Phase I test wells, White Sands Missile Range, Dona Ana County, New Mexico

By

Gene C. Doty (Doty)

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DEPARTMENT OF THE INTERIOR
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Albuquerque, New Mexico

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Introduction

Five test wells were drilled during late 1966 and early 1967 to explore the water-producing potential of four areas uprange from the Post Area, White Sands Missile Range. These wells were drilled as part of a continuing program of water-resources investigation (Phase I) detailed in the White Sands Missile Range Water Master Plan. The location of White Sands Missile Range in New Mexico and the Phase I project area within the Missile Range is shown on figure 1; the

Figure 1 (caption on next page) belongs near here.

location of the test wells on the Missile Range is shown on figure 2.

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The letter prefix to the test-well number identifies the separate areas of investigation: HTA-1 and HTA-2 are in the Hazardous Test area; SMR-3 is in the Small Missile Range area; MAR-4 is in the MAR well field area and NW30-1 is near the NW30 tracking station. The suffix number is in the consecutive number of test wells drilled in the area.

Figure 1.--White Sands Missile Range and Phase I project area
Dona Ana County, N. Mex.

2.--Test wells drilled in Phase I project, White Sands
Missile Range, Dona Ana County, N. Mex.

The HTA wells were drilled to ascertain if small quantities, 5 to 10 gpm (gallons per minute), of potable water were available for domestic use. SMR-3 was drilled to explore the quality and quantity of water available to wells penetrating a prominent alluvial fan north of two test wells drilled previously in the Small Missile Range area. Well MAR-4 was drilled to determine if a larger yield could be obtained from wells drilled west of the MAR production wells. Well NW30-1 was drilled to determine the quality and quantity of water available to wells in the general area of NW30 tracking station.

The U. S. Geological Survey, as a part of the continuing cooperative program with White Sands Missile Range, furnished technical advice for the location of the test wells and drilling specifications. During the drilling and testing operations the Survey advised the Corps of Engineers personnel administering the test-drilling contract, and collected geologic and hydrologic data. Geological Survey personnel involved in field-data collection included J. A. Basler, F. E. Busch, G. A. Dinwiddie, and the writer, supervised by J. B. Cooper, Hydrologist, and W. E. Hale, District Chief, Water Resources Division, Albuquerque, New Mexico.

The Phase I test wells were drilled into Quaternary and Tertiary and bolson deposits on the east side of the Organ and San Andres Mountains which flank the western edge of the Tularosa basin. Test wells HTA-1 and HTA-2 penetrated the intrusive igneous mass of the Organ Mountains; the other wells were completed in the bolson fill. The occurrence of potable water along the western flank of the Tularosa basin is dependent upon whether the water-bearing alluvial material was derived from older rocks containing gypsum and halite and whether surface water recharged to the aquifer has moved across rocks containing these minerals. The reader is referred to Dane and Bachman (1965) for background information on the geology of the area and to Davis and Busch (1968) for a discussion of ground-water occurrence.

Methods and procedures

Test wells HTA-1 and HTA-2 were drilled by a cable-tool drilling rig. Samples of drill cuttings were collected from the bailer at 5-foot intervals. The quantity of water encountered as the well was deepened was estimated from periodic bailing tests; the quality was monitored by electrical conductivity determination. Gamma-neutron logs were made in each well by U.S. Geological Survey personnel after the wells were drilled to total depth. Well HTA-1 was developed by bailing and surging and was test pumped with a small submersible pump. HTA-2 was filled and abandoned because of insufficient yield.

Test wells SMR-3, MAR-4,and NW30-1 were drilled by a conventional hydraulic-rotary rig. Drilling time was recorded by an automatic drilling-rate recorder. Samples of drill cuttings were collected from the return-flow sluice after each 5 feet of penetration and were not corrected for time lag; the samples were classified primarily for particle-size range. Water samples were collected as drilling progressed, using an expansion packer. A commercial logging company made electric logs when the wells had been drilled to total depth. Electric logs, drilling-time logs, and drill cuttings were examined to determine where perforated casing should be placed. Mill-cut slots, 1/8-inch wide were used in all perforated-casing sections.

After casing, each well was developed with a tight-fitting bailer and, if needed, a closed-surge block. A test pump was then installed and the well further developed by pumping and surging. The water level in the well was allowed to recover for several hours after development. The well was then test pumped for eight hours at a specified rate to determine the coefficient of transmissibility of the aquifer. Depth to water was measured with an electric tape at intervals during pumping and for several hours after pumping stopped. Pump discharge from well HTA-1 was measured with a stopwatch and a container of known volume; discharge of SMR-3, MAR-4, and NW30-1 was determined by an orifice plate. Sand content of discharge water was determined by an Imhoff sediment cone. All the wells, except HTA-2, were fitted with removable caps and were retained as water-level observation wells.

Results of drilling

Ground water in the Hazardous Test area is contained in the lowermost part of the alluvium, and in the fractured and weathered upper part of the underlying igneous bedrock. Well HTA-1 penetrated intrusive igneous bedrock of granitic composition, probably of Precambrian age, at a depth of 80 feet; well HTA-2 penetrated similar bedrock at a depth of about 60 feet (tables 2,3,4, and 5). At depth the material became increasingly harder to drill and the drilling of well HTA-2 was stopped before the planned depth of 250 feet was reached.

The material overlying the bedrock in both wells was an arkosic sand gravel. Gamma logs and neutron logs of the wells are shown in figure 3 (in pocket). Well HTA-2 could be bailed dry at a bailing rate

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of about a half gpm. The low yield did not justify casing and development of the well so it was plugged and abandoned. Well HTA-1 was pumped for eight hours at 25 gpm with 18 feet of drawdown. (figs. 4 and 5). Water from both wells was potable to total depth (table 1).

Figures 4 and 5 (captions on next page) belongs near here.

Figure 3.--Gamma and neutron logs of test wells HTA-1 and HTA-2 (in pocket)

4.--Drawdown in well HTA-1, Oct. 5, 1966.

5.--Residual drawdown in well HTA-1, Oct. 5, 1966.

The near-surface material explored by test well SMR-3 in the prominent alluvial fan north of the Small Missile Range was well cemented with calcium carbonate and drilling therefore was slow until adequate weight could be added to the tool string; the remainder of the drilling was accomplished routinely. The well penetrated fan deposits of sand, gravel, and some clay (tables 6 and 7). The first water sample was collected by bailing when the well had been drilled to 392 feet; 150 feet of temporary surface pipe was placed in the well to prevent caving of incompetent beds during sampling. The other two samples were collected as drilling progressed by installing a small submersible pump inside the pipe of the packer string. All the water samples collected were potable (table 1). Electric logs of the well are shown in figure 6 (in pocket).

Figures 6a-f (captions on next page) belongs near here.

The well was developed by bailing and surging, and by surging with the test pump. The coefficient of transmissibility determined from an 8-hour aquifer test was 350,000 gpd/ft (gallons per day per foot) (figs. 7 and 8). The well produced considerable sand during development

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but produced very little sand during the aquifer test.

Fgire 6a.--Induction electric log of SMR-3.

b.--Microlog of SMR-3.

c.--Induction electric log of MAR-4.

d.--Microlog of MAR-4.

e.--Induction electric log of NW30-1.

f.--Micrclog of NW30-1.

7.--Drawdown in well SMR-3, Jan. 14, 1967.

8.--Residual drawdown in well SMR-3, Jan. 14-15, 1967.

Test well MAR-4 was drilled into the upper part of the alluvial fan on which the MAR well field is situated. The well penetrated bolson and fan deposits of sand, gravel, and clay of Quaternary and Tertiary age (tables 8 and 9). Water samples were collected as drilling progressed. The shallowest sample was collected by bailing in an open hole in which approximately 200 feet of temporary surface casing had been set; the other two samples were collected by installing a submersible pump inside the pipe of the packer string. The water sample from total depth was nonpotable, and the well was completed in the potable water zone (table 1). Electric logs of the well are shown in figure 6 (in pocket). The well was developed by bailing and surging, and surging with the test pump. The coefficient of transmissibility, as determined from an eight-hour aquifer test, is 295,000 gpd/ft. (figs. 9 and 10). The well produced very little sand

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during test pumping.

