lithology as percentage of bulk volume is shown on the computed lithologic log of test well T-14 (fig. 3a). Volcanic materials are indicated to comprise 1 to 20 percent of the bulk volume from 4,040 to 4,230 feet. From 4,320 to 4,710 feet volcanic material is indicated to comprise 20 to 50 percent of the bulk volume. From 4,710 to the bottom of the log at 5,962 feet, 50 to 80 percent of the bulk volume is indicated to be volcanic material.

Samples of drill cuttings from the well were examined microscopically (table 2) and were found to consist mostly of arkosic sand, silt, and clay. Volcanic materials, if present, were not identified as such. Due to borehole conditions, it is possible that representative formation samples may not always have been obtained. It is also possible that assumptions made for the computer program were not compatible to formations drilled in test well T-14.

Porosity is also indicated on the computed lithologic log. The porosity determinations show some correlation with the sample-description log. For instance, the sample log indicates that the section below 4,650 feet is mostly sand--the computed porosity log indicates a sharp increase in total porosity beginning at 4,650 feet.

Salinity data, shown on computed log for the interval from 400 to 5,970 feet shows zones of maximum and minimum salinity although the computed salinity values do not agree well with laboratory analyses of water samples.

The individual logs were an aid in interpreting the general quality of the water in the formations penetrated in the hole. The dual induction-laterlog (fig. 2a) indicates that the salinity of the formation water increases gradually from a depth of about 515 feet to about 3,650 feet. From about 3,650 feet to total depth, the water is slightly less saline than water in the interval above 3,650 feet.

