AQUIFER-TEST DATA AND BOREHOLE-FLOW-TEST RESULTS FROM MONITORING WELL 16P52 AT THE SOUTH TREND DEVELOPMENT AREA NUMBER 1, McKINLEY COUNTY, NEW MEXICO

By Ken Stevens

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CONVERSION FACTORS

In this report figures for measurements, except water temperature, are given in inch-pound units only. The following table contains factors for converting to metric units:

Multiply inch-pound units	By	To obtain metric units
inch	2.54	centimeter
foot	0.3048	meter
foot squared per day	0.0929	meter squared per day
cubic foot per second	0.02832	cubic meter per second
mile	1.609	kilometer
gallon	3.785	liter
gallon per minute	0.06309	liter per second
gallon per minute per foot	0.207	liter per second per meter
pound	0.4536	kilogram

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ABSTRACT

Mobil Oil Corporation personnel have designated at least four sandstone intervals, A-D (top to bottom), on the single-point resistivity logs of wells drilled in the South Trend Development Area. This report presents time-drawdown data reported by Mobil Oil Corporation from singly (A or B or C or D sandstone interval) and multiply (A, B, C, and D sandstone intervals) completed wells for the August 16-17, 1982 aquifer test at the South Trend Development Area Site 1. This report also describes the results of flowmeter and brine-injection tests by the U.S. Geological Survey in monitoring well 16P52. Well 16P52 is open to sandstone intervals A, B, C, and D.

On July 26, 1982, water was injected at a rate of 1.43 cubic feet per minute above the A sandstone interval in well 16P52. Based on flowmeter data, the calculated rates of flow were 1.23 cubic feet per minute between the A and B sandstone intervals, 0.63 cubic foot per minute between the B and C sandstone intervals, and less than 0.17 cubic foot per minute between the C and D sandstone intervals.

Based upon brine-slug-injection tests conducted during August 1982, the calculated flow rates between sandstone intervals A and B are as follows: 0.01 cubic foot per minute upward flow (B to A) about 5 hours after pumping began for the aquifer test; 0.004 cubic foot per minute upward flow (B to A) about 21 hours after pumping began; and 0.0 cubic foot per minute about 46 hours after the pump was turned off. All other brine-slug-injection tests measured no flow.

INTRODUCTION

The U.S. Minerals Management Service (MMS) and the New Mexico Environmental Improvement Division (EID) have a basic responsibility for the appraisal of Mobil Oil Corporation's insitu uranium-leaching procedures on public land near Crownpoint, McKinley County, New Mexico (fig. 1). The company intends to leach uranium ore in situ from the Westwater Canyon Member of the Morrison Formation. One aspect of the agencies' responsibility is to insure that ground-water-quality monitoring is accomplished before, during, and after in situ leaching operations.

Based on guidelines provided by MMS and EID, Mobil has constructed monitoring wells on the perimeter of the project area (fig. 2). These monitoring wells are open to several ore-bearing and non-ore-bearing interbedded sandstones in the Westwater Canyon Member. MMS and EID requested the U.S. Geological Survey to extend a study of insitu uranium leaching, in progress, into the South Trend Development Area Site 1 location in order to investigate flow characteristics in multiply completed wells.

Purpose

The purpose of this report is to: (1) Present some of Mobil Oil Corporation's aquifer-test data from the South Trend Development Area Site 1; (2) document the U.S. Geological Survey brine-slug-injection test results from monitoring well 16P52 during the Site 1 aquifer test; and (3) document the U.S. Geological Survey injection and flowmeter test results from monitoring well 16P52.

Scope

This report is limited to documenting:

1. Time-drawdown data during the August 16-17, 1982, aquifer test at the South Trend Development Area Site 1.

2. Flowmeter data during injection testing of a monitoring well open to the A, B, C, and D sandstone intervals on July 26, 1982.

3. Brine-slug-injection data in a monitoring well open to the A, B, C, and D sandstone intervals during the August 16-17, 1982, aquifer test at the South Trend Development Area Site 1, and on August 19, 1982.

4. Calculating the intraborehole flow, the brine-slug-injection data.

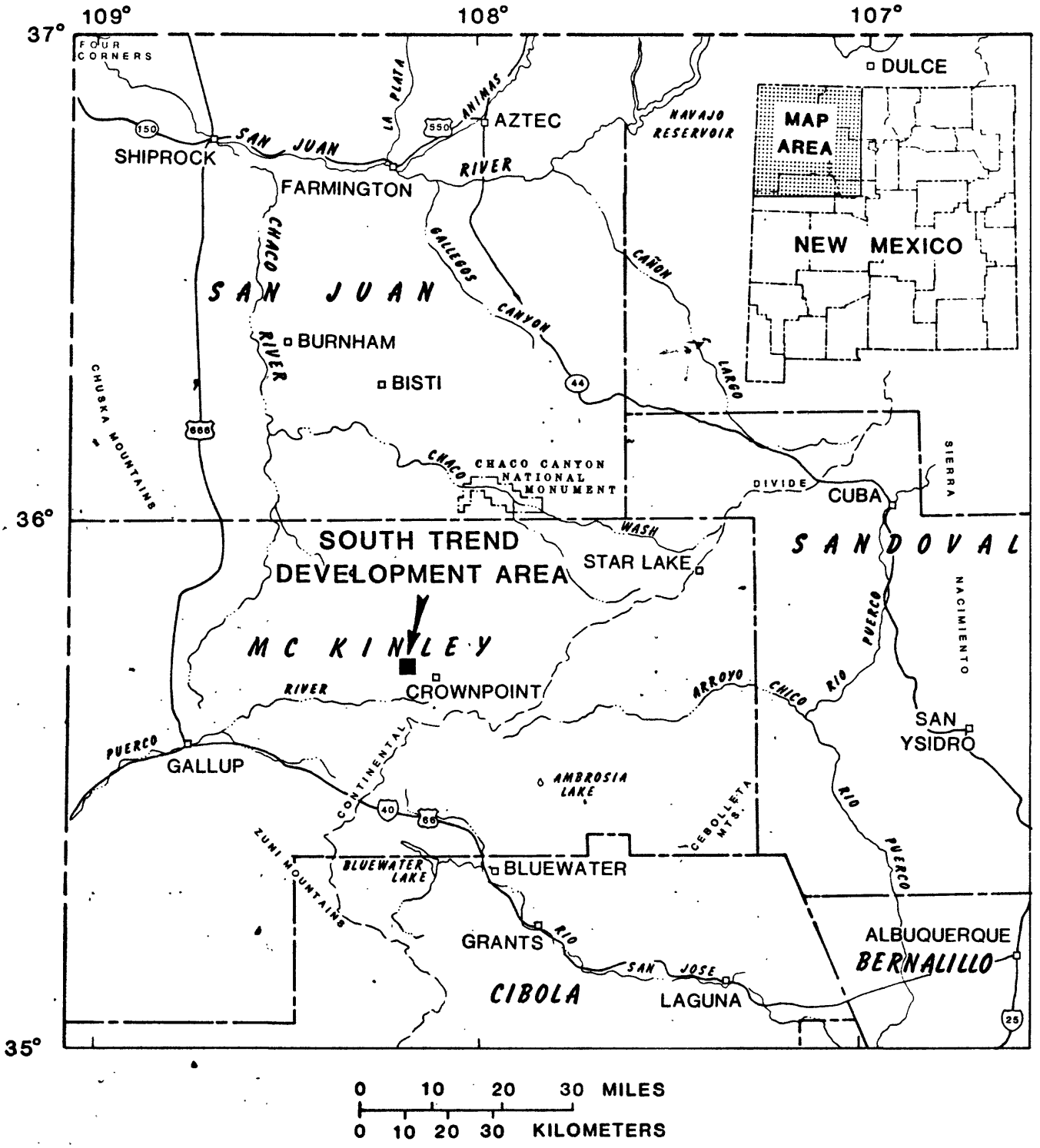

Figure 1.--Location of study area.

