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GEOLOGICAL SURVEY
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Circular 43

A PUMP TEST IN THE DAKOTA SANDSTONE AT WALL, SOUTH DAKOTA

by

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ABSTRACT

A pump test was conducted in the Dakota Sandstones at Wall, South Dakota, on October 7, 1972. Two observation wells responded to the pumping and an average value of permeability was calculated to be 9.42 gpd/sq ft. No deviation from the Theis type curve was observed during the 44 hours of pumping at 120 gpm.

INTRODUCTION

The Dakota artesian basin contains one of the world's most famous but least understood aquifers. The concepts outlined in Darton's (1909) classic paper have appeared in countless textbooks. According to Darton's theory, meteoric water is recharged into the high outcrop areas on the flanks of the Black Hills and travels eastward down dip under the prairie of South Dakota. Quantitative data in support of this theory has recently been published by Miller and Rahn (1974). Russell (1928) challenged this theory and suggested that connate water in storage could develop pressure by compaction of the sedimentary deposits. Gries (1958) reviewed the problem in the light of stratigraphic information made available by new deep well drilling. More recently, Swenson (1968) suggested that upward leakage from the underlying Paleozoic limestones could recharge the Dakota aquifer. Bredehoeft, et al., (in preparation) postulates yet another theory: that of downward leakage from topographically high western areas of the Cretaceous shale above the sandstones of the Dakota group.

There exists, then, one theory of *in situ* generation of artesian pressure in the sandstones of the Dakota group (Russell) and three steady-state recharge theories: (1) lateral recharge from outcrops (Darton), (2) upward leakage (Swenson), and (3) downward leakage (Bredehoeft, et al.). These three steady-state models are illustrated in figure 1.

There is no published information on a pump test in the Dakota sandstones in South Dakota where observation wells have been used. There is, however, some data available where specific capacity (pumping rate divided by drawdown) in a pumped well has been used to estimate transmissibility. However, specific capacity cannot be used to plot a time-drawdown curve from which leakage conditions can be determined. Such information requires an observation well (Walton, 1962; Neuman and Witherspoon, 1971).

The purpose of this report is to describe a pump test at Wall, South Dakota (see fig. 2). This test, conducted on October 6-9, 1972, included two observation wells which responded to the pumped well.

We wish to acknowledge our appreciation to Mr. Paul Goldhammer, superintendent of the Wall Water Department, for his assistance during the test. The project was financially supported by a grant from the South Dakota Water Resources Research Institute (A-034-SDAK). Mr. John Bredehoeft and Mr. E. F. LeRoux of the United States Geological Survey kindly read the manuscript and offered suggestions for improvement.

GEOLOGY

The stratigraphy of the basal Cretaceous sandstones underlying South Dakota is more complicated than was appreciated at the time that Darton first suggested his model of the Dakota artesian basin. Figure 3 illustrates the transgressive-regressive relationships of these water-bearing sandstones, using the Greenhorn limestone as a datum. At present the term Dakota is used in western and central South Dakota for the delta of sandstones lying above the Skull Creek shale (Gries, 1954; Schoon, 1972). Thin, western extensions of this sandstone wedge crop out as isolated channels and form the Newcastle sandstone of western South Dakota and eastern Wyoming.

The lower sandstones, which form the large outcrop areas on the flanks of the Black Hills, are called the Fall River and Lakota formations. In the wells at Wall, sandstones of the Dakota formation are cased off because of lower hydrostatic pressure and inferior water quality. The wells produce water only from the lower, Fall River-Lakota, aquifer. In this paper, for the sake of simplicity, we will refer to all of these sandstones as members of the Dakota group.

THE PUMP TEST

Figure 4 is a plat of Wall, South Dakota, showing the location of the three municipal water wells used in the current test. Well no. 1 is the pumped well; wells no. 2 and no. 3 are the observation wells. Each of the wells is over 3200 feet deep; stratigraphy, pump settings, screens, and water levels are indicated on figure 5.

All three wells were in alternate use by the City of Wall prior to the test. However, none had been pumped for more than 24 hours prior to the pump test. A recovery trend for the two observation wells was determined during this rest period. The pump test started at 2:45 p.m. on October 7, and the drawdown was determined in all three wells. These drawdowns were corrected to include the effects of the pre-test recovery trend. Well no. 1 was pumped at 120 gpm; wells no. 2 and no. 3 were the observation wells.

