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AQUIFER ANALYSIS
PART 2 - PHASE I
WELL FIELD DEVELOPMENT

FISH SPRINGS RANCH
HONEY LAKE VALLEY, NEVADA

WASHOE COUNTY
DEPARTMENT OF PUBLIC WORKS
UTILITY DIVISION

SEAL OF WASHOE COUNTY STATE OF NEVADA

P.O. BOX 11130 RENO, NEVADA 89520

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AUGUST, 1989

WASHOE COUNTY UTILITY DIVISION
RENO, NEVADA

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ACKNOWLEDGEMENTS

The Washoe County Utility Division would like to thank the Fish Springs Ranch personnel for their cooperation, assistance and patience during this program. The Utility Division also thanks Oasis Drilling for their excellent job in drilling and geologic interpretations during this program.

EXECUTIVE SUMMARY

As part of Washoe County's Well Field Development Plan, a project was undertaken to test five irrigation wells at Fish Springs, Honey Lake Valley in Washoe County. Ten monitor wells were constructed and approximately ten day pumping tests were completed on each well in order to determine the transmissivities, storativities and geologic characteristics at these respective sites.

The Wilson Well was pumped at 3,000 gpm for ten days with a total drawdown of 76 feet. The average transmissivity was 109,000 gpd/ft. with a storativity of 0.003. The Wilson Well is completed in a coarse grained sand aquifer, confined and of limited extent. Concentrations of sodium and sulfate predominate this water which has total dissolved solids (TDS) of 467 ppm.

The Ferrel Well is completed mostly in fractured volcanics. It was pumped at 1,420 gpm for ten days with a total drawdown of 148 feet. The average transmissivity and storativity were 105,000 gpd/ft and 0.006, respectively. This confined aquifer is linked to the same aquifer that the Wilson Well is completed in. Water quality is good with TDS of 233 ppm.

The Headquarters Well is completed in fractured volcanics and alluvial materials. The alluvial aquifer appears to be unconfined while the fractured volcanic aquifer is confined. The Headquarters Well was pumped at 3,080 gpm for six days with at total drawdown of 12 feet. A response in the Jarboe Well, 5,000 feet south, was noted. The average transmissivity and storativity is 285,000 gpd/ft and 0.007, respectively. Water quality is good with a TDS of 203 ppm.

The Jarboe well is completed mostly in fractured volcanics and confined in nature. It was pumped at 1,965 gpm for seven days with a total drawdown of 127 feet. The average transmissivity and storativity is 160,500 gpd/ft and 0.007. Water quality is good with a TDS of 165 ppm.

The Hodges Well is completed in a coarse grained gravel with semi-confined or confined aquifer conditions. It was pumped at 1,923 gpm for ten days with a total of 32 feet of drawdown. The average transmissivity and storativity is 165,000 gpd/ft and 0.0045. Water quality is good with a TDS of 200 ppm.

Negative boundary conditions exist at the Wilson, Hodges, and at the Jarboe Well. These impermeable boundaries generally caused a 50% reduction in transmissivity. Based on the data available from these tests it is conservatively estimated that 7,600-10,600 AF could be safely pumped, on an annual basis, from the Fish Springs area.