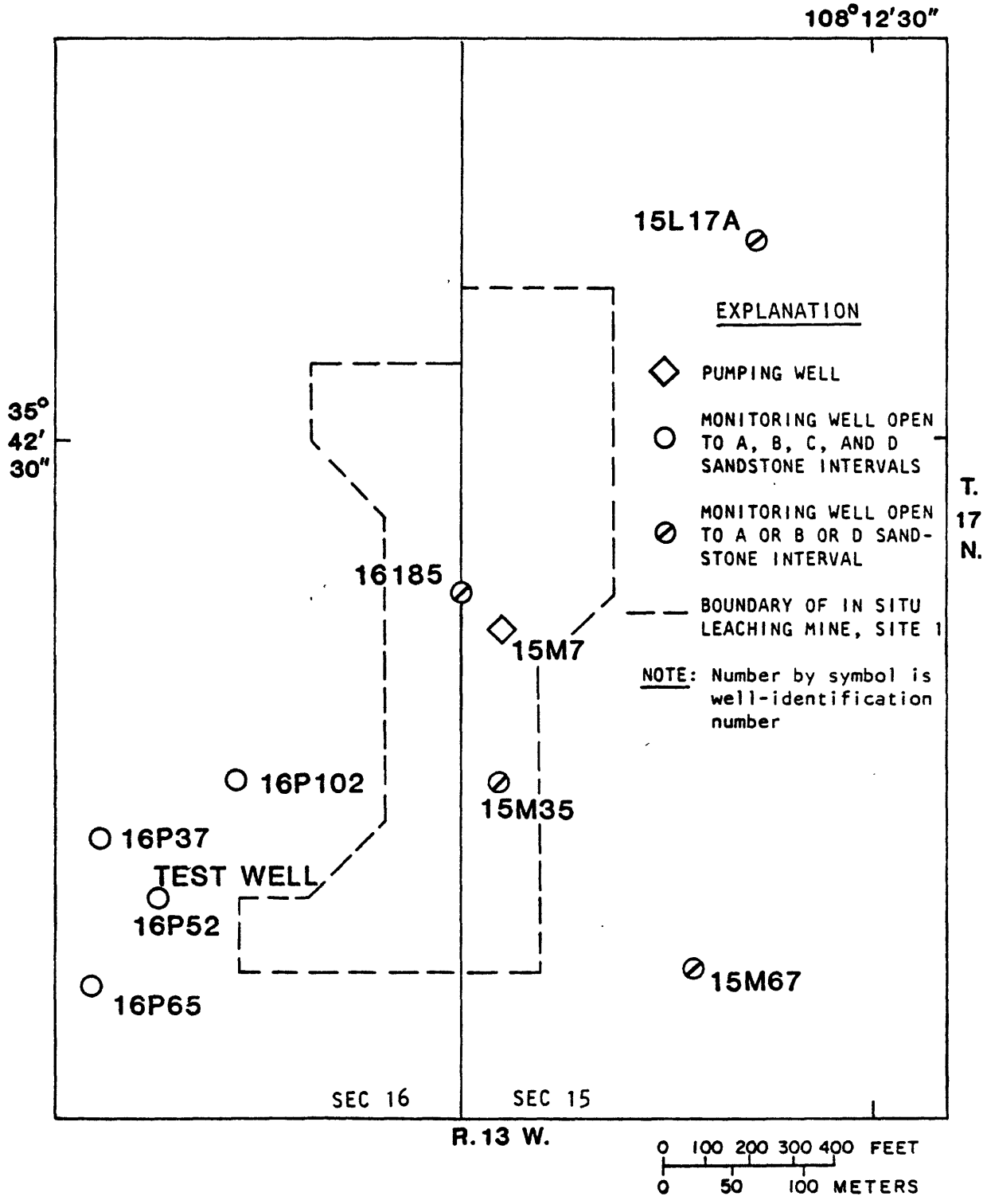

Figure 2.--Location of wells mentioned in report.

STRATIGRAPHY

A general stratigraphic column of the sedimentary units present in the South Trend Development Area and their approximate thickness is illustrated in figure 3. Mobil Oil Corporation personnel have designated four sandstone intervals, A-D (top to bottom), in the Westwater Canyon Sandstone Member in the Morrison Formation at Site 1 to be monitored.

WELL COMPLETION

Reported Completion Procedures for Well 15M7

Well 15M7, the pumping well for the aquifer test, was originally completed with jet perforations and developed in the B sandstone interval. For the aquifer test, the well was additionally jet perforated in A, C, and D sandstone intervals. The A, C, and D sandstone intervals were not developed. (Steingraber, W. A., Permitting Coordinator, Mobil Oil Corporation, oral commun. 1982).

Completion Procedures for Well 16P52

Well 16P52 was constructed by Mobil Oil Corporation. The well was jet perforated in the reported A, B, C, and D sandstone intervals (Cresswell, G. A., Manager Hydrological and Environmental Affairs, written commun., 1982) and developed by the U.S. Geological Survey. This 4.33-inch-diameter well was developed using a swabbing procedure in which the bottom of the swab was placed adjacent to different perforated areas. The lowest perforated area was first swabbed until the discharge was clear; then the swab was pulled up to the next area and the process was repeated. Well 16P52 was swabbed for about 20 hours.

The construction of well 16P52 is similar to the 20 other perimeter monitoring wells (fig. 2). A single-point electrical-resistance log of well 16P52 supplied by Mobil Oil Corporation is illustrated for the interval from the Dakota Sandstone to the bottom of the Westwater Canyon Member of the Morrison Formation in figure 4. The sandstone intervals A, B, C, and D are identified in figure 4. An electrical-conductivity log (no scale) from well 16P52 that illustrates the differences in ground-water conductivity in the area of casing perforations is shown in figure 5. Geophysical logging with the conductivity tool, which included logging for the injected-brine slugs, was run using the electrical-resistance module.