Figures 6 and 7 are the time-drawdown curves for wells no. 2 and no. 3 respectively. The data is plotted and analyzed using the formulas shown in Walton (1962). If more aquifer constants for the Dakota and overlying shales were known, a more rigorous analysis could have been attempted, such as the modified leaky aquifer analysis developed by Hantush (1960). The average values of transmissibility (T) and storage (S) are 2,165 gpd/ft and 0.000,0233 respectively. Since the average thickness of the sandstone unit tested is 230 feet, the average permeability is 9.42 gpd/sq ft.

Figure 8 is a distance-drawdown plot for all three wells after 44 hours of pumping. Using the Theim solution, a value of transmissibility of 4,320 gpd/ft is obtained.

DISCUSSION

The pump test data show that the Dakota sandstones are moderately permeable at Wall. In a region covered by relatively impermeable Cretaceous and Tertiary shales, the Dakota sandstones represent a viable ground water resource.

A significant conclusion of this pump test is the fact that neither observation well shows the slightest deviation from the Theis type curve (see figs. 6 and 7). There does not appear to be any evidence of leakage. This conclusion can also be confirmed by plotting the time-drawdown data on semi-log paper; it follows a perfectly straight line. The lack of leakage suggests that little recharge may be occurring, either upward or downward to the Dakota. Rather, recharge would appear to be laterally, according to Darton's original hypothesis.

It should be emphasized that the pump test was not run long enough to permit the conclusion that no leakage exists whatsoever. Indeed, it is doubtful if the effects would be evident under even prolonged pumping inasmuch as the vertical permeability of the overlying Pierre Shale is undoubtedly extremely low. Additionally, the underlying Paleozoics are not in direct contact with the Dakota group at this point.

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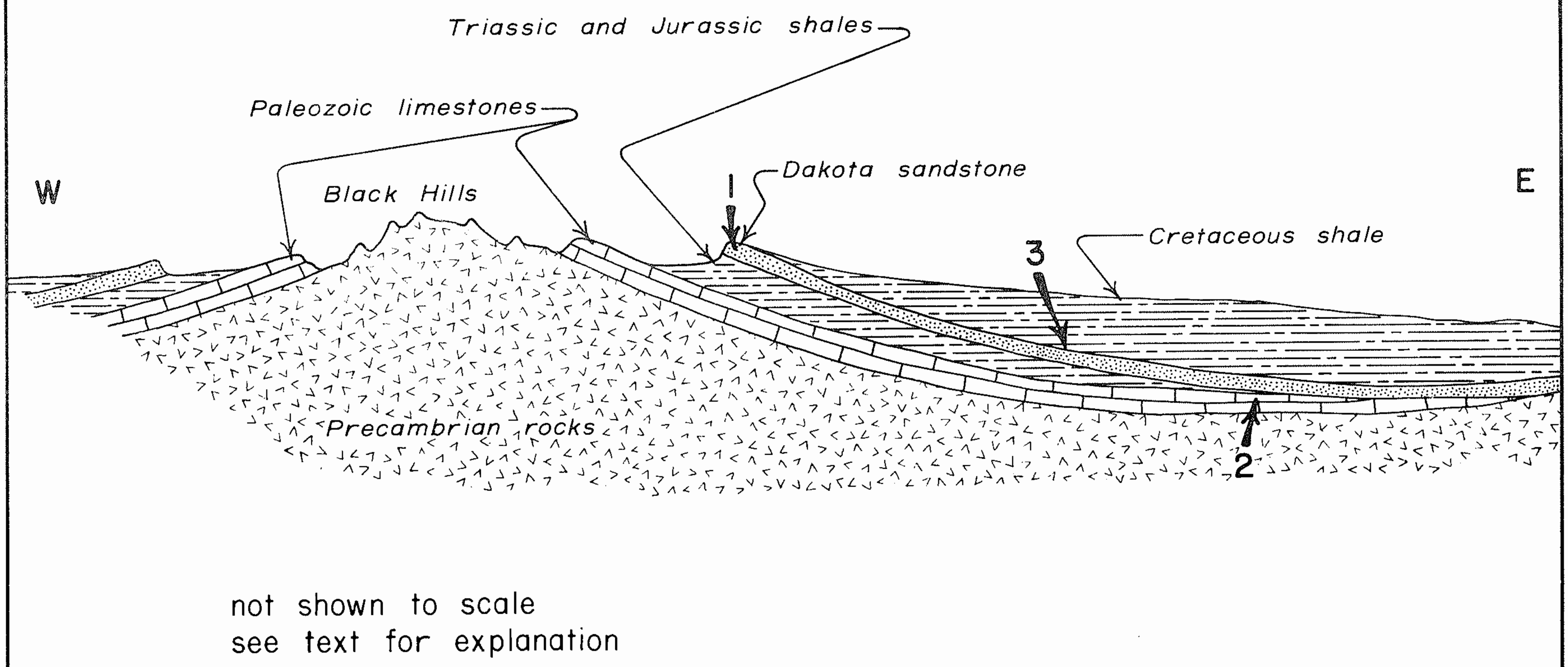