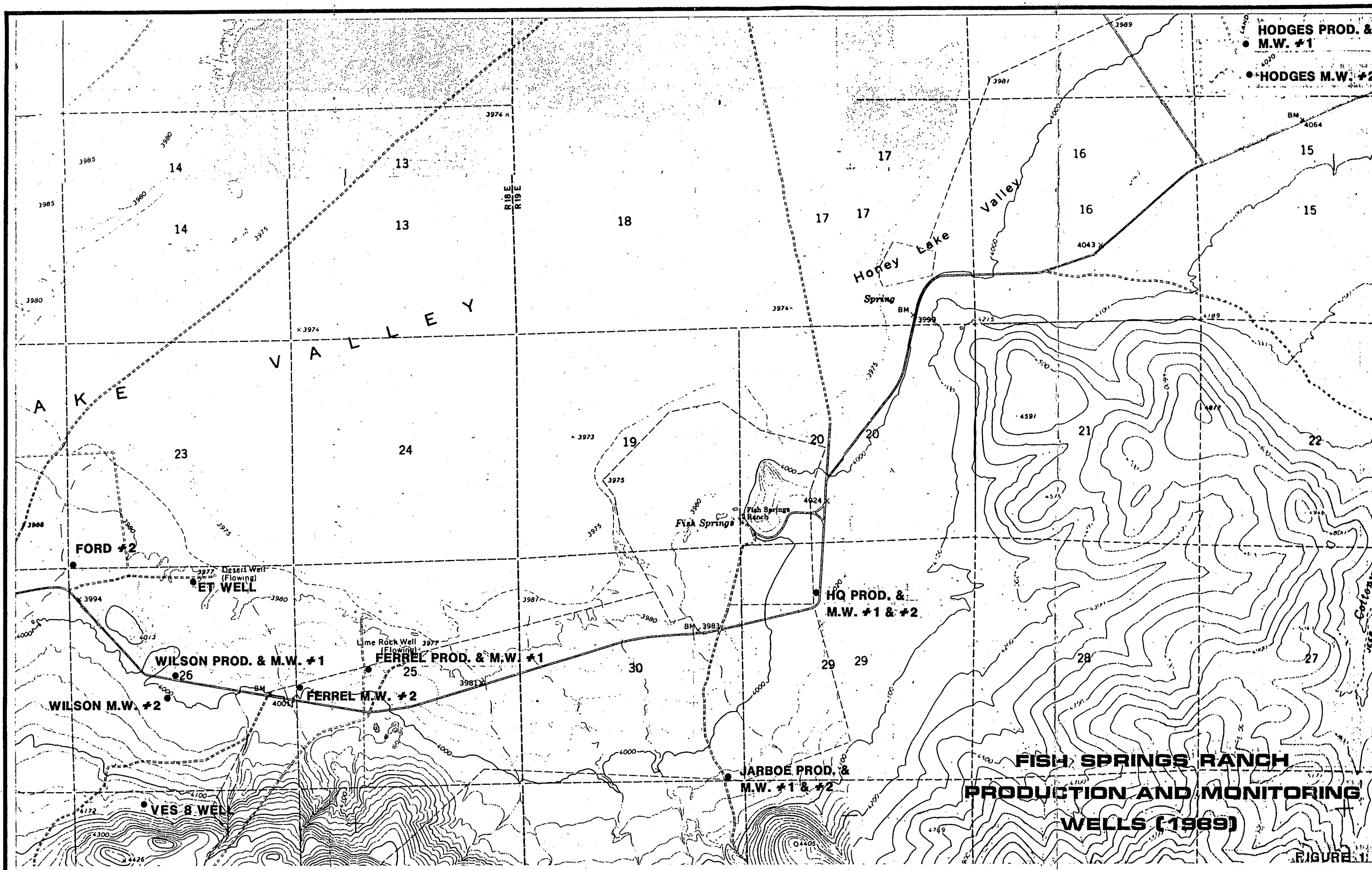
Considerable work needs to be accomplished to define and quantify groundwater recharge and discharge as well as water quality concerns. It is recommended that an exploratory drilling program begin as well as groundwater modelling.

INTRODUCTION

During the Spring of 1989, the Washoe County Utility Division initiated a monitoring well construction and test pumping program at the Fish Springs Ranch in Honey Lake. The purpose of the program was to better understand the aquifer responses to high yield production wells. Two monitoring wells were constructed for each of the five production wells. Each production well was pumped from seven to ten days.

The Fish Springs Ranch (Figure 1) operates five irrigation wells, each producing between 1500 to 3000 gpm. There were no observation wells in the immediate area so that aquifer response prediction was tenuous. Three of the production wells are completed and screened in alluvium as well as fractured volcanics. Lithologic logs and previous pumping tests yielded limited hydrologic information. The County's Well Field Development Plan's objectives were:

1. to determine the lithology of these aquifers
2. to derive accurate transmissivity and storativity values of the aquifers
3. to distinguish productivity zones in the respective lithologies
4. to better understand the aquifer geometry with respect to boundary conditions
5. to better understand long term aquifer response to pumping



FISH SPRINGS RANCH
PRODUCTION AND MONITORING
WELLS (1989)

FIGURE 1

GEOLOGY

The Fish Springs Ranch is situated on an alluvial veneered pediment bounded on the south by the fault blocked Virginia Range and to the north by playa and lacustrine deposits (Plate 1). The Virginia Range is composed of volcanic flow rock physiographically dipping northward into the Honey Lake Basin which is a structural depression. The volcanics are primarily faulted by north-south trending normal faults dipping eastward (Grose, 1984). The Warm Springs Valley fault zone bounds the Virginia Range to the southwest. The playa and lacustrine deposits of the Honey Lake Basin are reported to be in excess of one thousand feet, fine grained with very low hydraulic conductivity. These deposits are probably derived from the Virginia Range, the Fort Sage Mountains and to a lesser extent from the Lake Lahontan episode.

The irrigated lands are primarily on alluvial deposits grading from coarse to fine in a northward direction. These deposit thicknesses, vary from forty feet to in excess of 450 feet laterally and generally thicken northward toward the playa. Underlying these deposits are andesitic and basaltic flowrock, tuffs and cinder deposits.