Figure 9.--Drawdown in well MAR-4, Feb. 1, 1967

10.-- Residual drawdown in well MAR-4, Feb. 2, 1967

Well NW30-1 penetrated bolson and fan deposits of sand, gravel, and clay of Quaternary and Tertiary age (tables 10 and 11). The materials became finer at depth and more clay beds were penetrated in well NW30-1 than in wells SMR-3 or MAR-4. Water samples were collected as drilling progressed. The shallower sample was collected by bailing in an open hole with no surface casing; the deeper sample was obtained by setting a submersible pump inside the drill pipe or the packer string. Neither of the water samples were potable (table 1). Electric logs of the well are shown in figure 6 (in pocket). The well was completed so as to yield the best quality of water present in the section penetrated, as determined from the electric logs. It was developed by bailing and surging and by surging with the test pump. The coefficient of transmissibility, as determined from aquifer-test data, is about 130,000 gpd/ft (figs. 11 and 12). The well produced a slight amount of sand

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Figures 11 and 12 (captions on next page) belongs near here.

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and the water was still slightly hazy at the close of the aquifer test.

Figure 11.--Drawdown in well NW30-1, Feb. 24, 1967

12.--Residual drawdown in well NW30-1, Feb. 24, 1967

Conclusions and recommendations

Wells that yield small amounts (5 to 10 gpm) of potable water can be drilled in the Hazardous Test area. These wells should be drilled near surface drainage channels to obtain recharge, as the storage in the fractured igneous rock is small. The dependability of a well in the area is questionable because of the small amount of water in storage. The fracture pattern in the rock is not everywhere the same and it may be impossible to obtain a satisfactory yield at a given location.

Wells that yield several hundred gallons per minute of potable water can be constructed near well SMR-3. The quality of the water from well SMR-3 was higher in sulfate (200 ppm) than water from the Post Area well field but is within the limits recommended for human consumption. The area is topographically higher than the Small Missile Range and MAR facilities, and construction of pipelines for distribution of water by gravity flow to these areas would be feasible. Geographically, the SMR-3 well is well situated for uprange haulage. It is adjacent to a paved road and is several miles north of the present SMR water supply point. A ready supply of water for uprange haulage is available simply by equipping the test well with a pump and building a storage tank nearby.

Test well SMR-3 achieved the primary purpose of exploration in a most gratifying manner: Test results indicate that high-yield wells can be constructed in this area, and that the quality of the water is satisfactory. For planning and engineering purposes, however, important questions pertaining to the availability and permanence of a water supply in the area remain unanswered. Test well SMR-3 did not penetrate the saline-water interface, or bedrock, and the saturated thickness of the potable water-bearing beds is unknown. The areal extent of the potable water is unknown except in the direction of the two SMR wells to the south. Additional exploration by test drilling and geophysical methods is needed to determine the quantity of water available to a well field in this area.

Well MAR-4 vindicated previous opinions expressed by the Survey that wells with yields larger than that obtained from the wells in the present MAR well field could be constructed in the MAR-4 locality. The coefficient of transmissibility of wells in the present MAR well field is not larger than 20,000 gpd/ft; the coefficient of transmissibility of well MAR-4 was computed to be 295,000 gpd/ft (fig. 10). Specifications for production wells to be drilled near well MAR-4 should include provisions for drilling the pilot hole to at least 1,500 feet, and collecting a water sample from total depth to determine the change in water quality at depth. Pipelines should not be constructed prior to the drilling and testing of a proposed production well because the bolson and fan deposits are hetergeneous and the yield of wells a short distance apart may range widely.

The quantity of water yielded by well NW30-1 was average, or better, for a well completed in bolson materials. The coefficient of transmissibility was 130,000 gpd/ft (fig. 12). The quality of water ranged widely with depth. The specific conductance of a sample collected when the well was 352 feet deep was 1,490 micromhos at 25°C; the specific conductance of a sample collected from the interval 620 to 635 feet was 61,600 micromhos. The deterioration of water quality with depth is shown by the conductivity curve on the induction-electric log. From the water level to 300 feet the quality is nearly the same; from 300 to 350 feet the water quality worsens slightly; from 350 feet to total depth, the quality of water becomes steadily worse. The well was cased to 670 feet and the specific conductance of the pumped water was 16,700 micromhos, which suggests that more water was entering the well from the upper perforated sections than from the lower sections. The range in quality with depth also suggests that potable or near-potable water may be obtained from wells drilled higher on the fan slope nearer the recharge area. If wells are drilled in this area for production, exploration of the fan area for water of better quality, and careful selection of producing sections in the wells may result in obtaining water of a quality 10 to 60 times better than that obtained by indiscriminate and arbitrary well-location and completion methods.

References cited

Dane, C. H., and Bachman, G. O., 1965, Geologic map of New Mexico: U. S. Geol. Survey, scale 1:500,000, 2 sheets.

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

BASIC DATA

Table 1.--Results of chemical analysis of water samples collected from Phase I test wells, White Sands Missile Range.

Analyses by Geological Survey, United States Department of the Interior
(parts per million)

Well number	HTA-1	HTA-2	SMR-3	SMR-3	SMR-3	SMR-3	MAR-4	MAR-4	MAR-4	MAR-4	NW30-1	NW30-1	NW30-1
Sample interval	Total depth	open to 189	open to 392	707-742	973-1,010	total screen	open to 430	705-740	965-1,016	436-740	open to 352	620-735	Total screen
Date of collection	10/5/66	11/16/66	12/16/66	12/21/66	12/30/66	1/14/67	1/21/67	1/23/67	1/26/67	2/1/67	2/12/67	2/15/67	2/24/67
Temperature °F	72	-	74	81	81	79	74	82	82	77	73	80	78
Silica (SiO_2)	34	24	-	-	-	24	-	-	-	24	-	-	23
Iron (Fe) in solution	0.00	.02	-	-	-	.00	-	-	-	.13	-	-	.01
Manganese (Mn)	13	-	-	-	-	-	-	-	-	-	-	-	-
Calcium (Ca)	82	82	-	-	-	86				82	-	-	418
Magnesium (Mg)		13	-	-	-	47	-	-	-	40	-	-	264
Sodium (Na) / Potassium (K)	53	60	-	-	-	38	-	-	-	32	-	-	5,040
Bicarbonate (HCO_3)	221	238	-	-	-	262				258	-	-	203
Carbonate (CO_3)	0	0	-	-	-	0				0	-	-	0
Sulfate (SO_4)	116	115	212	215	209	200	177	178	164	166	613	2,330	744
Chloride (Cl)	28	34	46	34	44	41	34	38	480	34	156	24,200	5,520
Fluoride (F)	4.0	4.0	-	-	-	.5	-	-	-	.4	-	-	.7
Nitrate (NO_3)	29	22	-	-	-	7.2	-	-	-	6.6	-	-	0.1
Dissolved solids													
Calculated	468	471	-	-	-	573	-	-	-	512	-	-	10,100
Residue on evaporation at 180°C	-	476	-	-	-	568	-	-	-	570	-	-	10,500
Hardness as $CaCO_3$	260	250	-	-	-	406	-	-	-	370	-	-	2,130
Noncarbonate hardness as $CaCO_3$	79	65	-	-	-	192	-	-	-	158	-	-	1,960
Alkalinity as $CaCO_3$	-	-	-	-	-	-	-	-	-	-	-	-	-
Specific conductance (micromhos at 25°C)	711	746	884	886	900	896	778	799	2,150	794	1,490	61,600	16,700
pH	7.5	7.7	-	-	-	7.5	-	-	-	7.6		-	7.7
Color	0	-	-	-	-	-	-	-	-	-	-	-	3

Table 2.-- Record of test well HTA-1

Location: SW$\frac{1}{4}$SW$\frac{1}{4}$NE$\frac{1}{4}$ sec. 23, T. 21 S., R. 4 E.

Altitude: 5,018.23 feet.

Depth: (drilled): 250 feet (cased): 82 feet.

Date completed: Test pumped 10-5-66.

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

Drilling method: Cable tool.

Casing and well record: Eight-inch blank casing to 82 feet; open hole from 82 to 250 feet.

Well completion record: Concrete well head set; well retained for water-level observation.