Figure I. Three theories for steady-state recharge to the Dakota sandstones.

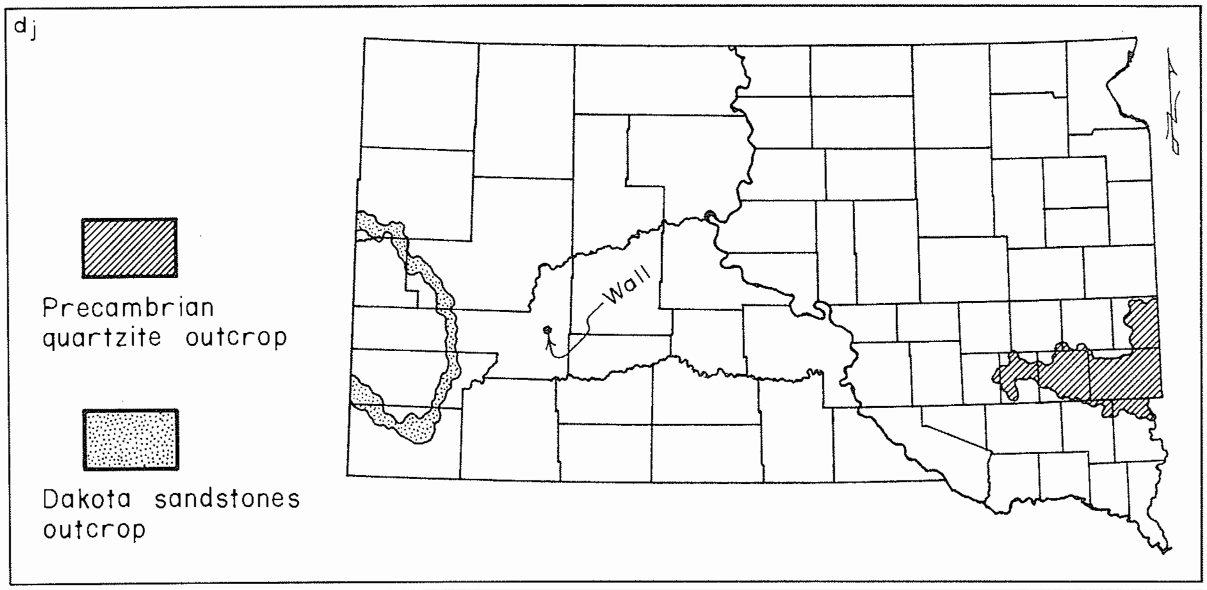


Figure 2. Map of South Dakota showing location of Wall.