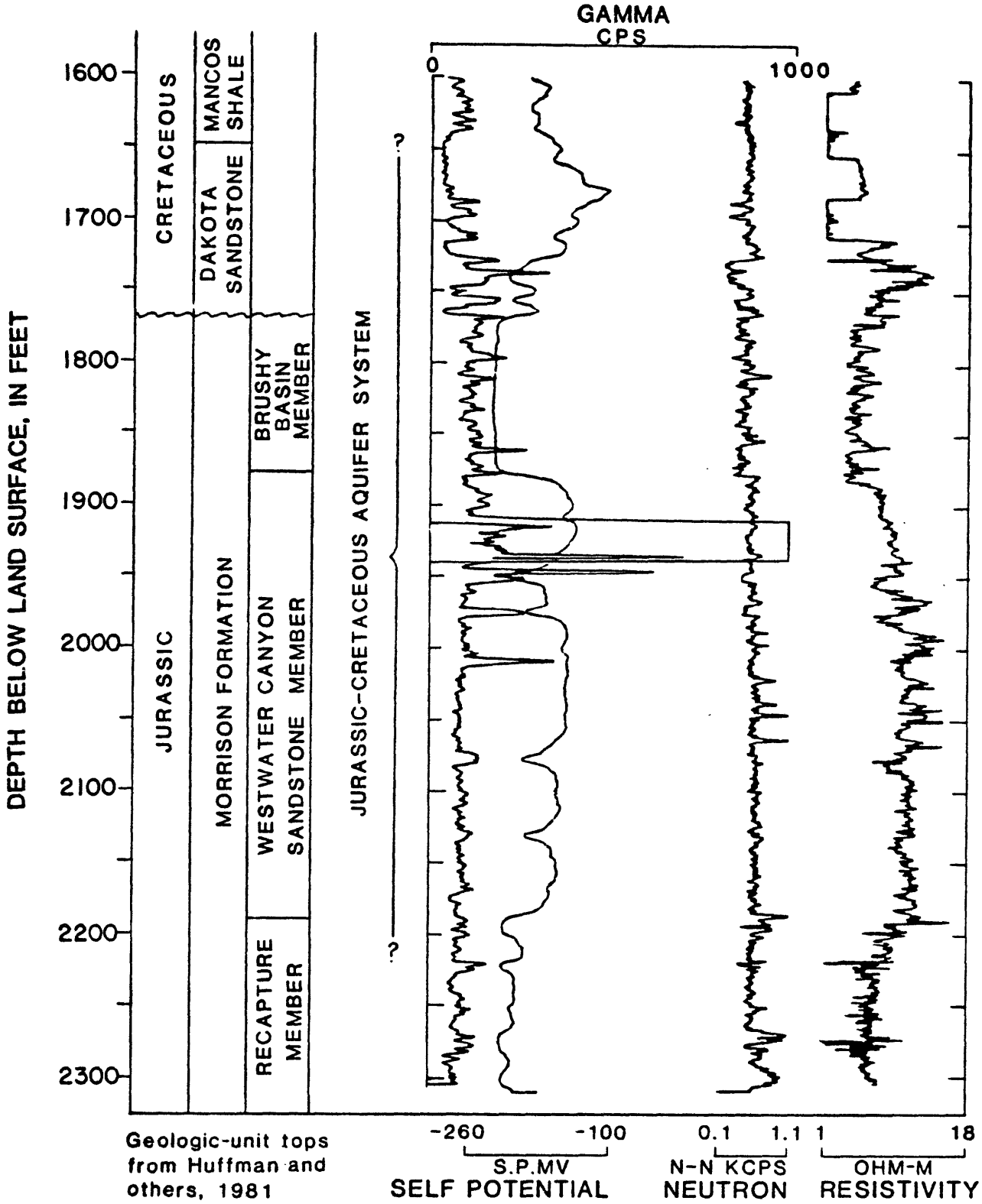

Figure 3.--Generalized stratigraphic column of the sedimentary units in the Jurassic-Cretaceous aquifer system in the South Trend Development Area, U.S. Geological Survey Well 4.

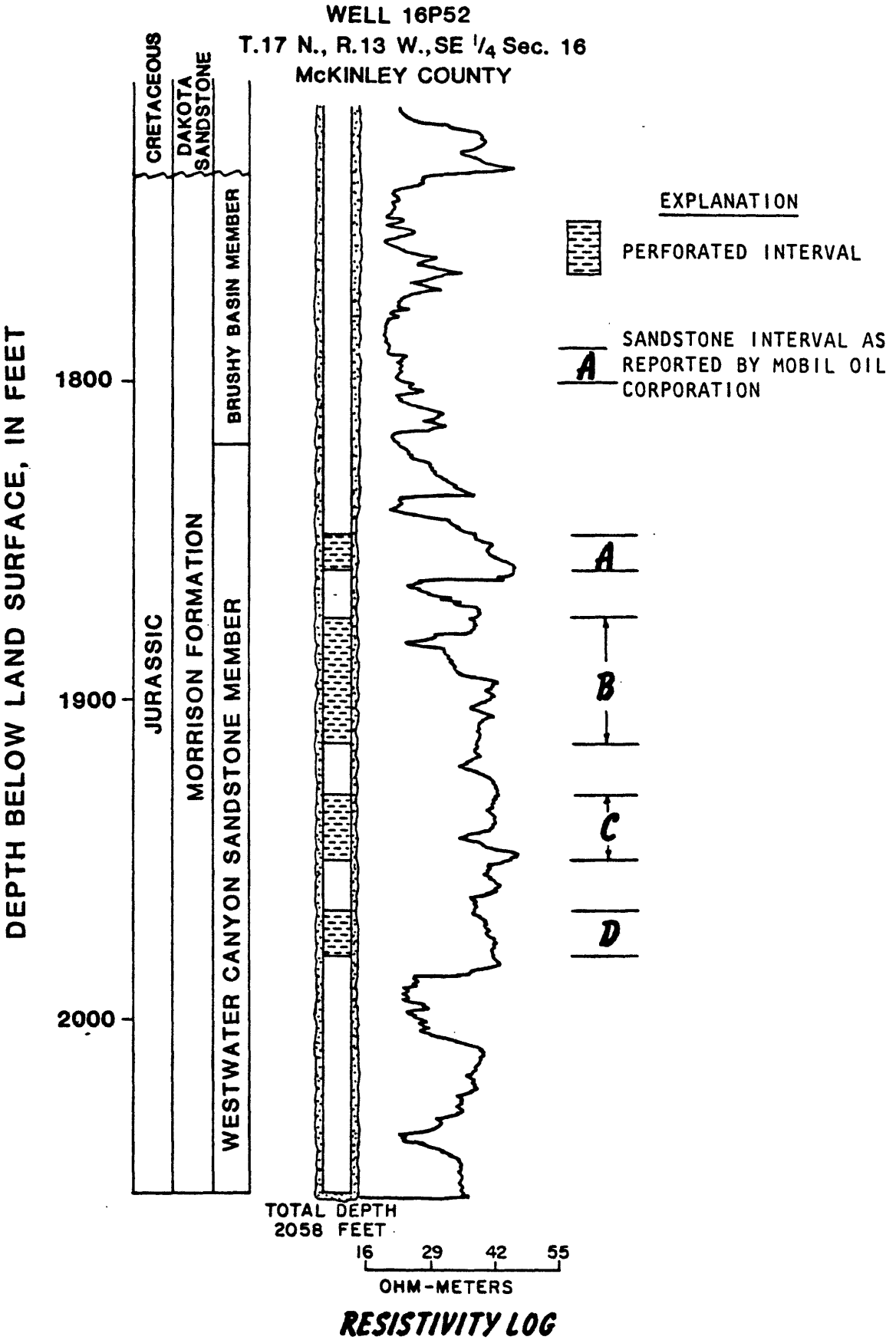

Figure 4.--Single-point electrical-resistance log illustrating the A-D sandstone intervals in the Westwater Canyon Sandstone and completion details of well 16P52.