Formation logs: Sample description (table 3) and radioactivity log (fig. 3)

Geologic source: Fractured granitic rock, probably of Precambrian age.

Yield: Well pumped at 26 gpm for 8 hours with 18 feet of drawdown.

Nonpumping water level: 78.40 feet below land surface datum 10-3-66.

Water quality: Potable, see table 1.

5018.23
78.40
4940

Table 3.--Sample description log of test well HTA-1

Material	Depth Interval (feet)	
Sand and gravel	0	80
Rock, granitic	80	250

Table 4.--Record of test well HTA-2

Location: $SW\frac{1}{4}SW\frac{1}{4}SW\frac{1}{4}$ sec. 11, T. 21 S., R. 4 E

Altitude: 5,437.30 feet.

Depth: (drilled): 189 feet (cased): not

Dates Completed: Drilling stopped 11-21-66

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

Drilling method: Cable tool

Casing and well record: None

Well completion record: Well filled and abandoned

Formation logs: Sample description (table 5) and radioactivity logs (fig. 3)

Geologic source: Fractured granitic rock, probably of Precambrian age.

Yield: Estimated 1/2 gpm, or less, by bailing.

Nonpumping water level: 77 feet below land surface 11-30-66

Water quality: Potable; see table 1.

5437.30
77
5360.30

Table 5.-- Sample description log of test well HTA-2

Material	Depth - Interval (feet)	
Sand and gravel	0	60
Rock, granitic	60	189

Table 6.--Record of test well SMR-3

Location: SW$\frac{1}{4}$SW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 34, T. 20 S., R. 5 E.

Altitude: 4,177.89 feet.

Depth (drilled): 1,010 feet (cased): 1,000 feet

Dates completed: Test pumped 1-14-67

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

Drilling method: Hydraulic rotary

Casing and well record: Eight-inch casing to 1,000 feet, 1/8-inch wide mill-cut slots from 330-355, 380-410, 565-605, 710-730, 770-790 and 925-990 feet.

Well completion record: Concrete well head set; well retained for water level observation

Formation logs: Sample description (table 7) and electric logs (fig. 6)

Geologic source: Bolson fill of Quaternary and Tertiary age.

Yield: Well test pumped at 212 gpm for 8 hours with 2.18 feet of drawdown.

Nonpumping water level: 296.56 feet below land surface datum on 1-14-67.

Water quality: Potable; see table 1.

4177.89
296.56
3881

Table 7.-- Sample description log of test well SMR-3

Material	Depth Interval (feet)	
Gravel and some sand	0	25
Sand	25	30
Gravel and some sand	30	55
Sand	55	75
Gravel	75	90
Sand	90	95
Gravel and some sand	95	140
Gravel	140	200
Gravel and some sand	200	220
Sand and gravel	220	225
Gravel	225	240
Gravel and some sand	240	275
Gravel and trace of sand	275	290
Sand and some gravel	290	295
Gravel	295	300
Gravel and some sand	300	320
Sand and some gravel	320	325
Gravel and sand	325	330
Sand	330	390
Gravel	390	425

Table 7.-- Sample description log of test well SMR-3 - Concluded

Material	Depth Interval (feet)	
Gravel and sand	425	435
Sand	435	600
Sand and gravel	600	645
Sand	645	740
Sand and clay	740	760
Sand	760	830
Sand and trace of clay	830	855
Sand	855	925
Sand and some clay	925	930
Sand	930	935
Sand and gravel	935	950
Sand and some gravel	950	1000

Table 8.--Record of test well MAR-4

Location: SW$\frac{1}{4}$NW$\frac{1}{4}$SE$\frac{1}{4}$ sec. 19, T. 19 S., R. 5 E.

Altitude: 4223.39

Depth (drilled): 1,016 feet (cased): 750 feet

Date completed: Test pumped 2-1-67

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

Drilling method: Hydraulic rotary

Casing and well record: Eight-inch casing to 750 feet; 1/8-inch wide mill-cut slots from 436-456, 466-476, 550-570, 600-660, and 720-740 feet.

Well completion record: Concrete well head set;well retained for water level observation.

Formation logs: Sample description (table 9) and electric logs (fig. 6)

Geologic source: Bolson fill of Quaternary and Tertiary age.

Yield: Well pumped at 235 gpm for 8 hours with 4.27 feet of drawdown.

Nonpumping water level: 303.16 feet below land surface on 2/1/67

Water quality: Potable in upper section, inferior at depth; see table 1.

4223.39
303.16
3920

4223.39
1016
3207

Table 9.--Sample description log of test well MAR-4

Material	Depth Interval (feet)	
Clay and some gravel	0	10
Gravel and some clay	10	25
Gravel and clay	25	30
No sample	30	35
Clay and gravel	35	50
Gravel and some clay	50	75
Clay and gravel	75	85
Gravel and clay	85	95
Gravel, some sand and clay	95	105
Sand and gravel	105	120
Sand and some gravel	120	140
Sand and clay	140	145
Sand	145	155
Sand and some gravel	155	175
Sand and trace of gravel	175	190
Gravel and some sand	190	255
Gravel and clay	255	265
Gravel and some clay	265	275
Gravel, sand, and trace of clay	275	320
Gravel, sand, and clay	320	325

Table 9.--Sample description log of test well MAR-4 - Continued.

Material	Depth Interval (feet)	
Gravel, some sand, and trace of clay	325	340
Gravel, clay, and some sand	340	345
Sand and gravel	345	380
Sand and some gravel	380	430
Gravel and sand	430	440
Sand and gravel	440	450
Sand	450	490
Gravel	490	535
Gravel, sand, and trace of clay	535	555
Sand and some gravel	555	605
Gravel and sand	605	615
Sand and some gravel	615	650
Sand and gravel	650	665
Sand, gravel, and some clay	665	680
Sand	680	700
Sand, trace of gravel and clay	700	715
Sand	715	740
Gravel and sand	740	745
Sand and gravel	745	770
Sand, gravel, and some clay	770	785
Sand, gravel and clay	785	790

Table 9.-- Sample description log of test well MAR-4 - Concluded

Material	Depth Interval (feet)	
Gravel, sand, and clay	790	795
Sand, gravel, and clay	795	805
Gravel, sand, and clay	805	820
Sand, gravel and clay	820	840
Gravel, sand, and clay	840	850
Sand, gravel, and clay	850	855
Gravel, sand, and clay	855	885
Sand, gravel and some clay	885	890
Gravel, sand, and clay	890	910
Sand and gravel	910	950
Sand, gravel and clay	950	965
Clay, sand, and gravel	965	970
Gravel, sand, and clay	970	975
Clay, gravel and sand	975	990
Sand, gravel, and clay	990	1,000

Table 10.- Record of test well NW30-1

Location: NW$\frac{1}{4}$NW$\frac{1}{4}$NE$\frac{1}{4}$ sec. 2., T. 17 S., R. 4 E.

Altitude: 4,139.87 feet.

Depth (drilled): 1,010 feet (cased): 670 feet

Dates completed: Test pumped 2-24-67

Drilling contractor: Boyd and Son Drilling Co., Los Cruces, N. Mex.

Drilling method: Hydraulic rotary

Casing and well record: Eight-inch casing to 670 feet; 1/8-inch wide mill-cut slots from 260-281, 290-298, 374-390, 442-452, 485-500, 520-526, 562-582, 630-654.

Well completion record: Concrete well head set; well retained for water level observation.

Formation logs: Sample description (table 11) and electric logs (fig. 6)

Geologic source: Bolson deposits of Quaternary and Tertiary age.

Yield: Well test pumped at 248 gpm for 8 hours with 30.84 feet of drawdown.

Nonpumping water level: 211.61 feet.

Water quality: Nonpotable; see table 1.