Plate 2 is a geologic fence diagram of a portion of Fish Springs Ranch. It was completed by Washoe County staff and is based on interpretation of lithologic drilling logs. The diagram is dominated by a conjectural fault between the Ferrel Irrigation Well and the Ferrel Observation Well #2. This conjectural fault is probably a continuation of faulting in the Virginia Range and mapped in Section 1, T.25N, R.18E (Grose, 1984).

To the west of this fault is an alluvial "pocket" of coarse to medium sand. The geometry is not known, but probably extends or grades westward near the Warm Springs Valley fault zone to Section 27 (?) and 28, T.26N, R.18E. The pocket is bounded to the south in Section 35 by the volcanics and to the north by the playa in Section 23 (?). This alluvial aquifer will be referred to as the Wilson Aquifer, as it is the aquifer that the Wilson Well is completed in. The Wilson observation boreholes encountered this sand until a clay was penetrated. It is not known how thick the clay is, but it contained volcanic fragments and is believed to be a weathered unit of the volcanics as illustrated in the fence diagram. The Ford Wells #1 and #2 (Section 22) are completed in mostly fine grained sands and clays which should be differentiated from the "pocket" sediments hydrogeologically.

To the east of this conjectural fault are the volcanics which dip eastward toward the Headquarters and Jarboe Wells. The thickness of the alluvium increases from 40 feet at the Ferrel to 165 feet at the Headquarters. It most probably thickens northward toward the playa as well as becoming finer grained. From the drilling operations it was difficult to determine fault zones in the volcanics. A notable "rubble" zone was penetrated from 165 to 180 feet at the Headquarters, but was apparently absent at the Jarboe. The volcanics are generally thought to have been extruded and then flowed horizontally and continuously in the local area. Clinker zones are probably the porous media for groundwater movement within these volcanics.

The Hodges Well is located in an alluvial sub basin (Figure 1 and Plate 1). The ephemeral Cottonwood Creek has deposited mostly coarse grained sands and gravels in the vicinity of the Hodges Well. These sediments probably become finer grained and grade to clay in the playa area (Section 3, 9, 17, T.26N, R.19E). The coarse grained sediments at the Hodges Well are about 370 feet thick and overlay volcanics. Very little clay was encountered during drilling operations, suggesting rapid uplift and extensive erosion of the Virginia Range to the south and east.

DRILLING OPERATIONS

The objective of the drilling program was to complete monitoring wells in the significant aquifers underlying the Fish Springs Ranch area. Since three of the production wells were perforated in both alluvial and volcanic formations, bservation wells were constructed so as to isolate individual aquifers. This would allow definition of the respective aquifer hydraulic parameters through aquifer response during pumping. At the Wilson and Hodges Wells, two observation wells were drilled to help delineate the alluvial aquifers.

Oasis Drilling was awarded a contract to drill and construct these monitoring wells. Drilling commenced February 23, 1989 and was completed April 19, 1989. A Midway Model 15 Direct Rotary drilling rig was used to drill 6" nominal diameter boreholes. Two inch diameter steel casing was used as well casing. The gravel consisted of 3/8" sorted Auburn gravel (quartz). In all cases an approximate 50 foot sanitary seal completed the borehole. Development was by air lift.

The figures in Appendix A depict the lithology and well construction for each observation well. Figure A1 depicts construction of the Wilson Observation Well #1 (east). This 440 foot well was perforated in the same zones as the irrigation well and was located 150 feet east of the irrigation well. A second observation well was constructed 500 feet to the south of the irrigation well (Figure A2). This well was completed to 230 feet as the "pocket" alluvial aquifer thinned southward.

Figure A3 depicts lithology and well construction at the Ferrel Observation Well #1. Based on the Ferrel well log, it was expected to encounter alluvial material down to 240 feet. However, the alluvial material proved to be forty feet thick. Drill cuttings of the volcanics below the alluvium were somewhat differentiated as altered and mixed mafic volcanics (40-90 ft.), mixed basaltic and red cinder rich volcanics (90-150 ft.) and basalt (150-250 ft.). This observation well was also perforated in the same zone as the Ferrel irrigation well.

Figure A4 illustrates the lithology and well construction of the Ferrel Observation Well #2 (west). This well was completed to a depth of 210 feet in fine to medium sands. It is believed that this formation is of the same type of detritus that the Wilson Wells were completed in. Apparently, the same clay lense overlies the Wilson Aquifer at the surface.