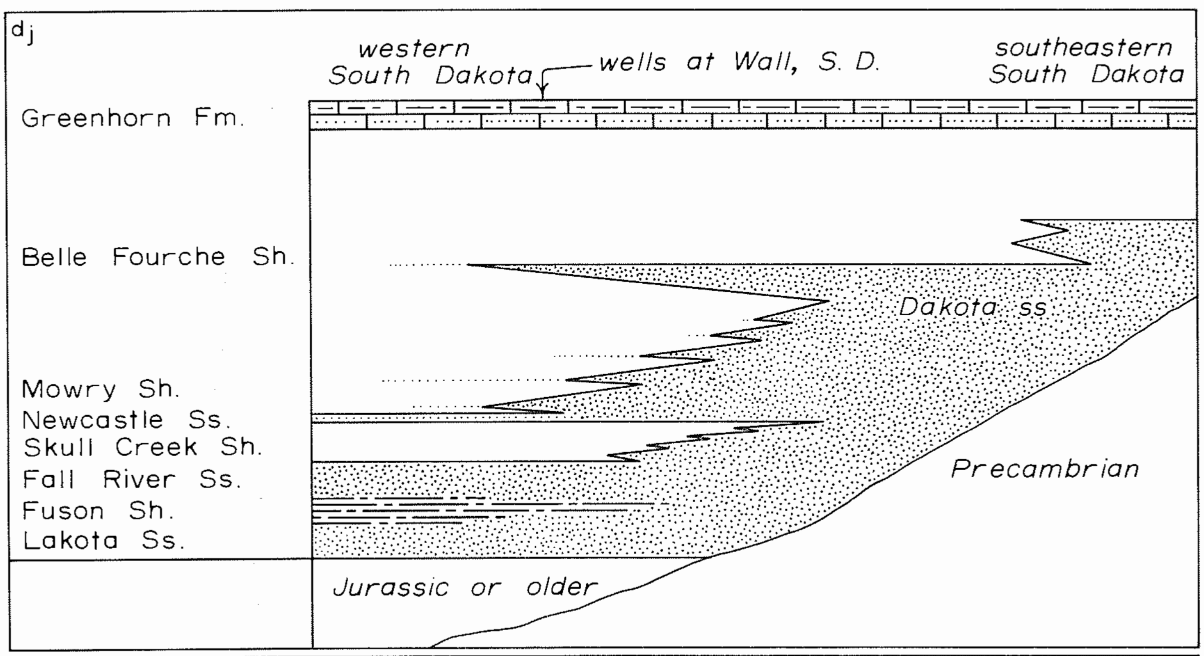
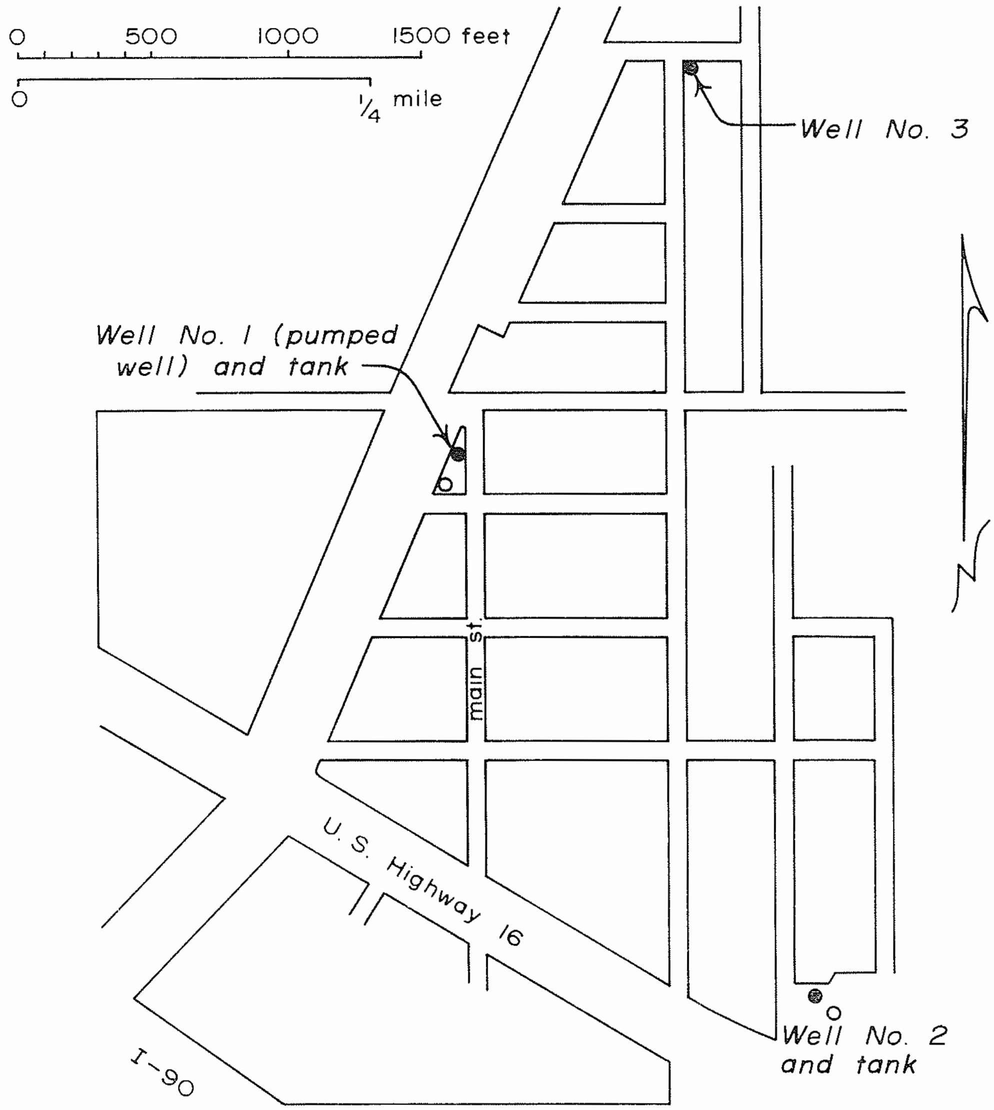