4139.87
211.6
3928

Table 11.--Sample description log of test well NW30-1

Material	Depth Interval (feet)	
Gravel and some clay	0	30
Sand and gravel	30	50
Clay sand and gravel	50	55
Sand and gravel	55	80
Gravel clay and trace of sand	80	90
Gravel sand and trace of clay	90	95
No sample	95	105
Gravel and some sand	105	150
Gravel, sand, and trace of clay	150	165
Gravel, trace of sand and clay	165	190
Sand and some clay	190	225
Sand and gravel	225	235
Gravel and sand	235	255
Sand and gravel	255	275
Sand, some gravel and clay	275	315
Sand, clay, and gravel	315	330
Sand, some clay and gravel	330	350
Gravel, sand and some clay	350	395
Gravel	395	450
Gravel and sand	450	470

Table 11.- Sample description log of test well NW30-1 - Continued

Material	Depth Interval (feet)	
Sand and gravel	470	480
Gravel and sand	480	490
Sand and gravel	490	500
Gravel, sand, and some clay	500	510
Sand and gravel	510	515
Gravel, sand, and some clay	515	520
No sample	520	525
Gravel, sand, and trace of clay	525	550
Gravel, sand, and clay	550	555
Gravel sand and some clay	555	565
Sand and gravel	565	585
Sand, some clay and trace of gravel	585	590
Sand and gravel	590	595
Sand	595	600
Gravel, sand and clay	600	605
Sand, clay, and some gravel	605	610
Gravel, sand, and some clay	610	620
Sand, gravel, and some clay	620	675
Clay, sand and gravel	675	680
Sand, gravel and clay	680	700
Sand, some clay and gravel	700	730

Table 11.--Sample description log of test well NW30-1 - Concluded

Material	Depth Interval (feet)	
No sample	730	735
Clay, some gravel and sand	735	770
Sand, some gravel and clay	770	775
Sand, clay and some gravel	775	800
Gravel, clay, and some sand	800	805
Clay, gravel, and sand	805	820
Sand, clay and gravel	820	830
Clay, sand, and some gravel	830	855
Sand, clay and some gravel	855	920
Sand and some gravel	920	965
Clay, sand, and some gravel	965	985
Sand, clay, and some gravel	985	1,000

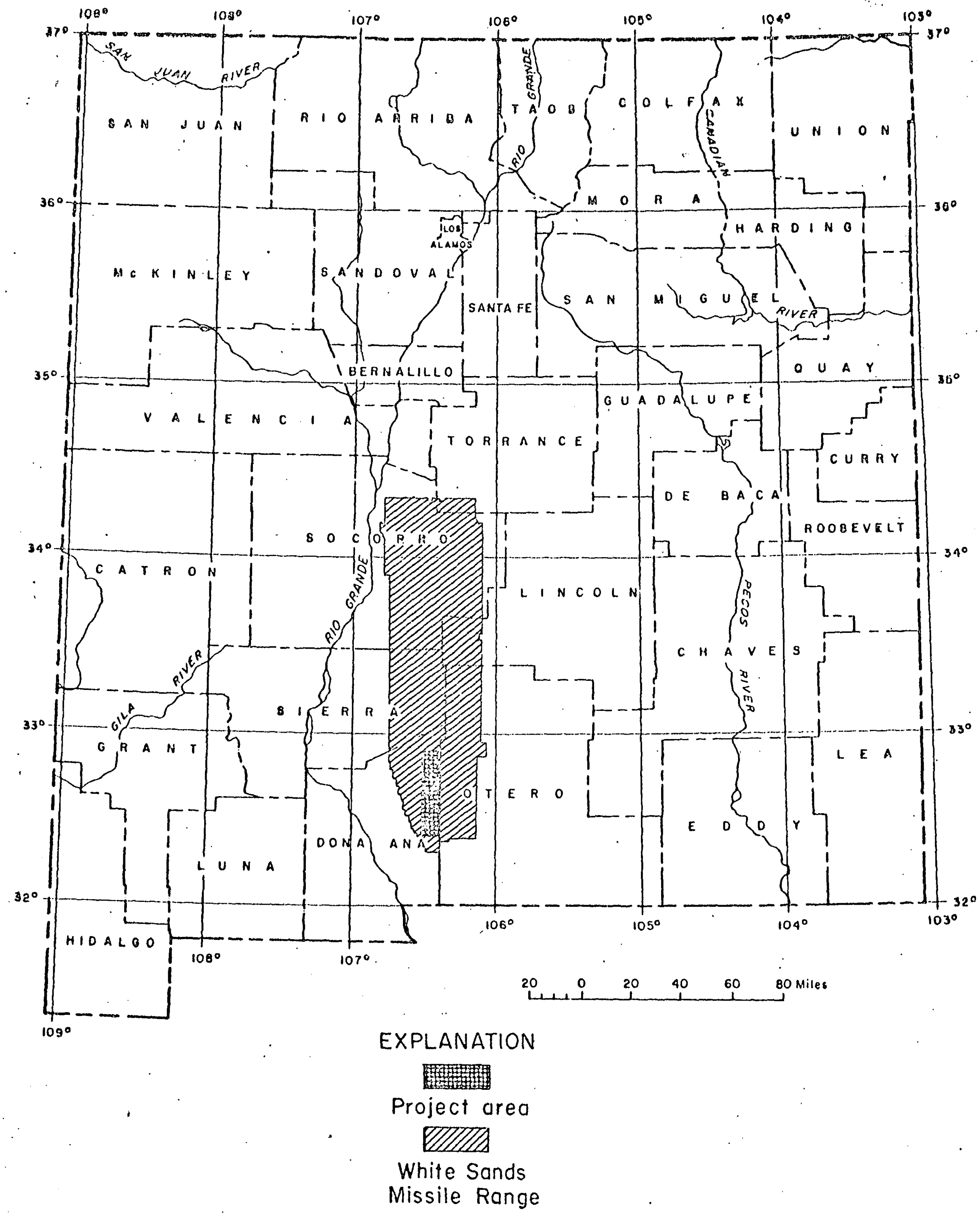
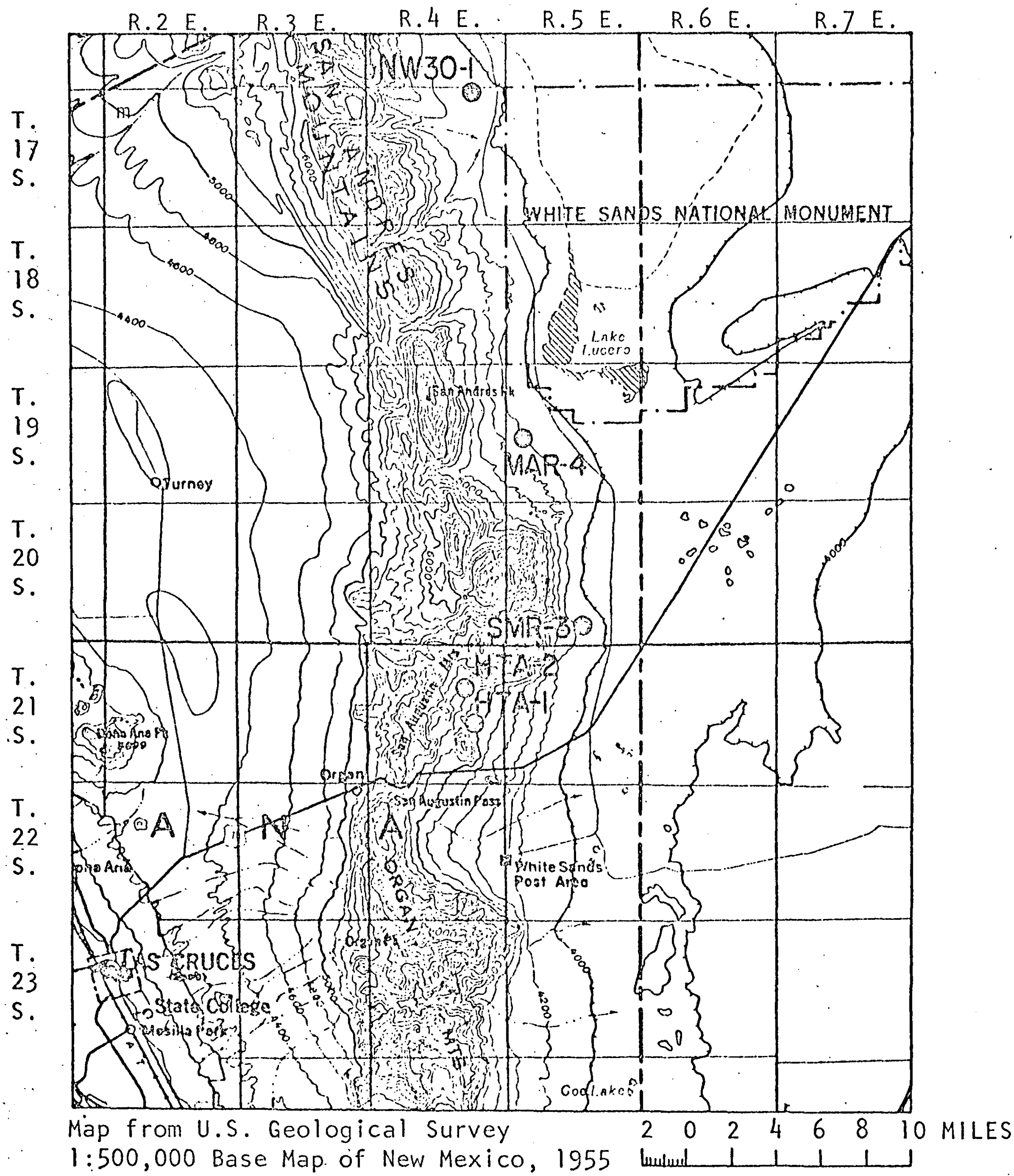