The Jarboe irrigation well (Figure A5) is completed in alluvial deposits (0-116 ft.) and volcanics to a depth of 500 feet. The top of the perforations in the well begin at 95 feet. In order to differentiate the contribution of flow from the alluvium, a shallow well was drilled to 105 feet (Well #2). The first Jarboe Observation Well was drilled to 500 feet, perforated in the volcanics to 140 feet and sealed from 130 feet to surface. This design was to isolate response to pumping in the volcanic aquifer. Medium grained sand comprised the alluvium to 116 feet. Basalts (116-343 ft.) primarily overlay a rounded to angular sediment deposit (343-365 ft.). Andesites and basalts alternate to 500 feet. Possible fracture or clinker zones may be at 165 feet, 248 feet, 295 feet, 331 feet, 370 feet, and especially at 420 feet where significant circulation loss occurred.

The Headquarters irrigation (Figure A6) well was reported to be cased to 100 feet with perforations at 60 to 100 feet. Open hole construction was utilized then, from 100 feet to 400 feet. Alluvial deposits are 165 feet thick overlying a rubble zone (165-180 ft.), mixed volcanics (180-220 ft.), tuffs (220-300 ft.) and basalt (300-400 ft.). Clinker zones may exist at 287 feet, 330 feet and possibly fractured below 350 feet. The observation wells were constructed much like the Jarboe Wells. HQ#1 was perforated from 200 feet to

400 feet and sealed from 190 feet to surface. HQ#2 was perforated in the alluvium from 49 feet to 175 feet. The rubble zone was monitored in HQ#2.

Finally, two observation wells were constructed at the Hodges irrigation well. Figure A7 illustrates the construction. Hodges #1 is 150 feet west of the irrigation well and is perforated in the same zones as the Hodges irrigation well. It's total depth is 260 feet. Hodges #2 is located 760 feet south of the irrigation well and is completed to a depth of 126 feet. Medium to coarse gravel exists from the surface to 380 feet and lie on undistinquished volcanics.

PUMPING TESTS

Set Up and Measurement - Wilson Pump of Woodland, California was awarded the contract to set up pumping tests for Washoe County. Each irrigation well was equipped with a stilling well for water level monitoring. Each well discharge was linked to ten inch, above ground, irrigation pipeline in order to transport the discharge away from the area of influence. This distance was typically one half mile. The pipeline was equipped with a McCrometer totalizing meter and an orifice plate-manometer at the discharge end. In this way the flow rate could be measured by, 1) the totalizer, 2) the meter rate and 3) by a manometer tube.

Typically, the irrigation well and both monitoring wells were equipped with an electric sounder (Actat or Powers) and water levels were measured accurately to the nearest hundredth of a foot from a common measuring point. Other wells in the vicinity were also measured periodically. At start-up one person per well was used for the first 100 minutes in the test. The pumping tests lasted from seven to ten days. Barometric pressure was monitored throughout the program and used in the analysis of the data. At least one person was on site at all times. Recovery data was monitored in the same format for as long as possible.

Table 1 summarizes the pumping test data. The Wilson test ran for 10 days at a pumping rate of 3050 gpm. The final pumping level was 105.96 feet resulting in 75.78 feet of total drawdown.

The Headquarters test ran for six days before pump problems forced an early shutdown. The initial pumping rate was at 3080 gpm for 6.1 days with a pumping level at 48.73 feet resulting in 12.35 feet of total drawdown. At this point pumping rates dropped, most significantly at 9355 minutes to 2650 gpm. The flow rate was manually reduced to less than 2500 gpm and finally shut down at 10,105 minutes. Possible explanations for the flow reductions were debris clogging the pump intake or that the pump bowls broke suction.

The Ferrel test ran for ten days at an average pumping rate of 1420 gpm. The initial rate was 1500 gpm, but was reduced to 1360 gpm at 3070 minutes as the pumping level was quickly approaching the pump intake. The flow rate was difficult to maintain and pumping levels were initially impossible to measure due to cascading water and well inefficiency. The final pumping level was approximately 148 feet resulting in total drawdown of approximately 131 feet.

The Jarboe test ran for seven days. A broken fuel pump ended the test at 1570 minutes. The test restarted after 1380 minutes of recovery and ran for 9990 minutes at a pumping rate of 1965 gpm. The pumping level was at 176.65 feet resulting in 127.44 feet of drawdown. The flow rate was difficult to maintain due to well inefficiency.

The Hodges test ran for 10 days at a flow rate of 1923 gpm. The final pumping level was 68.67 feet resulting in 31.94 feet of drawdown.