Figure 3. Generalized cross-section of Cretaceous sandstones in South Dakota (after Gries, 1954).



• Well   o Tank

Straight line distance between wells:

Wells No. 1 and 2 = 2,450 feet

Wells No. 1 and 3 = 1,727 feet

Wells No. 2 and 3 = 3,600 feet

Figure 4. Map of Wall, South Dakota, showing location of three wells.

dj

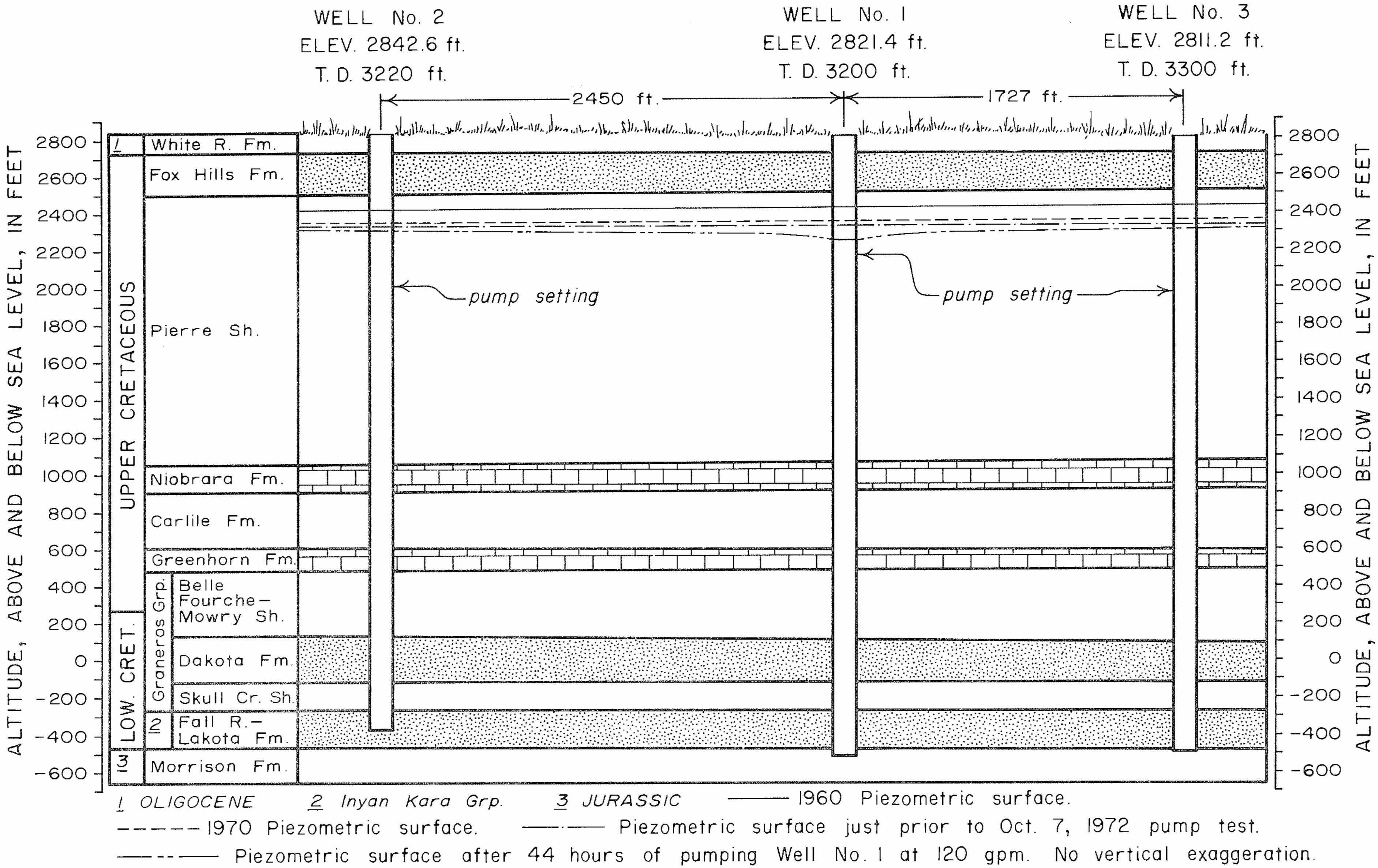


Figure 5. Geological cross-section at Wall, S. D., showing the three wells.