Figure 1.--White Sands Missile Range and Phase I project area, Dona Ana County, N. Mex.



Map from U.S. Geological Survey
1:500,000 Base Map of New Mexico, 1955

EXPLANATION
Contour interval 200 feet
Datum is mean sea level
SMR-3 Test well

Figure 2.-- Test wells drilled in Phase I project, White Sands Missile Range, Dona Ana County, New Mexico.

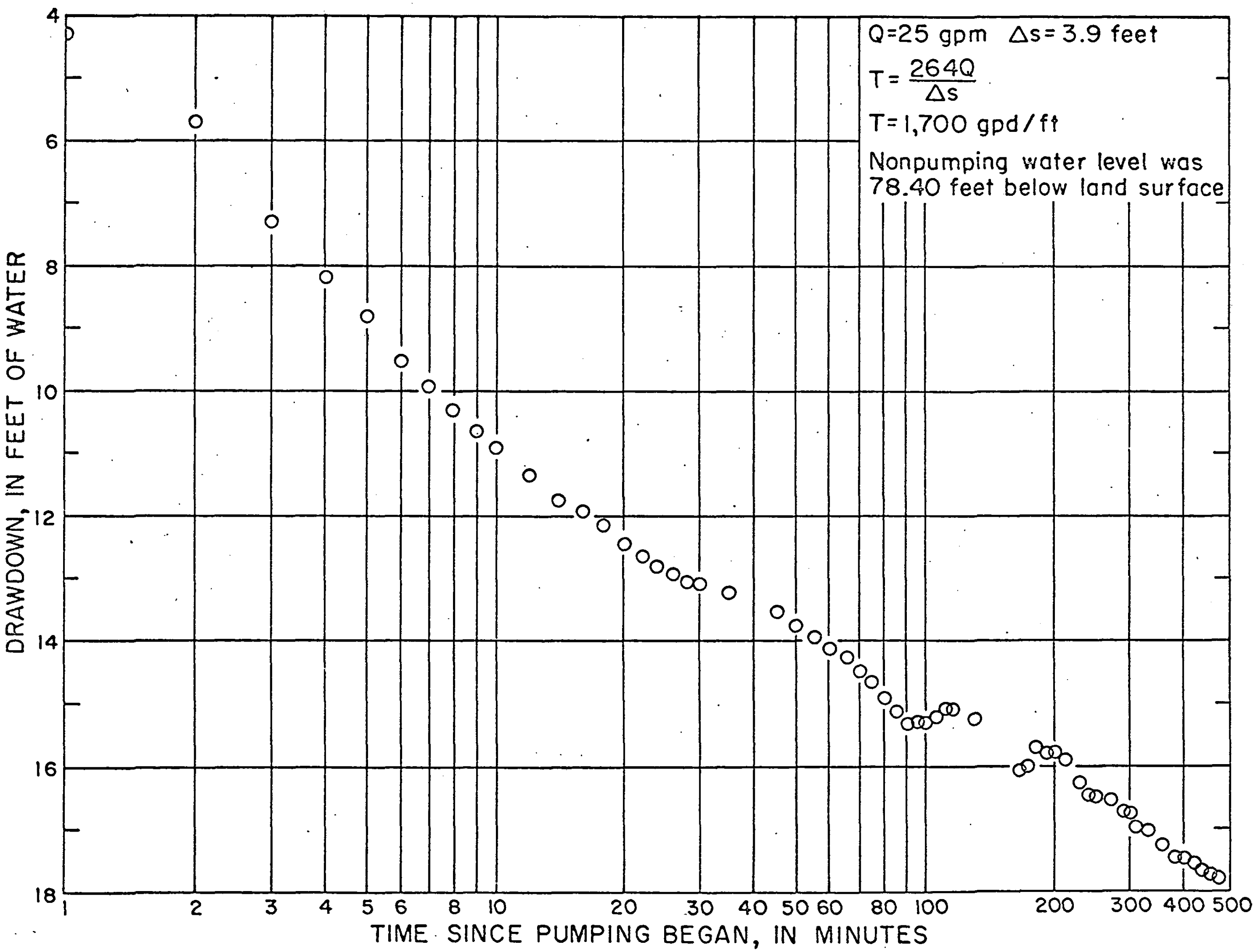


Figure 4.--Drawdown in well HTA-1, Oct. 5, 1966.