TABLE 1

SUMMARY OF PUMPING TEST DATA

WELL	DATES OF TESTING	DURATION (MINUTES)	PUMPING RATE (GPM)	STATIC LEVEL (FEET)	TOTAL DRAWDOWN (FEET)
Wilson	03/05-03/15	14405	3050	30.18	75.78
Obs #1				28.53	35.46
Obs #2				33.25	18.48
Headquarters	03/17-03/24	8735	3080	36.38	12.35
Obs #1				34.77	17.64
Obs #2				36.19	5.02
Ferrel	03/29-04/08	14339	1420	17.13	148
Obs #1				18.06	11.59
Obs #2				24.65	3.44
Jarboe	04/13-04/20	9990	1965	49.21	127.44
Obs #1				52.53	9.36
Obs #2				49.07	2.58
Hodges	04/22-05/02	14344	1923	36.73	31.94
Obs #1				37.84	14.03
Obs #2				45.82	6.72

RESULTS AND DISCUSSION

Wilson Well

The Wilson well and two observation wells are completed in alluvial sediments and derive ground water from a confined aquifer. Figures 2 through 8 are plots of the pumping test data from these wells and the VES 8 well. The discharge for the ten day pumping test was held at a constant 3,100 gpm.

Figure 2 shows plots of the data from the pumping test on the Wilson Well. An impermeable boundary occurs at t=160 minutes which causes the transmissivity to decrease in the vicinity of the well from 114,000 gpd/feet to 65,000 gpd/feet. Figure 3 shows plots of the data from Observation Well #1 located 150 feet to the east of the Wilson Well and supports the data from Figure 2. Figure 4 shows plots of the drawdown data from the Observation #2 Well located 500 feet to the south of the Wilson Well. This also reflects a boundary effect, but later in time (approx. 1000 min) and the apparent transmissivities are higher. At Observation Well #2 the change in slope may also have occurred at t=150 min. so that the data reflects two boundaries. What complicates this analysis is the fact that the alluvial aquifer thickens from the volcanic hills to the South towards the Wilson Well, (see Figure 1). Because of the thickening aquifer the data appear more as a curve than as a straight line in Figure 4.

Figures 5, 6 and 7 are the recovery curves for the Wilson, Observation #1 and Observation #2 wells, respectively. They generally are mirror images of the plots of the drawdown data.

The VES 8 Well was undergoing monitoring by the U.S.G.S. The well was being monitored with a data logger and water level sensor. This equipment was checked on March 14, 1989 and accessed to Washoe County to make individual measurements. It was later found that the U.S.G.S. equipment was faulty so that no information was collected during the Wilson pumping test by the U.S.G.S. The information collected by Washoe County is plotted on Figure 8