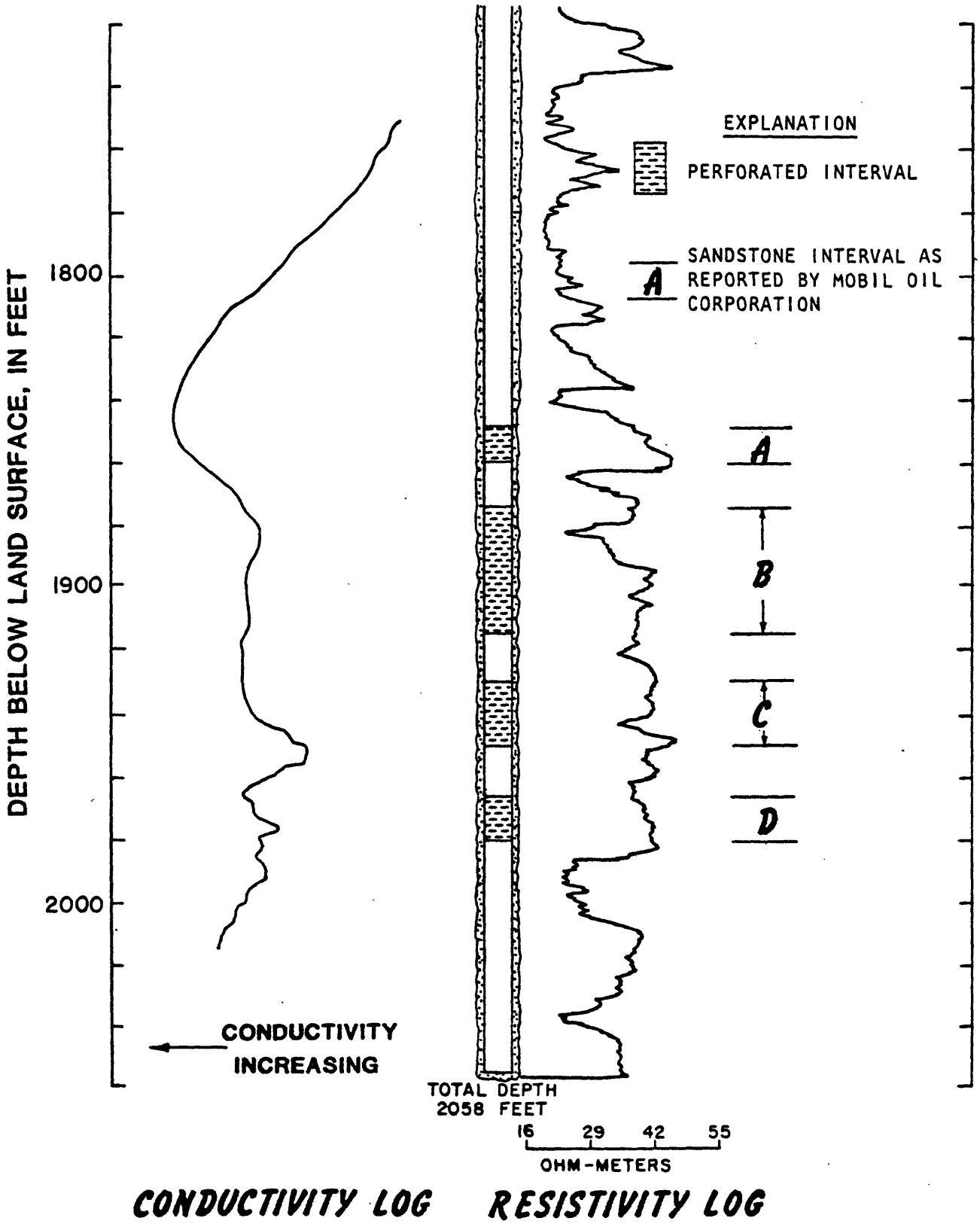

Figure 5.--Conductivity log of the perforated section of well 16P52.

TESTING

Aquifer Test

The aquifer test was started at Site 1 (Mobil Oil Corporation, 1982) at noon, August 16, 1982, and ended at noon, August 7. Well 15M7 (fig. 2) was pumped for 24 hours at about 10.0 cubic feet per minute. Twenty-six wells completed in the Westwater Canyon Member and two wells completed in the Dakota Sandstone were monitored for drawdown and recovery. A log-log, mass plot of drawdown(s) versus time divided by distance from the pumped well squared (t/r^2) is illustrated in figure 6. The data are shown for three monitoring wells completed in the A, B, C, and D sandstone intervals in the Westwater Canyon Member. A similar mass plot is shown in figure 7 for four monitoring wells completed in the A or B or D sandstone interval in the Westwater Canyon Member.

The time-drawdown data illustrated in figures 6 and 7 were computed by the U.S. Geological Survey from copies of the recorder strip charts used during the aquifer test by Mobil Oil Corporation to record water-level data. The strip charts are published by Mobil (1982). (Steingraber, W. A., oral commun. 1982). The U.S. Geological Survey was not a participant in the aquifer test.

Well Testing

Well-injection testing - flow-meter results

On July 26, 1982, water was injected into well 16P52 above the uppermost perforated zone while U.S. Geological Survey personnel used a borehole flowmeter suspended within the well casing to measure flow in the borehole. The position of the flowmeter in the borehole, the recorded flowmeter revolutions, the calculated count rate per minute, and the calculated approximate flow rate are shown in figure 8. The flow-rate calculations are based on the assumptions that (1) the injected water flows vertically in the well bore and horizontally into the sandstone intervals, (2) the counts per minute recorded from the flowmeter are directly proportional to a velocity (counts per minute is proportional to feet per minute), and (3) the continuity equation, $Q=AV$, is applicable (Q = flow rate, A = cross-sectional area, V = velocity).

At the injection rate of 1.43 cubic feet per minute, the number of revolutions recorded with the borehole flowmeter at the top of the A sandstone interval (fig. 8) was 43 counts per minute. The cross-sectional area of the 4.33-inch-diameter well is 0.1 square foot; therefore, 1.43 cubic feet per minute divided by 0.1 square foot is equivalent to 43 counts per minute.