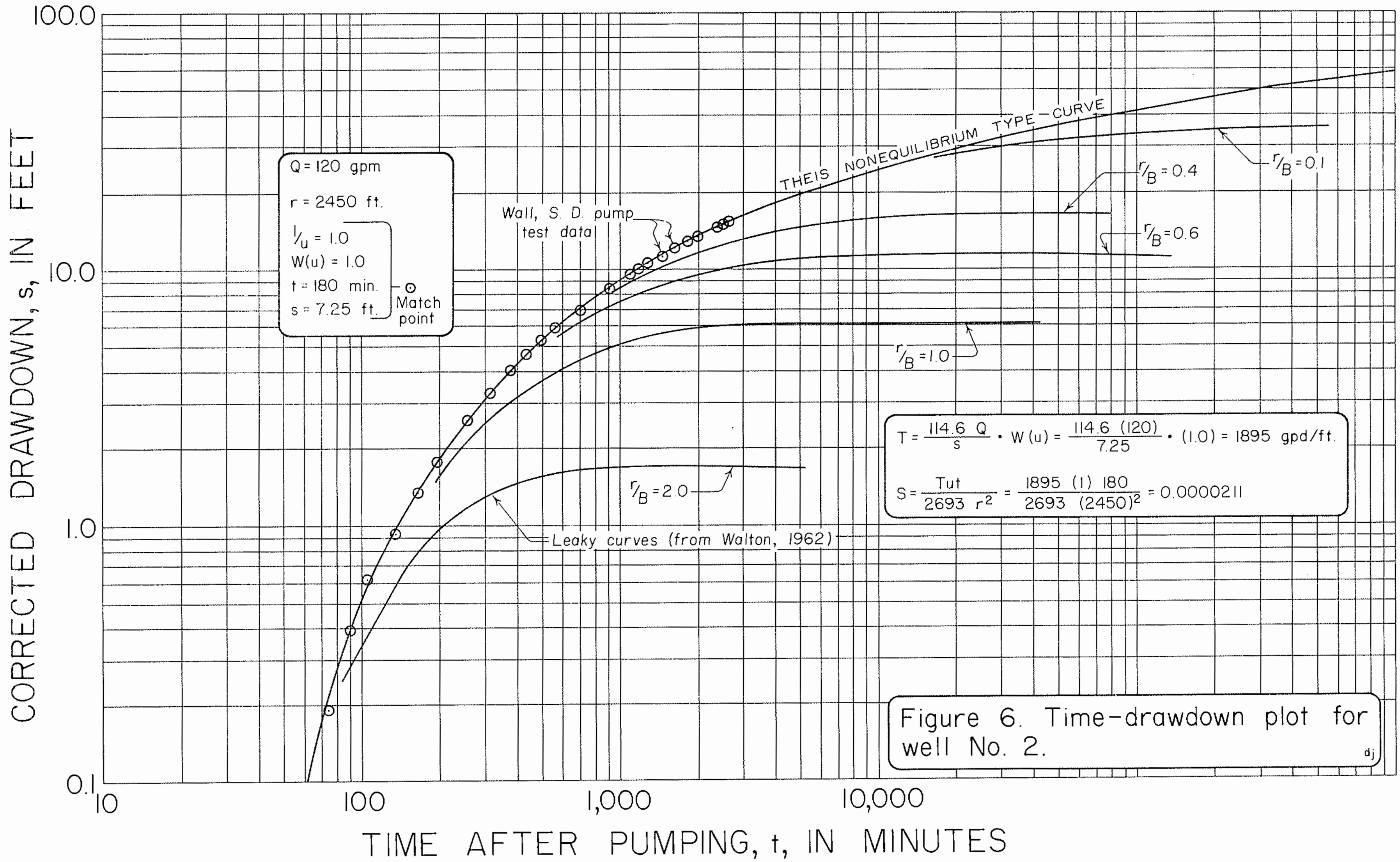


Figure 6. Time-drawdown plot for well No. 2.