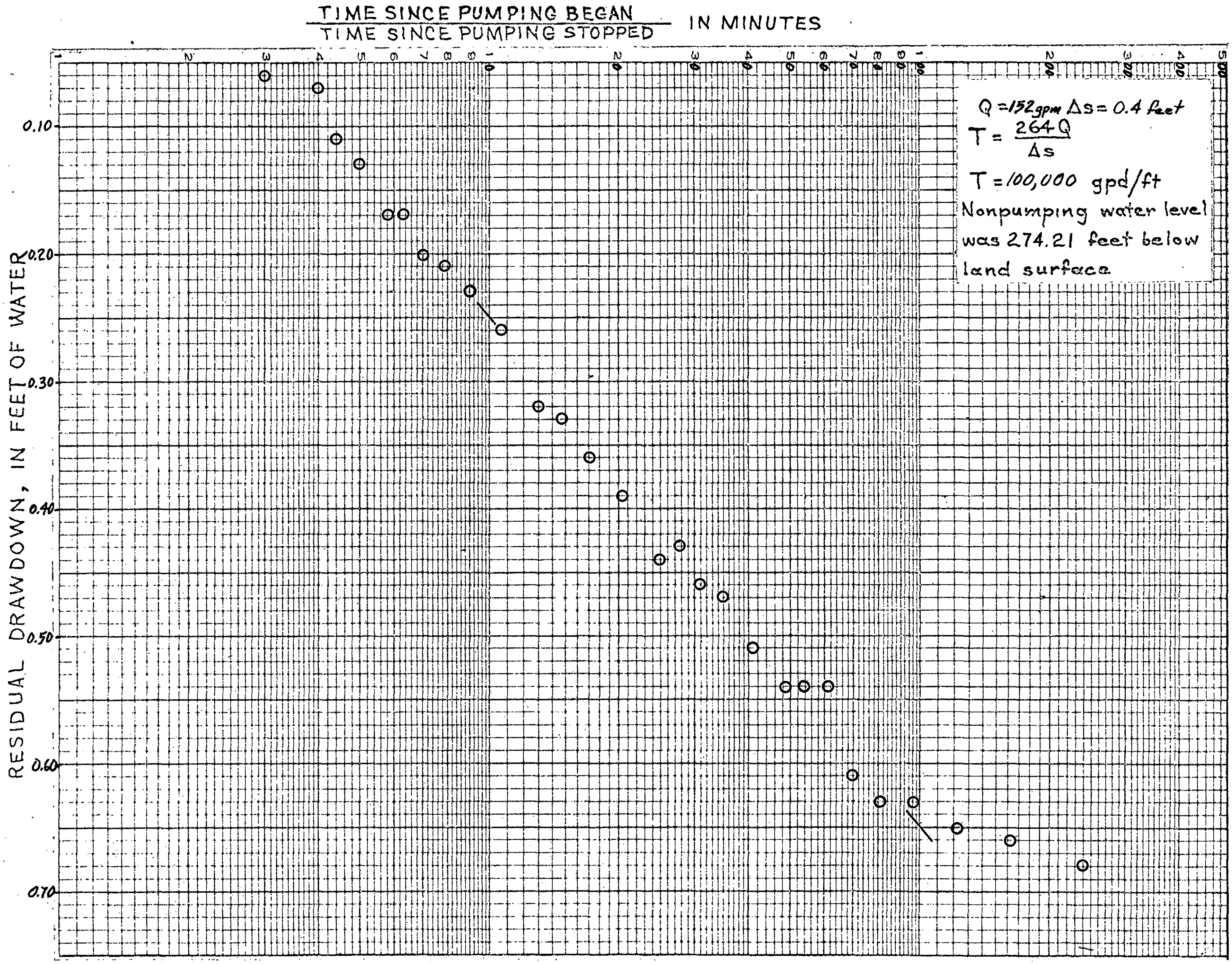


Figure 5.--Residual drawdown in test well SMR-4, December 29, 1967, White Sands Missile Range, Dona Ana County, N. Mex.

The proximity log-microlog with caliper (fig. 2b) indicated the relative permeability of the formations penetrated in the hole, and the hole size. These data combined with data from the sidewall neutron porosity log (fig. 2c) were used to determine aquifer zones for water sampling and suitable depths in the hole at which to place the packer.

The borehole compensated sonic gamma-ray log (fig. 2d) and the compensated formation density log, with gamma-gamma (fig. 2e) were useful in the interpretation of drill-cutting samples (table 2) and to Geological Survey geophysicists as an aid in the interpretation of surface seismic and electrical resistivity data.

The temperature log (fig. 2f) could not be completed below a depth of 3,290 feet due to a bridge in the hole. In addition, it is probable that tool trouble prevented accurate measurements of temperature. Extrapolation of log data below 2,500 feet and a bottom-hole temperature recorded by a maximum-reading thermometer suggests a near-surface temperature of 85°F. The temperature of the water sample taken at the well head from the completed well (table 3) was 24°C (75°F). The temperature of the water sample was measured within a few minutes after the water was removed from the formation. Thus, the measured temperature of 24°C is thought to be within a few degrees of formation temperature.

The interpretation of geophysical logs using a computer is a logical technical advancement. Borehole conditions in part unfavorable to logging make test well T-14 a poor testing ground for the procedure.

General geology

Rocks exposed in the Post Area range in age from Precambrian to Holocene. The Organ and San Augustin Mountains are composed principally of Tertiary intrusive and extrusive rocks. In the northern part of the San Augustin Mountains and in the San Andres Mountains, Paleozoic sedimentary rocks overlie Precambrian granite. The north half of the reentrant is a pediment surface developed on a Precambrian basement complex; several prominent hills of Precambrian rocks rise above the pediment surface. The south half of the reentrant is underlain by unconsolidated bolson deposits (Herrick, 1960, p. 2) as is the main part of the Tularosa Basin east of the reentrant.

Because the Tularosa Basin is a bolson, as the term is generally used (Fenneman, 1931, p. 385), all unconsolidated materials within the basin are referred to as bolson deposits. These unconsolidated materials include older materials of probable Tertiary age as well as younger deposits of Quaternary age. The bolson deposits within the basin consist of alternating layers of clay and sand. Most of the sand layers contain some clay. Many of the deposits are gypsiferous. The sand is composed principally of feldspar and quartz, derived from the granite and related igneous rocks of the Organ and San Augustin Mountains, and is generally poorly sorted.

The present topography of the area was produced by faulting and erosion during Tertiary and Quaternary time. A pronounced scarp in the bolson deposits extends along much of the eastern base of the Organ Mountains (Herrick, 1960, p. 41).

Herrick (1960, p. 26) states that in the reentrant, bolson deposits extend to depths greater than 1,500 feet and probably overlie rocks that are mainly Precambrian granite.