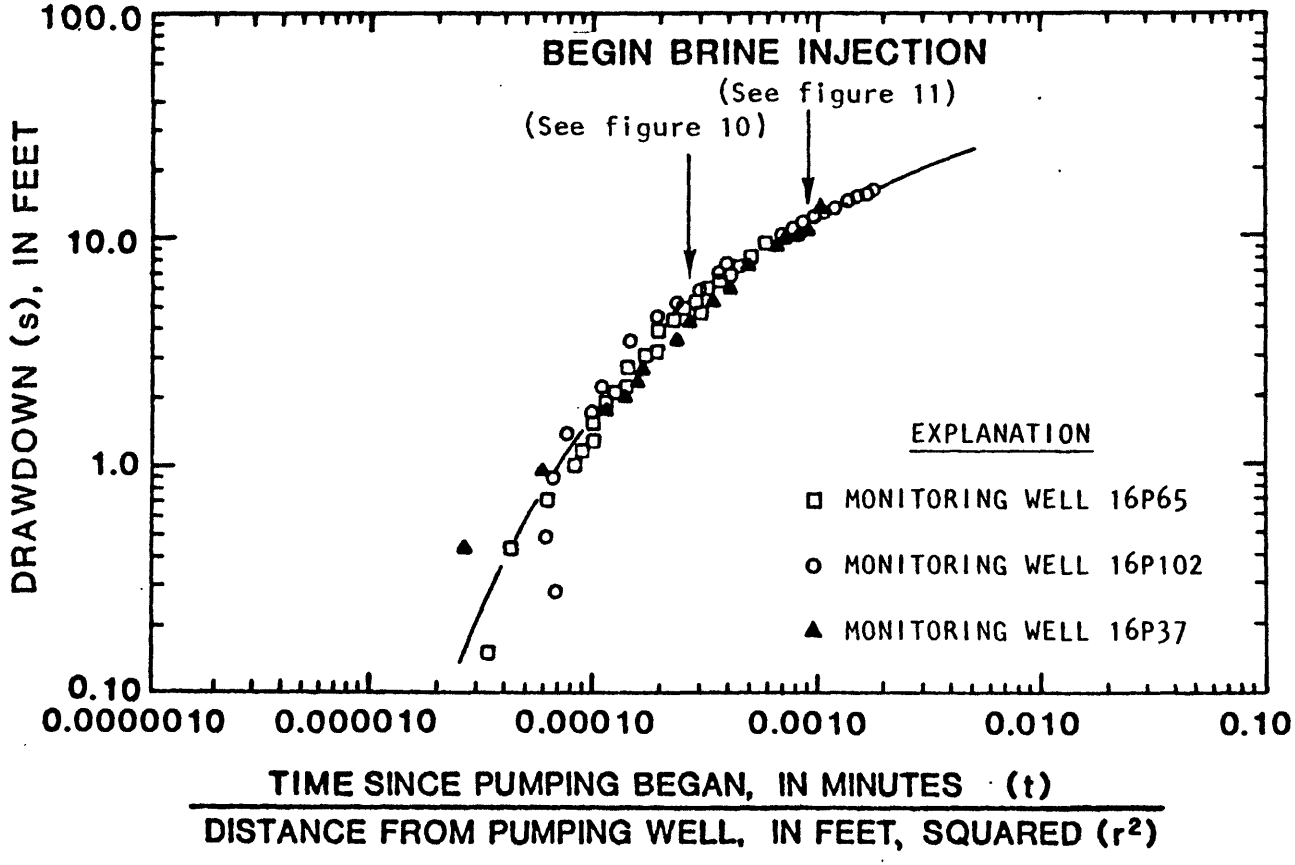

Figure 6.--Mass plot of time-drawdown data from monitoring wells completed in the A, B, C, and D sandstone intervals at Site 1.

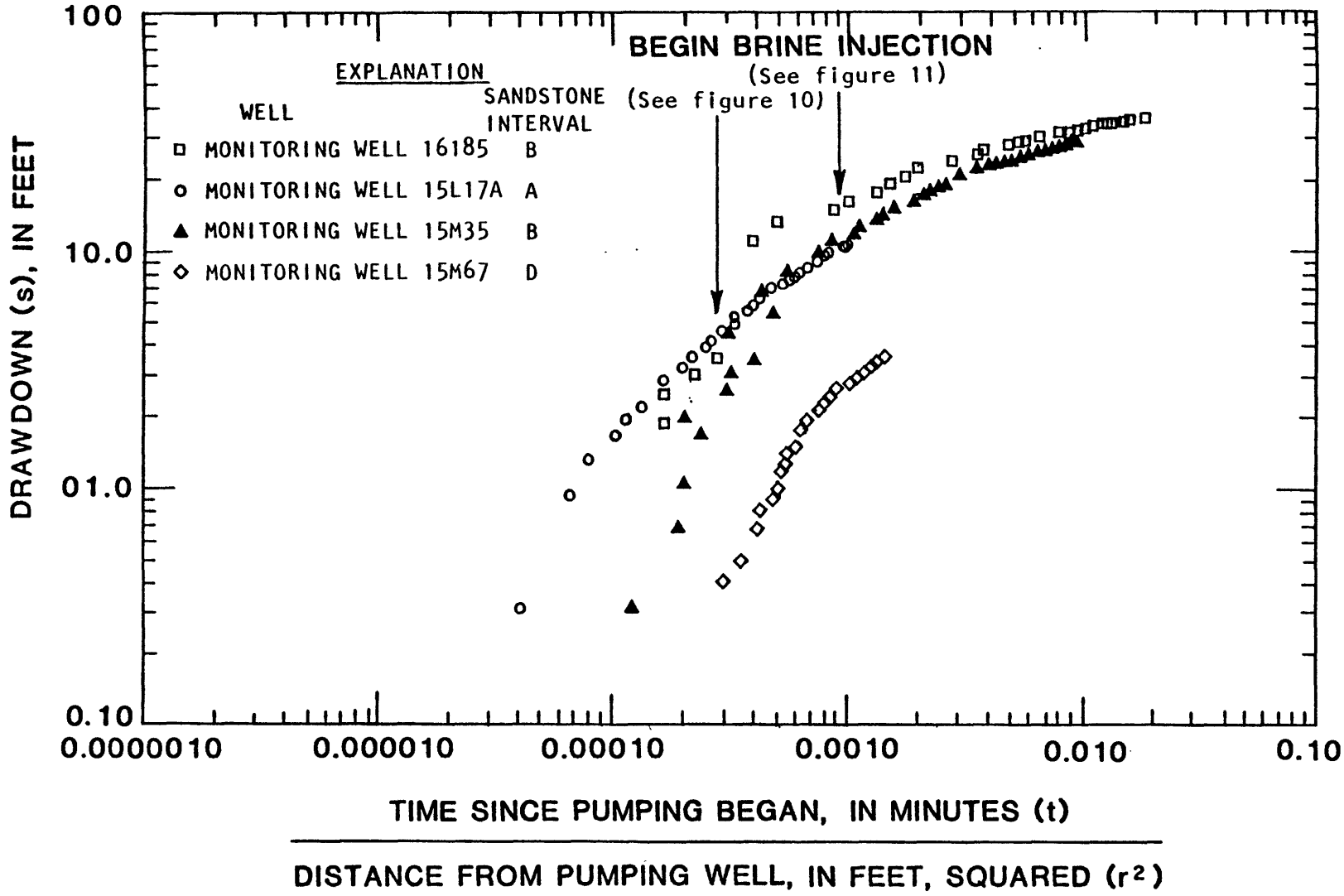

Figure 7.--Mass plot of time-drawdown data from monitoring wells completed in the A, B, or D sandstone intervals at Site 1.