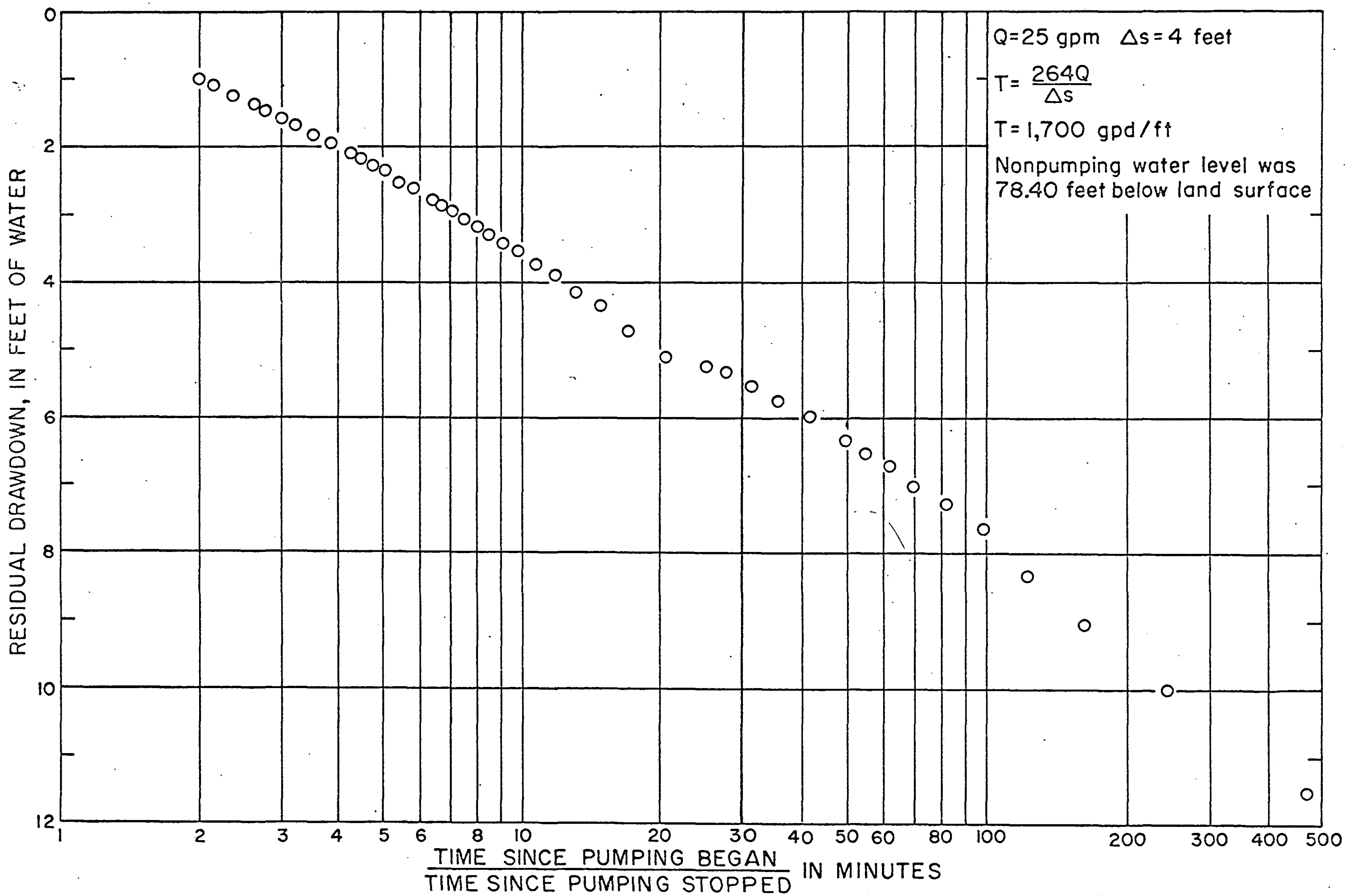


Figure 5.--Residual drawdown in well HTA-1, Oct. 5,1966.

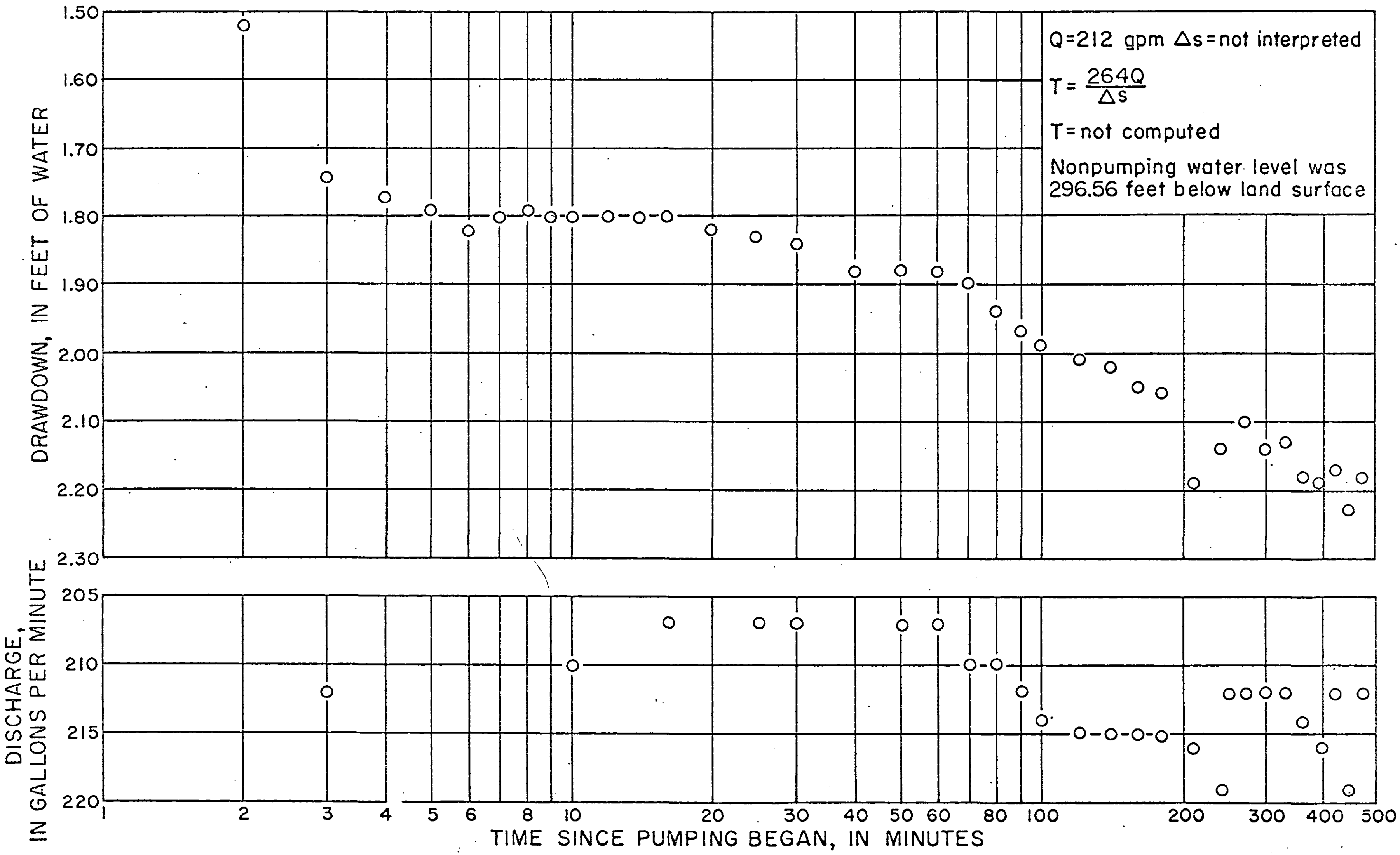


Figure 7.--Drawdown in well SMR-3, Jan. 14, 1967.

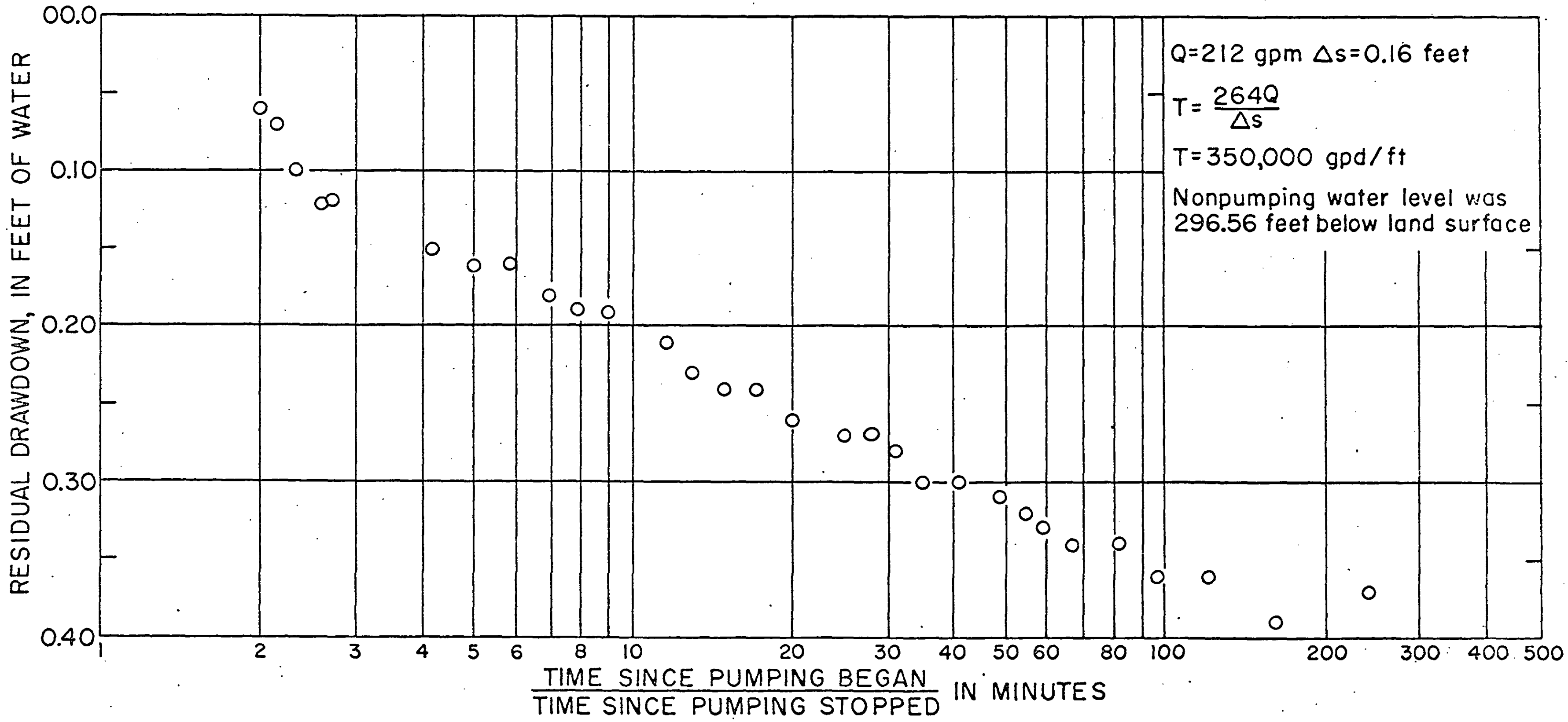


Figure 8.--Residual drawdown in well SMR-3, Jan. 14-15, 1967.