Geologic section penetrated by test well T-14

The material penetrated during the drilling of test well T-14 consists mostly of sand, silt, and clay (table 2). Some samples of drill cuttings contained gravel and pieces of gypsum crystals. The geophysical logs and the drilling-time log (fig. 2a) indicate that most of the section penetrated is moderately to tightly compacted. Highly compacted clay with shaly partings (reported by drillers in the area as shale, or hard rock, and which has sometimes been mistaken for bedrock) was penetrated from 2,820 to 3,070 feet and from about 3,670 to 4,010 feet.

About 25 percent of the section penetrated to a depth of 5,200 feet consists of material containing a predominance of sand-sized grains. Clay and silt are abundant in most samples. Sandy zones range in thickness from 10 to 270 feet. The sand beds within these zones are believed to range in thickness from a few inches to a few feet and to be interlayered with clay beds. From 5,200 to 6,005 feet sand is the predominant formation material.

In the interval from 6,005 to 6,015 feet, three pieces of a gray-green igneous rock were recovered by the core barrel. The core sample was examined by Robert H. Weber, Senior Geologist, New Mexico Bureau of Mines and Mineral Resources, and was identified (written communication, 8-12-70) as "a porphyritic igneous rock of rhyolitic to quartz latitic composition. It consists of phenocrysts of pink to gray orthoclase, grayish plagioclase, quartz, chlorite after biotite, and hematite set in an aphanitic groundmass. The rock is altered somewhat, possibly weathered, and appears fragmental hence possibly of pyroclastic origin. These determinations are based on sight identification under the binocular microscope without confirmation by petrographic techniques." The rock pieces recovered in the core barrel were rounded, where not bit-cut or fractured, and are thought to be pieces of one or more cobbles or boulders. The test well did not penetrate material identifiable as bedrock.

Table 2.--Sample description log of test well T-14, Post Area, White Sands Missile Range, Dona Ana County, N. Mex.

Sample descriptions by Gene C. Doty

Material	Depth interval (feet)	
Sand, coarse, rounded to angular, poorly sorted, arkosic; silt and clay, and some granule to pebble gravel; gypsum crystals in some samples below 40 feet ----------------------------------	0	105
Clay, tan and greenish-gray, sandy and silty; some pebble gravel ----------------------------	105	120
Sand, as 0-5, and tan and white clay ---------------	120	180
Clay, tan and white, sandy and silty ---------------	180	430
Sand, very fine to fine, angular to rounded, moderately well sorted, and some clay ---------	430	460
Clay, tan and white, sandy -------------------------	460	490
Sand, very coarse to very fine, angular to rounded, poorly sorted, and clay --------------	490	530
Clay, tan and white, sandy, and some granule gravel-	530	540
Sand, as 490-530, and clay -------------------------	540	560
Clay, tan and white, sandy. Some samples contain selenite gypsum -------------------------------	560	780
Clay, tan and white, sandy, and calcareous mudstone fragments. Some samples contain a few particles of granule to pebble gravel, or selenite gypsum -------------------------------	780	1,420

Table 2.--Sample description log of test well T-14, Post Area, White Sands Missile Range, Dona Ana County, N. Mex. - Continued

Material	Depth interval (feet)	
Sand, very coarse to very fine, rounded to angular, poorly sorted, arkosic, much magnetite, and some clay	1,420	1,430
Clay, tan, white, and gray-green, sandy, and calcareous mudstone fragments. Some samples contain a few particles of granule to pebble gravel	1,430	1,750
Silt, gray, some clay, very fine sand, and pebbles	1,750	1,790
Sand, very fine to very coarse, angular to rounded, poorly sorted, arkosic, silty; some chips of clay, and selenite gypsum	1,790	1,820
Clay, tan, white, and gray, sandy; some granule gravel and lumps of mudstone	1,820	1,890
Sand, as 1,790 to 1,820	1,890	1,900
Clay, as 1,820 to 1,890	1,900	1,910
Sand, as 1,790 to 1,820	1,910	1,920
Clay, tan, white and gray, silty, sandy; few particles of granule to pebble gravel	1,920	1,930
Silt, gray, with some sand, and clay	1,930	1,960
Sand, very fine to coarse, angular to rounded, poorly sorted, arkosic, and clay, and silt	1,960	2,030
Silt, gray, clay, and sand	2,030	2,120