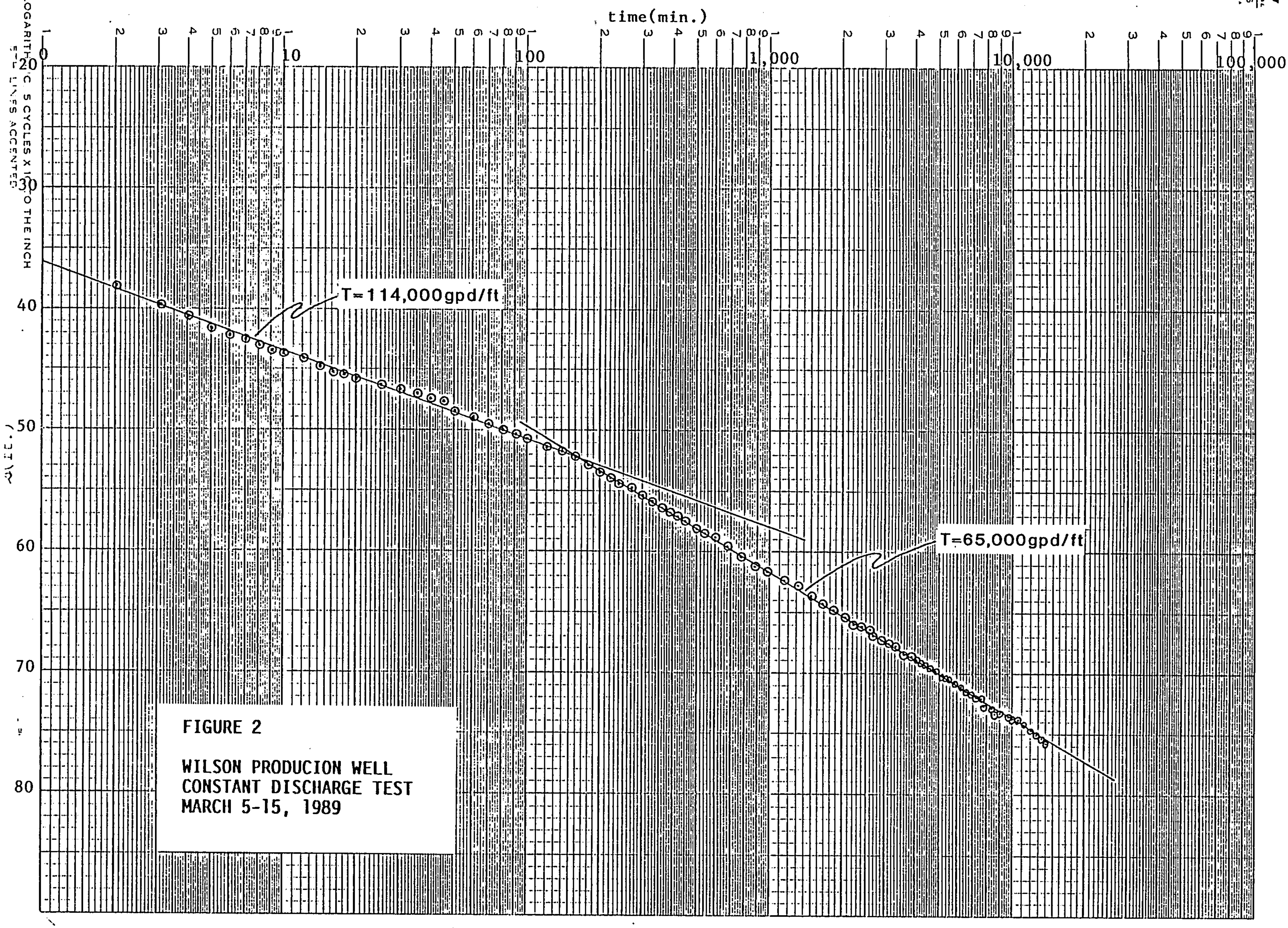


FIGURE 2

WILSON PRODUCION WELL
CONSTANT DISCHARGE TEST
MARCH 5-15, 1989

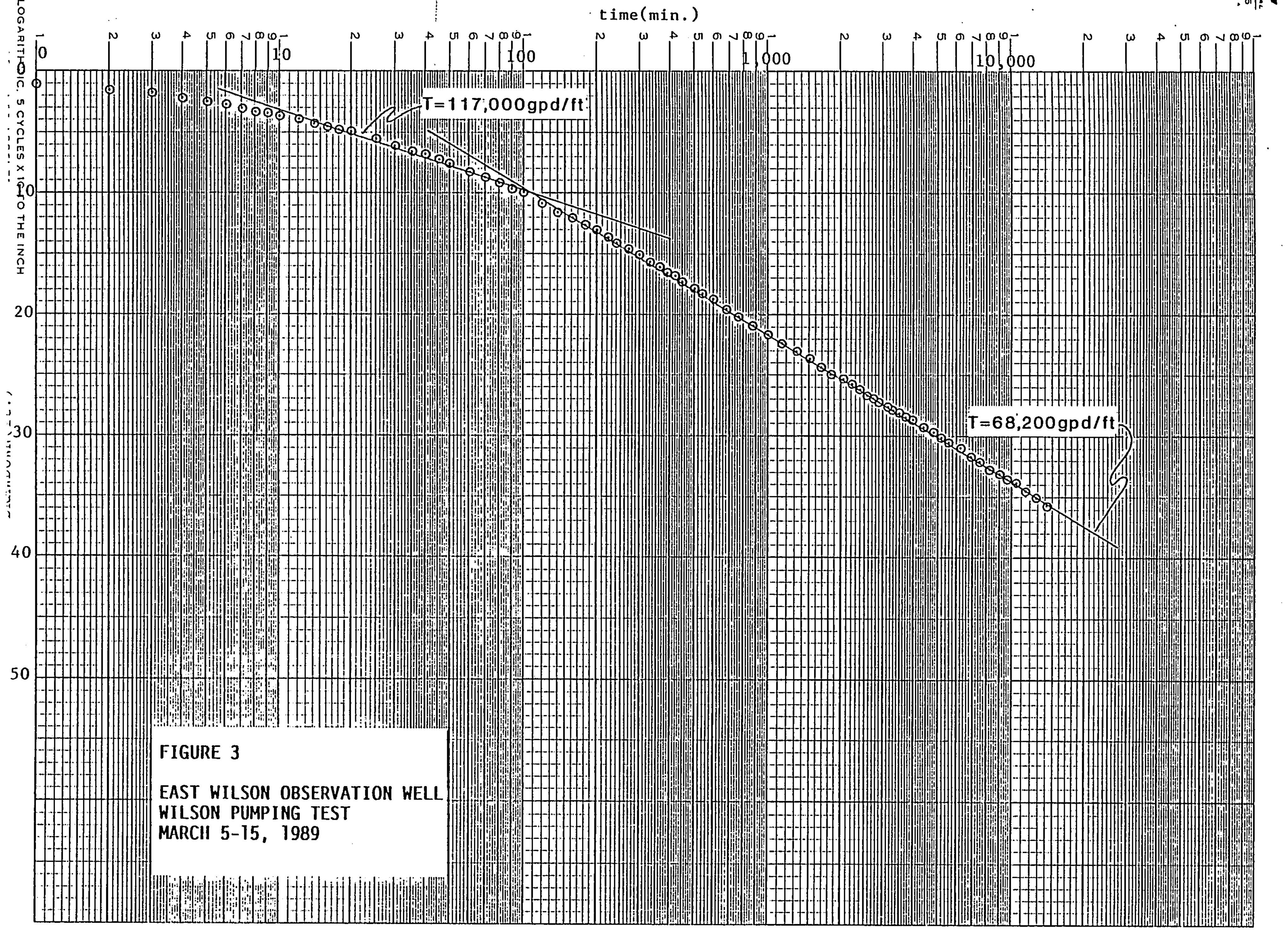