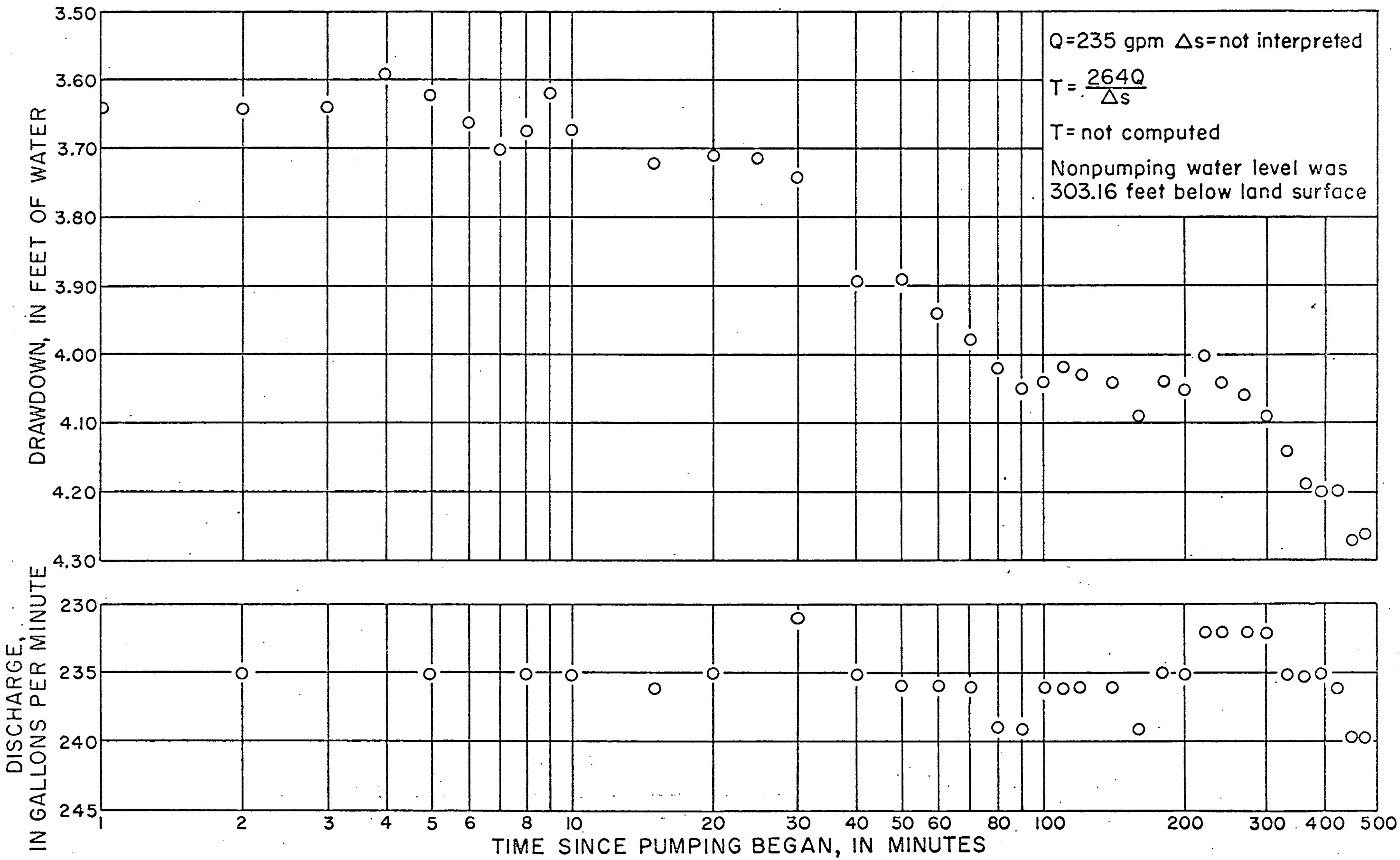


Figure 9.--Drawdown in well MAR-4, Feb. 1, 1967.

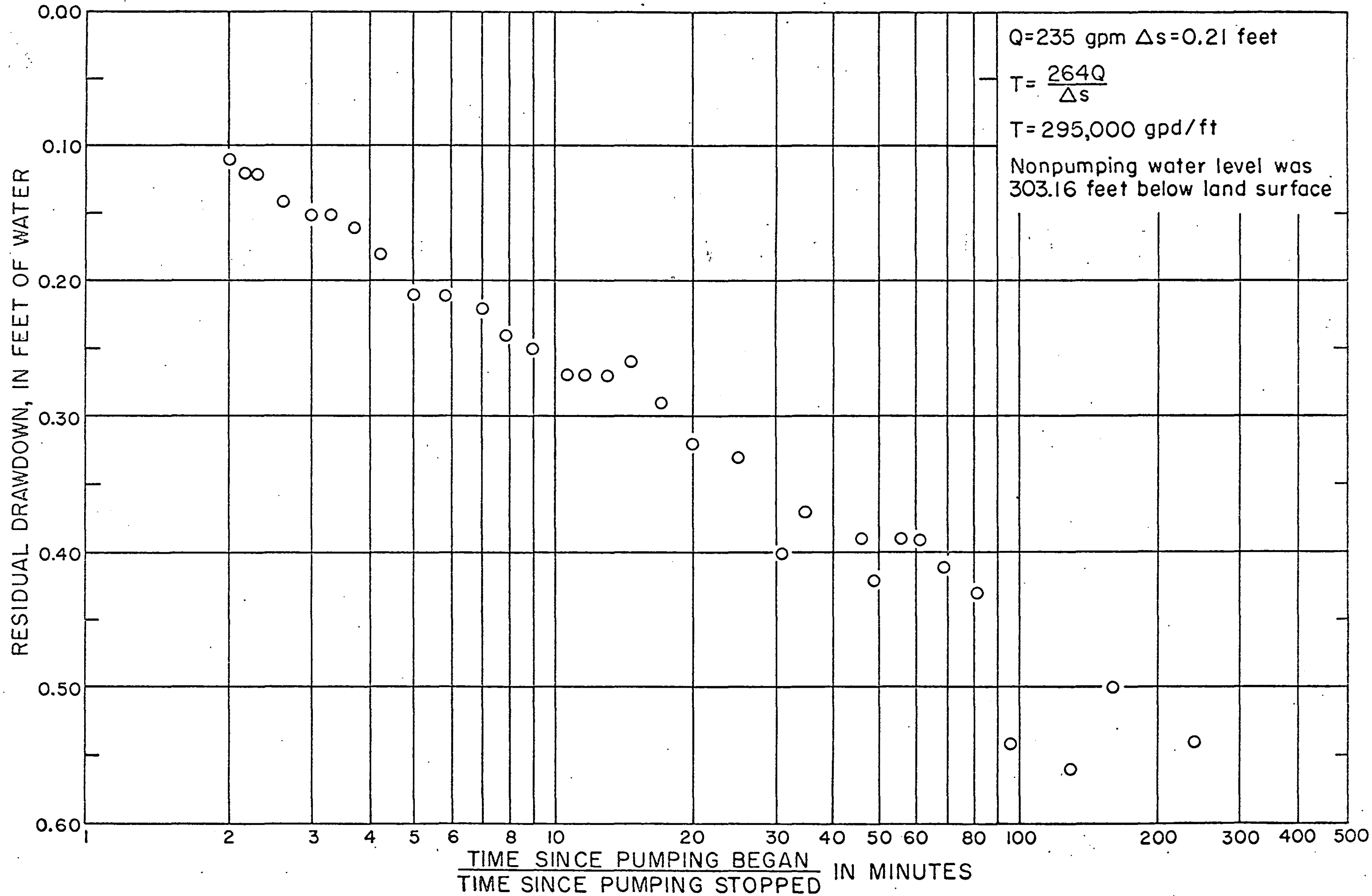


Figure 10.--Residual drawdown in well MAR-4, Feb. 2, 1967.