Table 2.--Sample description log of test well T-14, Post Area, White Sands Missile Range, Dona Ana County, N. Mex. - Continued

Material	Depth interval (feet)	
Sand, as 1,960 to 2,030, silt, and clay ------------	2,120	2,130
Silt, gray, clay, and sand ------------------------	2,130	2,150
Sand, as 1,960 to 2,030, silt, and clay ------------	2,150	2,300
Clay, gray, tan, and white, silty, sandy -----------	2,300	2,330
Sand, as 1,960 to 2,030, silty, clayey -------------	2,330	2,450
Clay, as 2,300 to 2,330, silty, sandy --------------	2,450	2,490
Sand, as 1,960 to 2,030, silt, and clay ------------	2,490	2,510
Clay, gray, tan, and white, silty, sandy -----------	2,510	2,640
Sand, as 1,960 to 2,030, clay, and silt ------------	2,640	2,670
Clay, gray, tan, and white, sand, and silt ---------	2,670	2,690
Sand, as 1,960 to 2,030, clay, and silt ------------	2,690	2,720
Clay, gray, tan, and white, sand, and silt ---------	2,720	2,770
Sand, as 1,960 to 2,030, clay, and silt ------------	2,770	2,820
Clay, green-gray, tan, and white, calcareous, with shaly parting, some sand, and silt; some samples contain gypsum fragments, and pyrite, or magnetite; some pieces of clay are stained by carbonaceous material ----------------------	2,820	3,070
Sand, as 1,960 to 2,030, gray-green, and tan clay --	3,070	3,080
Clay, as 2,820 to 3,070, and some silt, and sand ---	3,080	4,650
Sand, very coarse to very fine, rounded to angular, poorly sorted, arkosic; some granule gravel, clay, and silt ---------------------------------	4,650	4,700

Table 2.--Sample description log of test well T-14, Post Area, White Sands Missile Range, Dona Ana County, N. Mex. - Concluded

Material	Depth interval (feet)	
Sand, as 4,650 to 4,700, and gray and tan clay in chips	4,700	4,870
Clay, tan, and gray-green, and some sand	4,870	4,880
Sand, as 4,650 to 4,700, clay, and silt	4,880	5,150
Clay, tan, and gray, and sand	5,150	5,200
Sand, very fine to very coarse, angular to rounded, poorly sorted, arkosic, and gray-green clay	5,200	5,670
Sand, as 5,200 to 5,670, and some clay	5,670	6,005
Core, sample, gray-green (three pieces of cobbles or boulders), porphyritic igneous rock of rhyolitic to quartz latitic composition	6,005	6,015

The senior author's opinion is that some of the materials penetrated in test well T-14 are lake bed deposits similar to those in Lake Lucero, about 25 miles north of the Post Area. The sand in the lower part of the sequence may represent older alluvial fan material, which suggests that the axis of the depositional trough in the basin has shifted to the west since deposition began, or that debris from the uplifted mountains was initially coarse and only small amounts of clay were formed in the short distance of transport.

The thickness of the bolson deposits and the type of bedrock in the Tularosa Basin near the Post Area of the Missile Range has not been determined. A section composed of bolson deposits was penetrated in a 4,260 feet deep oil-test well located 6½ miles south of test well T-14 (Kottlowski and others, 1956, p. 82).

Data were obtained from geophysical logs to enable refinement of a seismic-refraction profile made in 1966 in the vicinity of the Post Area (Zohdy and others, 1969, p. 15). Calculated velocities in the sediments were compared with velocities obtained from the sonic log (fig. 2d). The results suggest that the computed depths to bedrock along the basinward half of the profile should probably be increased by about 10 to 15 percent (Zohdy and others, 1969, p. 16 and fig. 5b).

The seismic profile line located 2 miles north of the location of test well T-14 indicated a depth of 5,400 feet to bedrock. An increase of 15 percent would place the bedrock at a depth of about 6,200 feet.