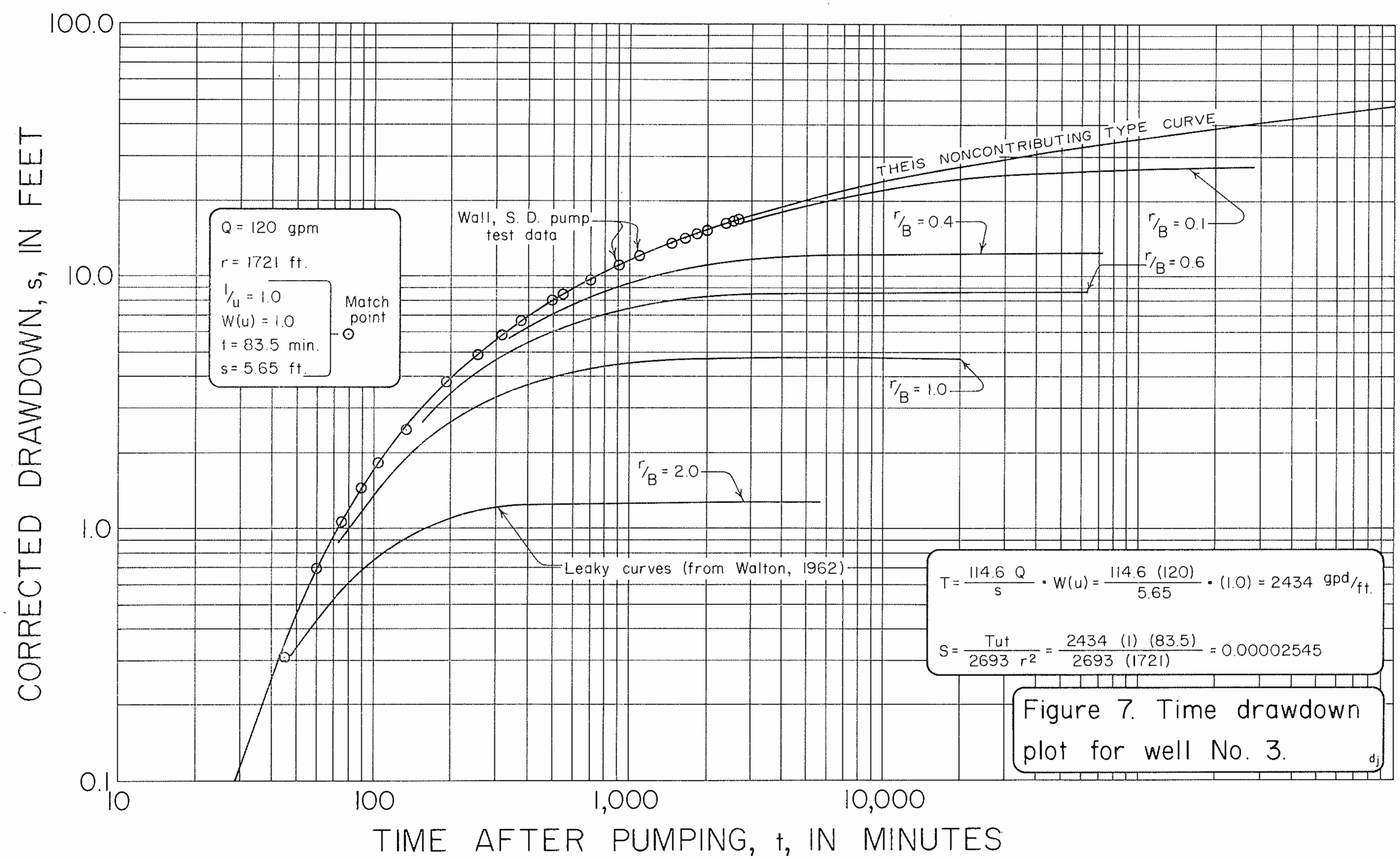


Figure 7. Time drawdown plot for well No. 3.