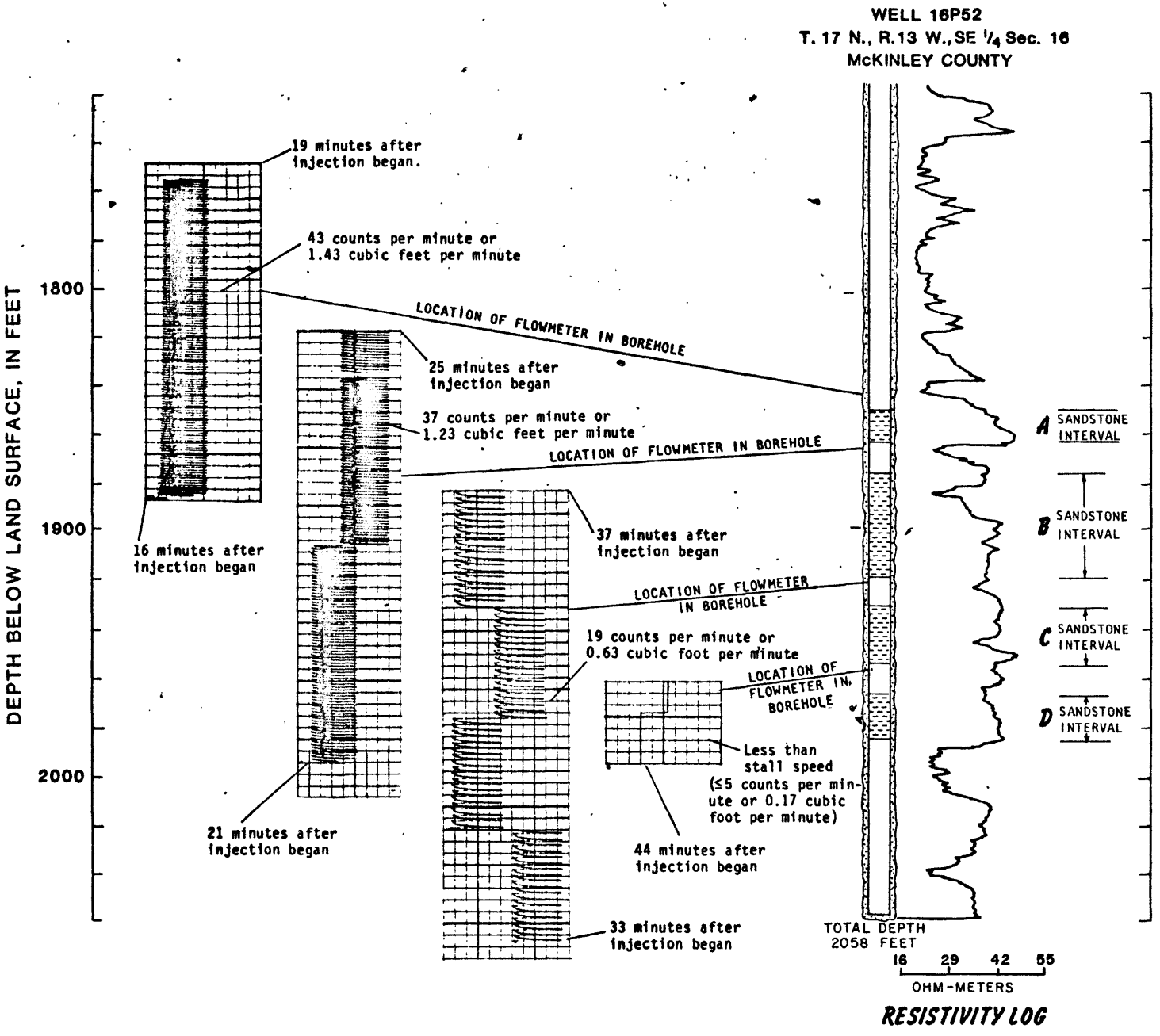

Figure 8.--Flowmeter results from well 16P52 during injection and calculated flow rates.

The flow rate for the blank-casing section between sandstone intervals A and B is calculated as:

Flow between A and B sandstone intervals =
(1.43 cubic feet per minute) x (37 counts per minute / 43 counts per minute)

or 1.23 cubic feet per minute. The calculated flow between sandstone intervals B and C is 0.63 cubic foot per minute. Between C and D, the flow rate was less than the stall speed of the flowmeter, which is about 5 counts per minute. The inference is that no more than 0.17 cubic foot per minute is flowing between the C and D sandstone intervals.

The calculated decrease in flow as a function of the sum of length of perforations in the borehole is shown in figure 9. If the sandstone interval spanned by the perforations acts as a geohydrologic unit, the probable contributions of ground water from each sandstone interval during pumping from 16P52 are shown in table 1. These calculations are based on the assumption that withdrawal stresses are similar to injection stresses.

Table 1. Calculations of ground-water contributions from each sandstone interval during the pumping of well 16P52

Sandstone interval	Perforated interval		Percent of flow	Cumulative percent of flow between sandstone intervals
	In feet	As percentage of all perforated intervals		
A	10	12	12	88
B	41	47	47	41
C	21	24	24	17
D	15	17	17	0

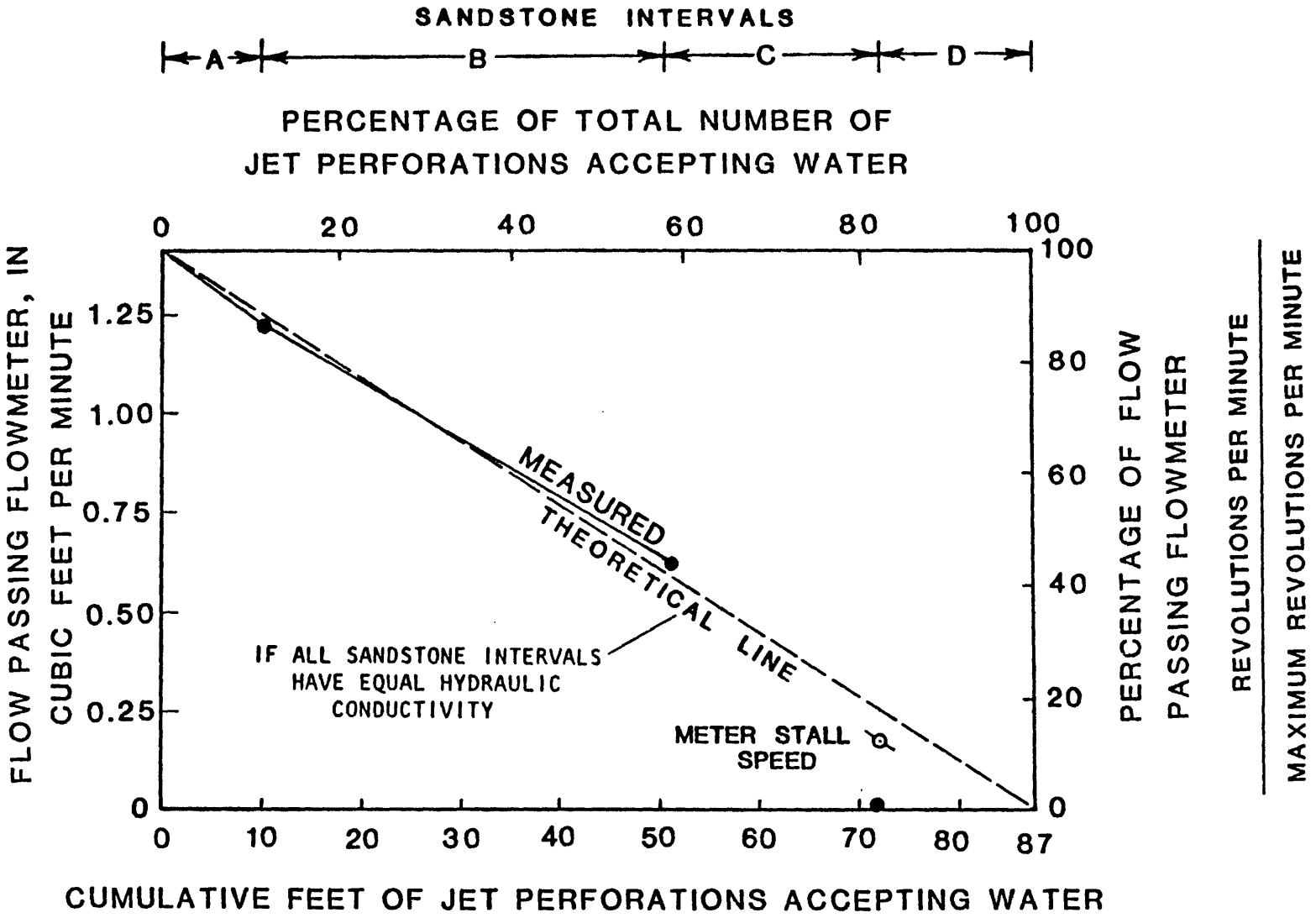

Figure 9.--Summary of flowmeter results from well 16P52 plotted as a function of perforated interval length.