FIGURE 3

EAST WILSON OBSERVATION WELL
WILSON PUMPING TEST
MARCH 5-15, 1989

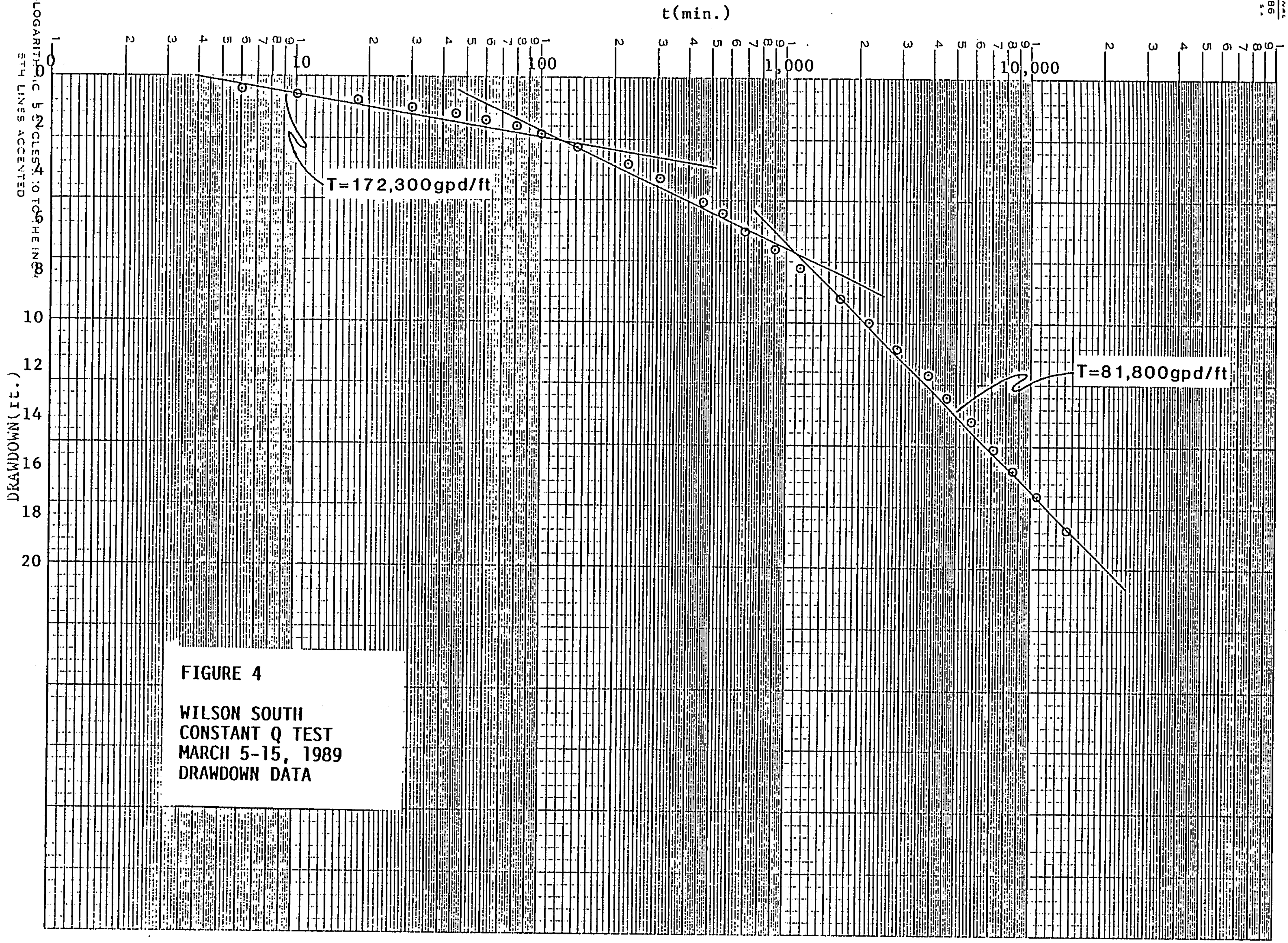


FIGURE 4

WILSON SOUTH