Adjusted velocities suggest that below 5,100 feet the velocity gradually increases to about 15,200 feet per second (Zohdy and others, 1969, p. 16). Such a velocity is comparable to reported velocities of 13,100 - 18,700 feet per second for seismic waves in granite rocks and 11,000 - 20,000 feet per second in limestone (Dobrin, 1960, p. 22).

Chemical quality

Samples of water were collected from six intervals in test well T-14 for chemical analyses (table 3). The analyses show that the water below 2,590 feet is highly saline. Of the six samples, only the one collected from the depth interval of 210 to 360 feet (sample 6, table 3) is of potable water.

Two samples of brine were collected from test well T-14 for carbon isotope determinations. The sample collected from the depth interval of 4,865 to 5,900 feet gave a radiocarbon age of 9,500 years relative to the modern standard; no determination was made for $\delta^{13}C$. The sample, from a depth interval of 5,890 to 6,000 feet had a radio-carbon age of 14,700 years and a $\delta^{13}C$ value of -12.5 permil relative to the PDB (Peedee Belemnite) standard. These data are insufficient for computing a correction for the mean age of the brine. A tritium analysis for one sample determined that the concentration was below detection, indicating that the brine was older than 50 years, and not significantly contaminated by the atmosphere.

Table 3.--Chemical analyses of water samples from test well T-14, Post Area, White Sands Missile Range, Dona Ana County, N. Mex.

Concentrations reported in mg/l (milligrams per liter)

Sampling depth (feet)	5,890–6,000[a/]	4,865–5,900[a/]	4,140–4,900[a/]	3,700–4,100[a/]	2,590–3,700[a/]	210–360[b/]	Drilling water
Date of collection	9/4/67	10/3/67	10/5/67	10/6/67	10/13/67	10/20/67	2/10/66
Sample number	1	2	3	4	5	6	7
Silica (SiO_2)	65	54	24	19	17	0.42	--
Calcium (Ca)	1,300	2,170	2,120	1,260	1,660	32	38
Magnesium (Mg)	72	8.8	27	62	792	1.9	8.5
Sodium (Na)	19,000	15,000	15,100	17,600	41,400	146	30
Bicarbonate (HCO_3)	166	94	71	71	112	133	138
Carbonate (CO_3)	0	0	0	0	0	9	0
Sulfate (SO_4)	1,500	1,230	1,240	1,450	1,060	161	57
Chloride (Cl)	30,800	25,700	25,900	28,500	66,800	82	12
Fluoride (F)	2.1	2.3	2.6	1.8	.7	.5	.4
Nitrate (NO_3)	5.1	4.9	4.2	5.1	14	2.7	4.8
Dissolved solids							
Sum	52,800	44,300	44,500	48,900	112,000	543	258
Residue on evaporation at 180°C	55,700	47,900	48,700	51,500	117,000	593	248
Hardness as $CaCO_3$	3,550	5,450	5,400	3,400	7,400	88	130
Non-carbonate	3,410	5,370	5,340	3,340	7,310	0	17
Specific conductance (micromohs/cm at 25°C)	75,200	63,700	63,700	69,900	136,000	833	381
pH	6.9	6.9	6.3	6.1	6.7	8.6	7.3
Color	100	110	50	20	70	200	--
Density g/ml at 20°C	1.034	1.028	1.028	1.031	1.077	1.000	1.000
Temperature (°C)	54	53	43	49	29	24	22

a/ Sample collected through hole packer after completion of drilling.

b/ Sample collected from bailer after well completion.

Water samples 1 through 5 (table 3) were collected by bailing through the drill stem in the interval above the packer. Sample 6 was collected by bailing the well after final completion. In all cases the procedure used was to remove sufficient fluid from the hole until the water cleared and the field specific conductance stabilized for a period of at least 1 hour. The following tabulation shows the time required to bail water from the sampled interval and the approximate quantity of fluid removed from the interval.

Sample no.	Bailing time (hours)	Fluid removed (gallons)
1	9	240
2	18	600
3	3	240
4	9	160
5	6	110
6	7	1,600

The water sample collected from an interval of 210-360 feet in the well is potable and is of surprisingly good quality for a well located so far from the fan slope where the Post Area well field is situated. The chemical character of the water from this interval is similar to that of water from the Post Area well field.