Brine-injection testing

Borehole flowmetering procedures are intended primarily to determine high borehole velocities. A different procedure, brine-slug injection, can be used to measure small borehole velocities, such as those which occur within a monitoring well completed in more than one geohydrologic unit during an aquifer test.

Brine-slug injection consists of injecting a small quantity of brine (10 cubic centimeters), several times the salinity of the borehole water, into the borehole at a known location. The position and shape of the slug is determined by logging slowly downward in the well using a conductivity tool. The velocity of the fluid in the borehole is measured by tracing the movement of the centroid or peak concentration of the brine in the borehole in a similar manner as is used in dye-tracing techniques in streams (Hubbard and others, 1982, fig. 2).

Brine-injection results from well 16P52 during the aquifer test of August 16-17, 1982, and, after the recovery period on August 19, 1982, are illustrated in figures 10, 11, and 12. The concentration peaks of the brine, locations of the brine, and time of logging into the top of the brine are shown in the figures. No brine-injection data are available for pre-aquifer-test conditions.

The first brine was injected between the B and C sandstone intervals (fig. 10) about 4 hours after the start of the aquifer test. The position of the brine in the borehole was recorded four times in 40 minutes after injection. The salinity of the brine was about 1,500 micromhos per centimeter at 25° Celsius and the salinity of the borehole fluid was about 415 micromhos. There was no apparent net movement of the brine between the B and C sandstone intervals.

Brine was injected between the A and B sandstone intervals about 5 hours after the start of the aquifer test. About 4 feet of net upward movement was recorded 41 minutes and 45 seconds after injection (fig. 10). The calculated upward velocity is 0.11 foot per minute. The flow rate is 0.01 cubic foot per minute for the 4.33-inch-diameter well.

The results of brine-injection tests made on August 17, 1982, are shown in figure 11. The brine injectioned between the A and B sandstone intervals at 9:17 a.m., about 21 hours after the start of the test, also had net upward flow. The flow rate was calculated to be about 0.004 cubic foot per minute. No flow was indicated by the brine slugs injected in the middle of the B sandstone interval at a depth of 1,890 feet or the slug injected between the B and C intervals at 1,920 feet.

The brine-injection tests on August 19, 1982, 46 hours after the aquifer test was stopped, are shown in figure 12. No intraborehole flow was observed.

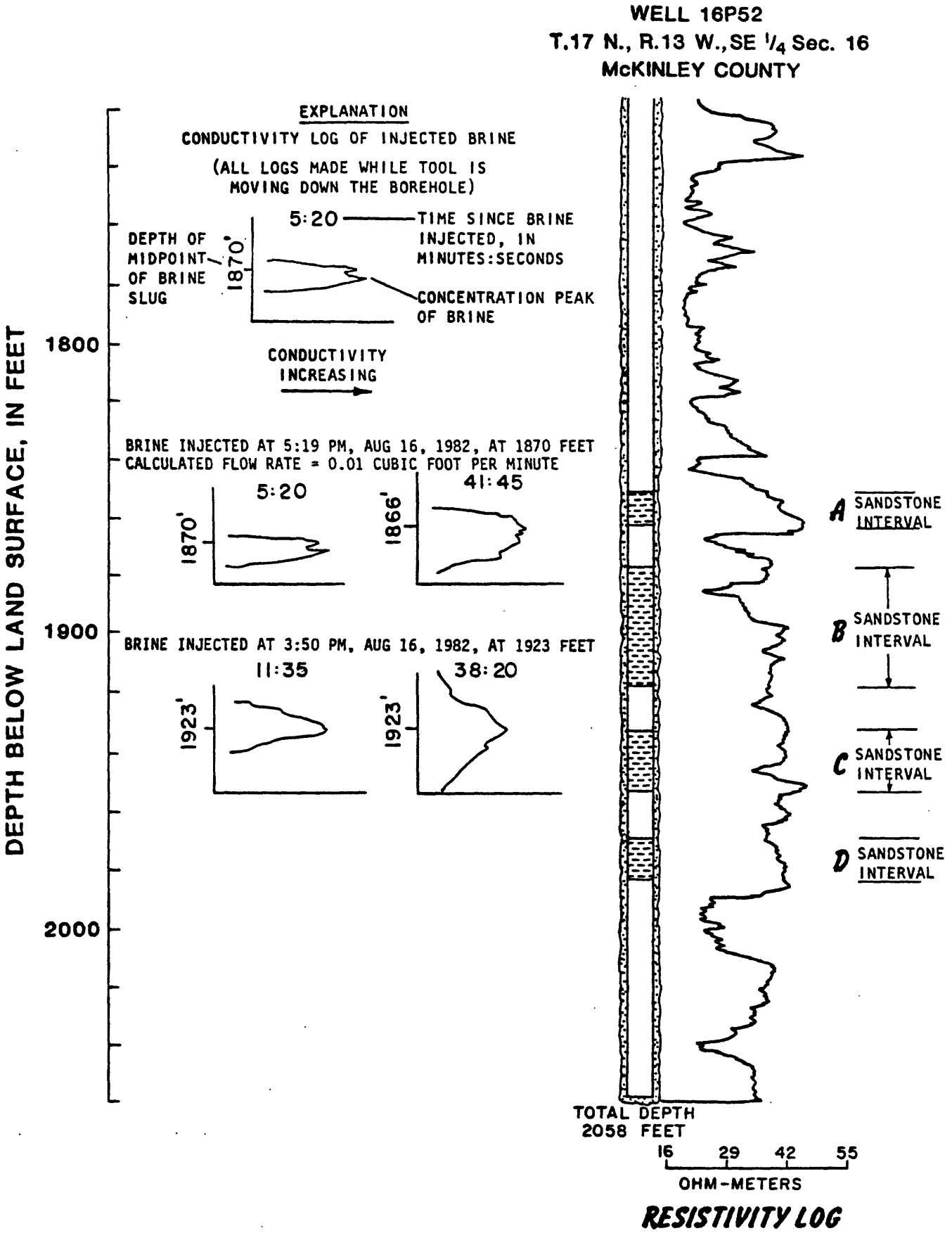

Figure 10.--Brine-injection test results for August 16, 1982, from well 16P52.