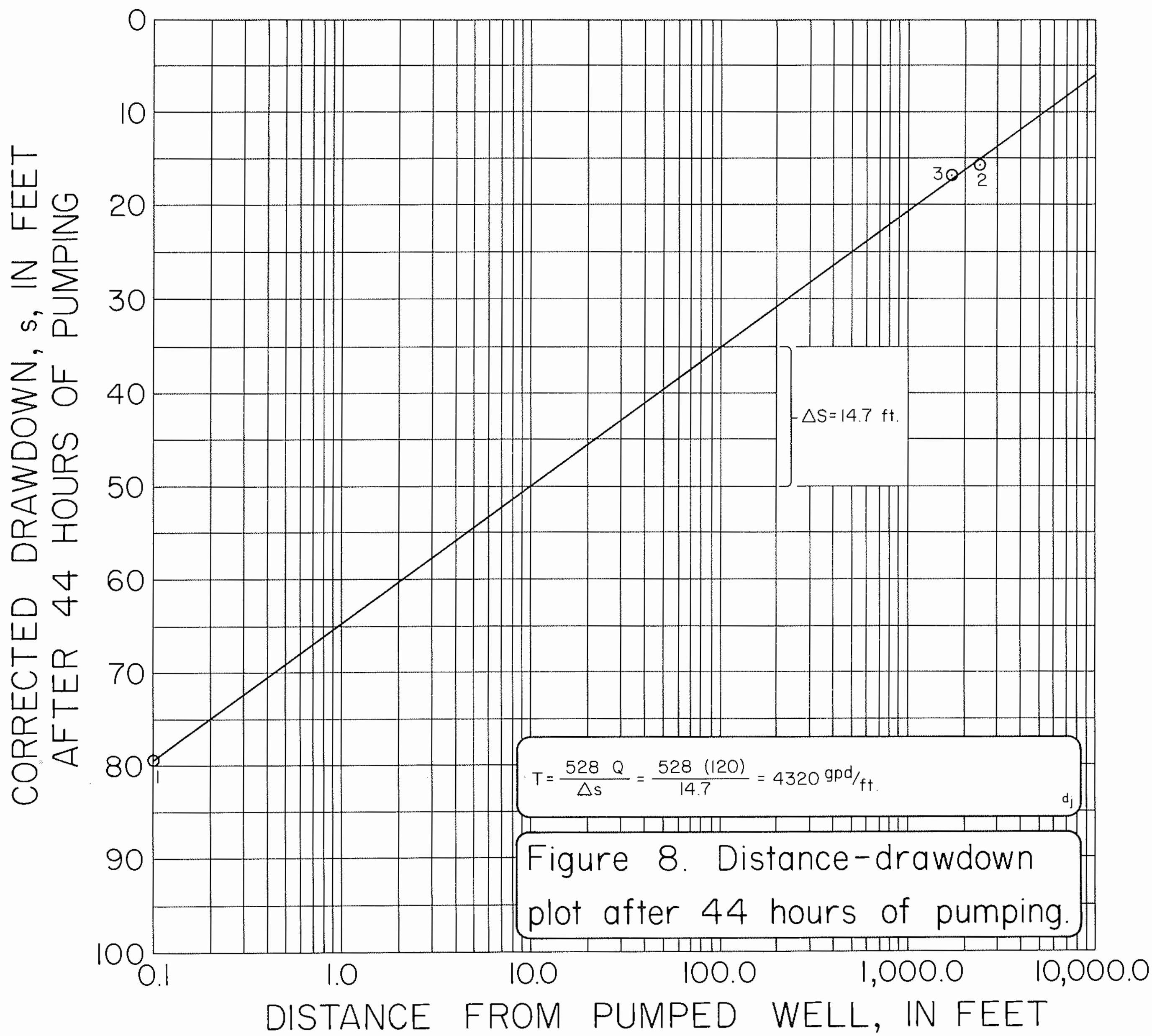


Figure 8. Distance-drawdown plot after 44 hours of pumping.