The well was bailed for several hours before the sample was collected and the likelihood of the water being return water from drilling operations is slight. However, to determine whether the formation water is as good as that of the sample, a pump should be installed in the well and the well pumped until the water has a constant pH and specific conductance. Water-level change in the well should be monitored during pumping and water samples should be collected for chemical analysis. The upper section of the well could not be electric logged because of the casing in the well but the first large change in water quality below the casing is at a depth of about 515 feet. If the water to a depth of 515 feet is similar to that obtained in the sample, a saturated zone about 400 feet thick contains potable water in this area.

Conclusions

Data were obtained from the drilling of test well T-14 that fulfill four of the five stated objectives for the drilling of the well:

1. An indication of quality of water present in aquifers never before investigated in the area was obtained. The dissolved solids in water samples collected below a depth of 360 feet ranged from 44,300 to 112,000 mg/l. These data indicate that future withdrawals of potable water in the area must come from the aquifer in the upper part of the zone of saturation.
2. Large quantities of near-potable water were not found in the Post Area. The quality of the water from a depth of about 550 feet to about 900 feet might be suitable for economic desalting techniques. However, water-bearing zones within this interval are of insufficient thickness and permeability to yield large amounts of water.
3. The depth to bedrock and the thickness of the bolson fill was not established. However, it is known that the bolson fill at the test well site is thicker than 6,015 feet.

A much better understanding of the geologic processes by which the basin was formed would have been obtained had the well penetrated older, stratigraphically identifiable rocks. Also, information needed for basinward-depth control on the bedrock surface was not obtained, however sonic velocity information from the test hole has aided refinement of previous seismic measurements.

4. The physical and lithologic composition of the bolson fill indicate that materials penetrated, at least to a depth of 5,200 feet, are mostly lake-bed deposits similar to those in Lake Lucero. Sand beds below 5,200 feet may represent older alluvial fan material.
5. Computer-processing techniques were found to be of limited value in the interpretation of lithology although porosity determinations shown on computed logs agree somewhat with other data.

It is suggested that the slotted pipe intervals between depths of 210 and 360 feet in test well T-14 be thoroughly developed by pumping and that water samples be collected for analysis so as to establish certainty that the formation water tapped by the well is as good as that of the sample obtained by bailing the completed well.

References cited

Craig, Harmon, 1953, The geochemistry of the stable isotopes: Geochim. et Cosmochim. Acta, v. 3, p. 52-92.

Davis, L. V., and Busch, F. E., 1968, Summary of hydrologic investigations by the U.S. Geological Survey at White Sands Missile Range, N. Mex.: U.S. Geol. Survey open-file rept., 146 p., 27 figs.

Dobrin, M. B., 1960, Introduction to Geophysical Prospecting: New York, McGraw-Hill Book Co., Inc., 446 p.

Fenneman, N. M., 1931, Physiography of western United States: New York, McGraw-Hill Book Co., Inc., 534 p.

Herrick, E. H., 1960, Ground-water resources of the Headquarters (cantonment) area, White Sands Proving Ground, Dona Ana County, N. Mex.: U.S. Geol. Survey open-file rept., 203 p., 33 figs.

Hood, J. W., 1968, Ground-water investigations at White Sands Missile Range, New Mexico, July 1960 - June 1962: U.S. Geol. Survey open-file rept., 153 p., 28 figs.

Kottlowski, F. E., Flower, R. H., Thompson, M. L., and Foster, R. W., 1956, Stratigraphic studies of the San Andres Mountains, New Mexico: N. Mex. Inst. Min. and Tech., State Bur. Mines and Mineral Res., Memoir 1, 132 p., 20 figs.

Pearson, F. J., Jr., and White, D. E., 1967, Carbon-14 ages and flow rates of water in Carrizo Sand, Atacosa County, Texas: Water Resources Research, v. 3, no. 1, p. 251-261.

Rankama, Kalervo, 1963, Progress in isotope geology: John Wiley & Sons, Inc. (Wiley-Interscience, Inc.) New York, 705 p.

Zohdy, A. A. R., Jackson, D. B., Mattick, R. E., and Peterson, D. L., 1969, Geophysical Surveys for ground water at White Sands Missile Range, New Mexico: U.S. Geol. Survey open-file rept., 144 p., 17 figs.