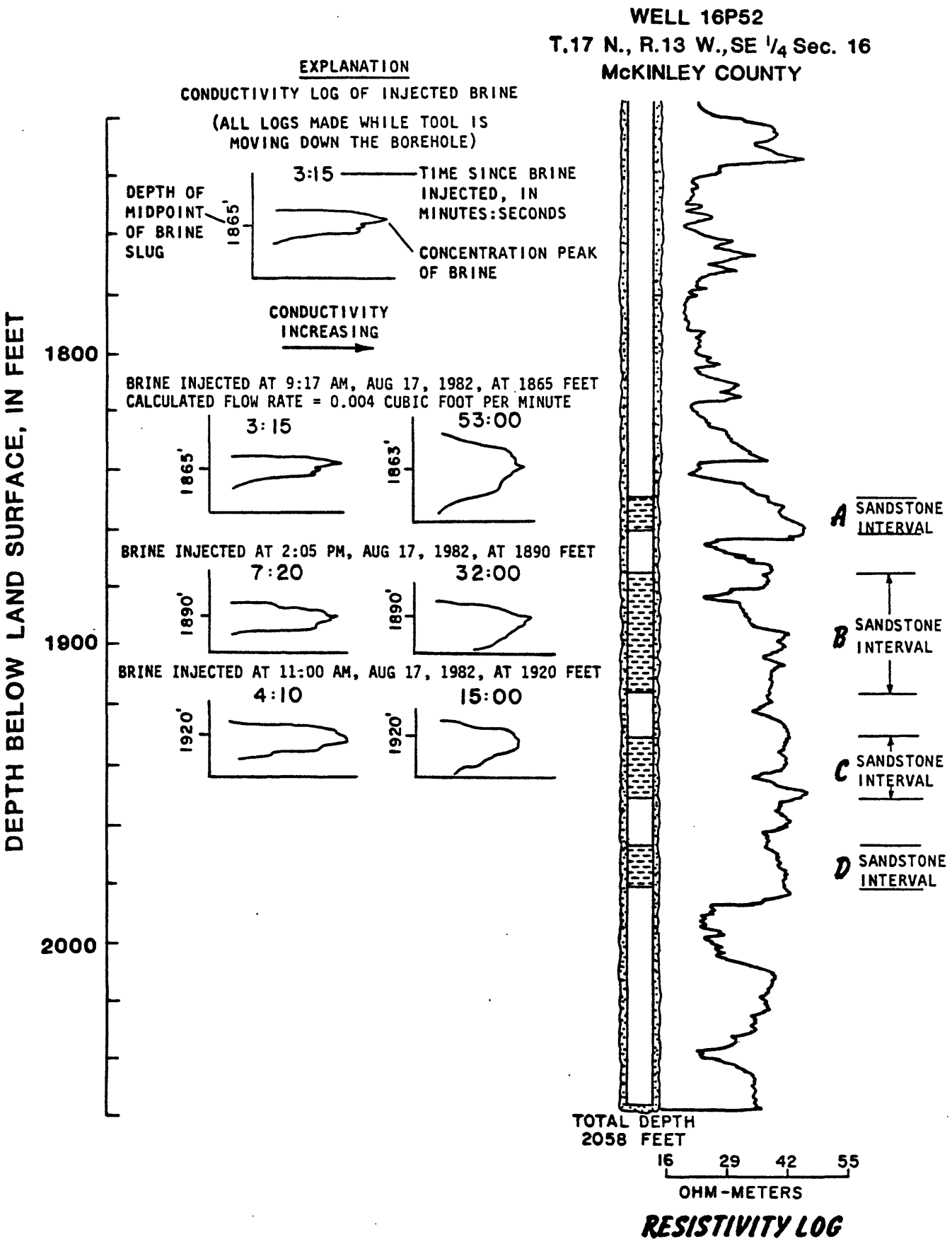

Figure 11.--Brine-injection test results for August 17, 1982, from well 16P52.

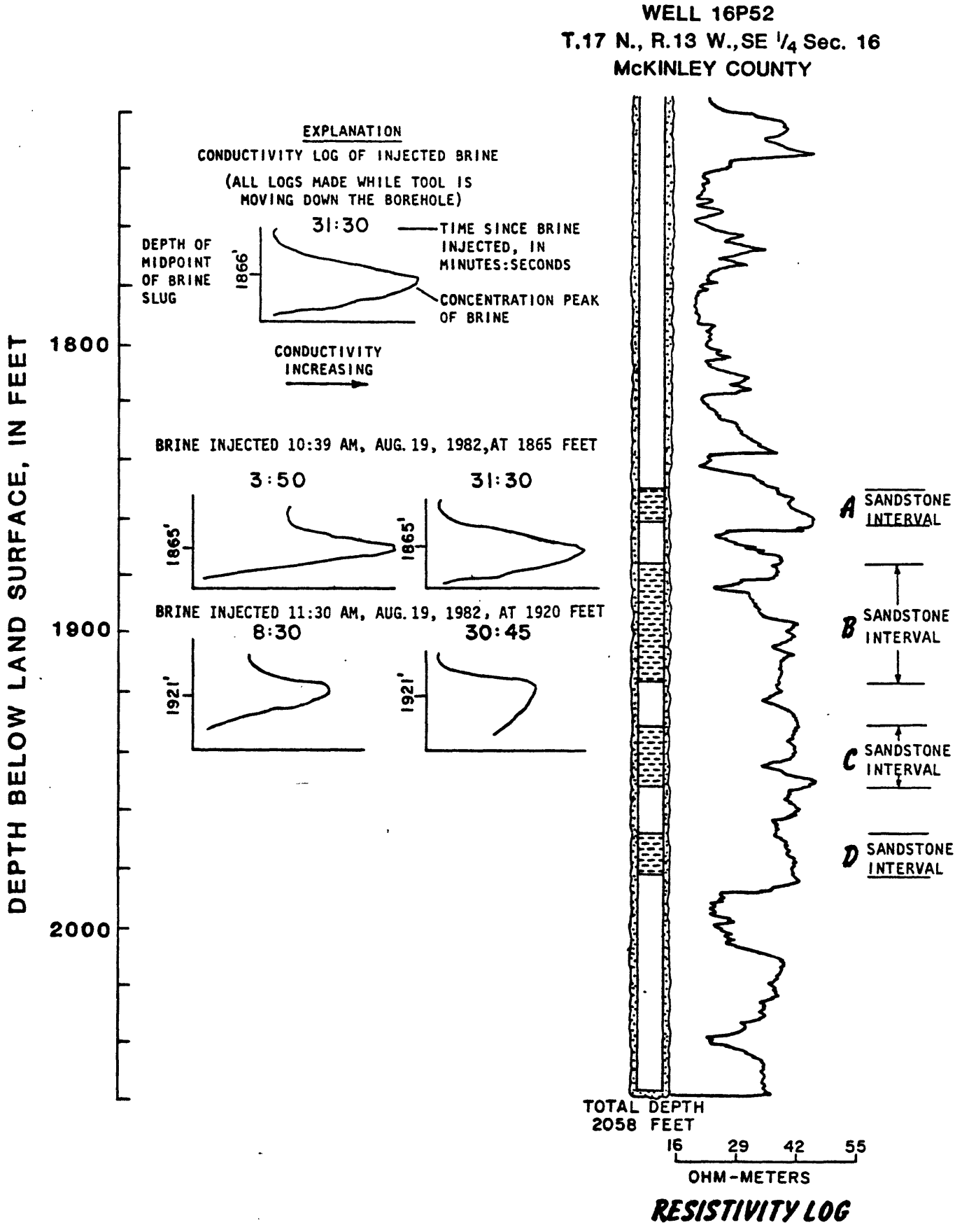

Figure 12.--Brine-injection test results for August 19, 1982, from well 16P52.

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