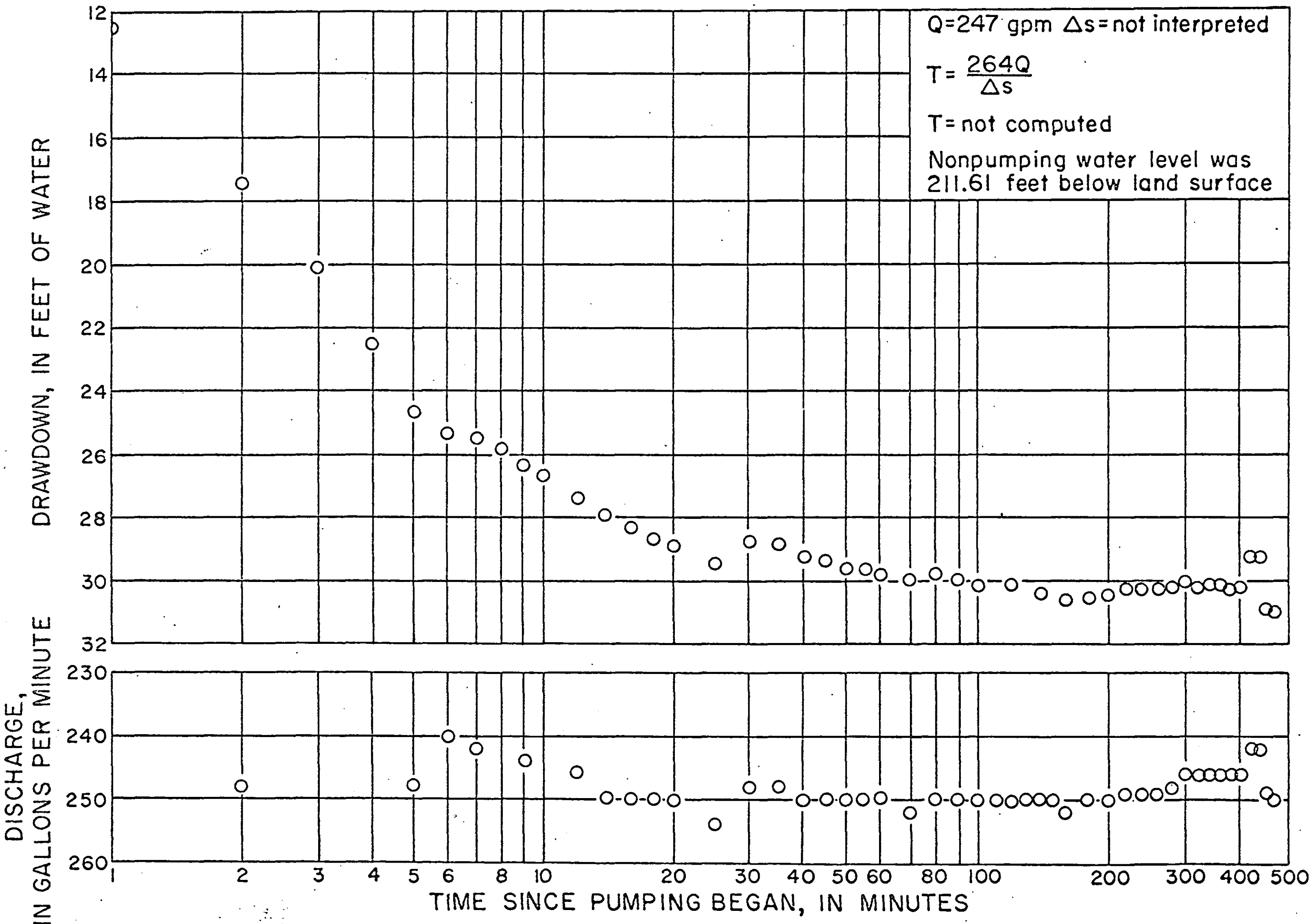


Figure 11.--Drawdown in well NM30-1, Feb. 24, 1967.

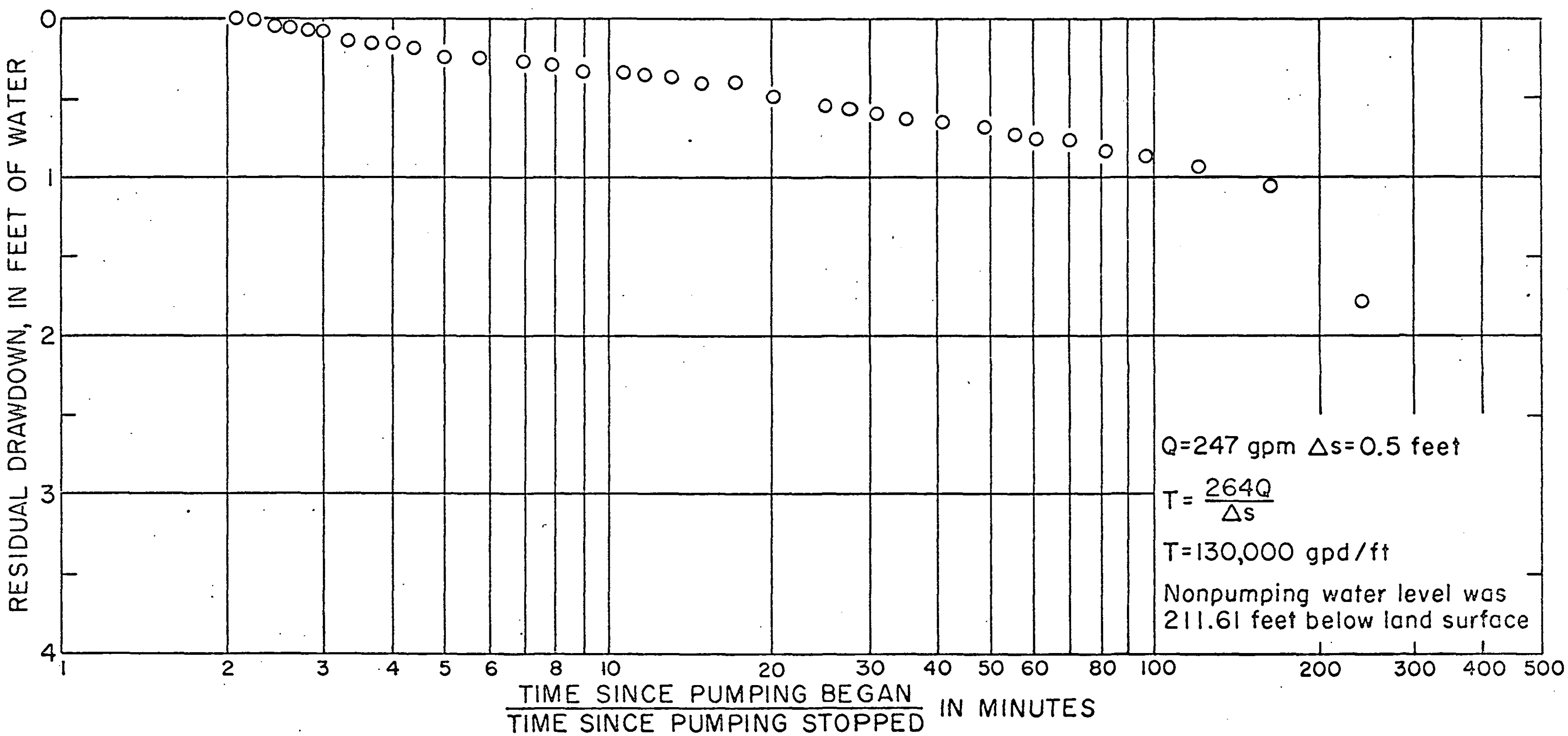


Figure 12.--Residual drawdown in well NW30-1, Feb. 24, 1967.