CONSTANT Q TEST
MARCH 5-15, 1989
DRAWDOWN DATA

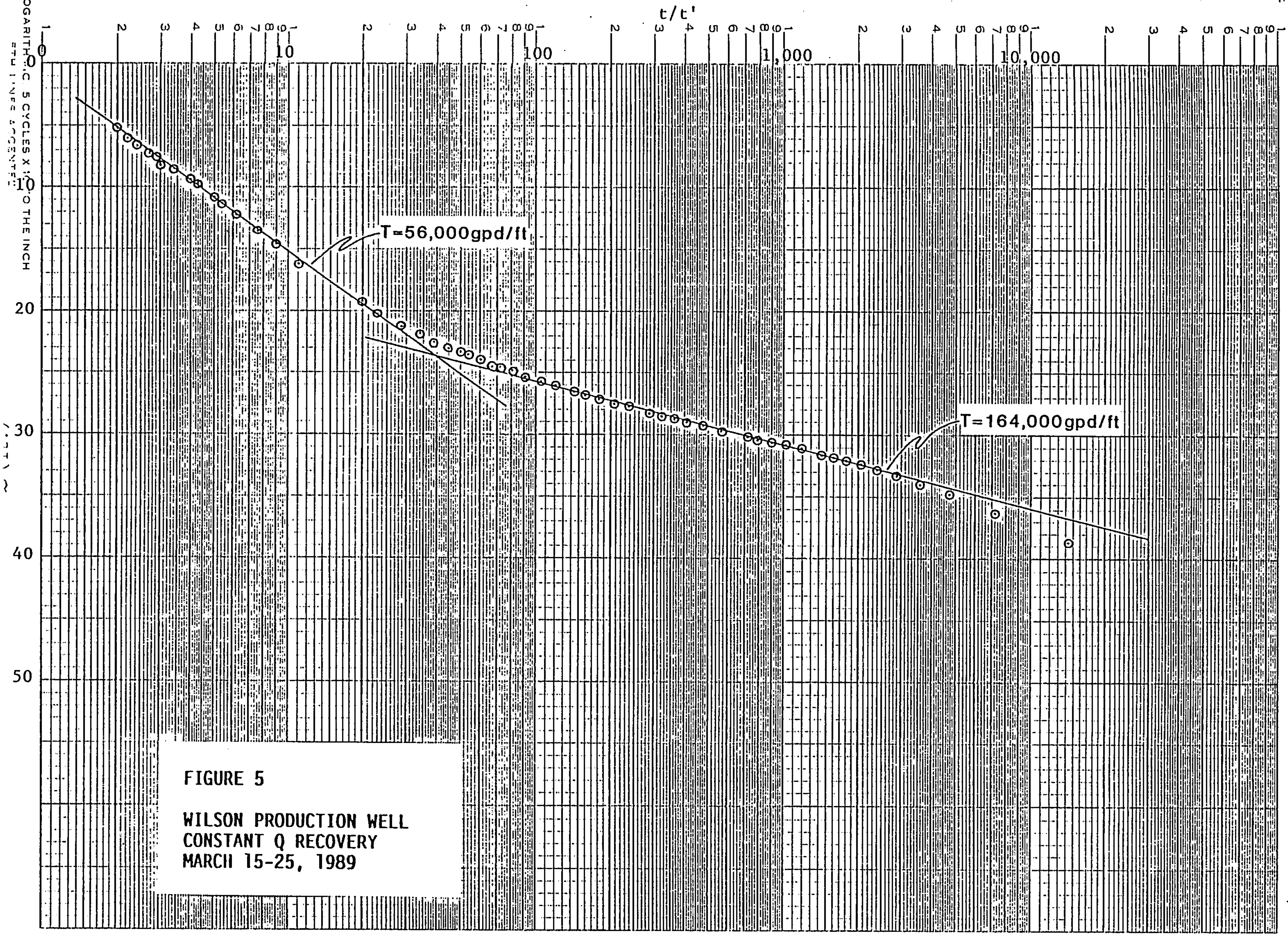


FIGURE 5

WILSON PRODUCTION WELL
CONSTANT Q RECOVERY
MARCH 15-25, 1989

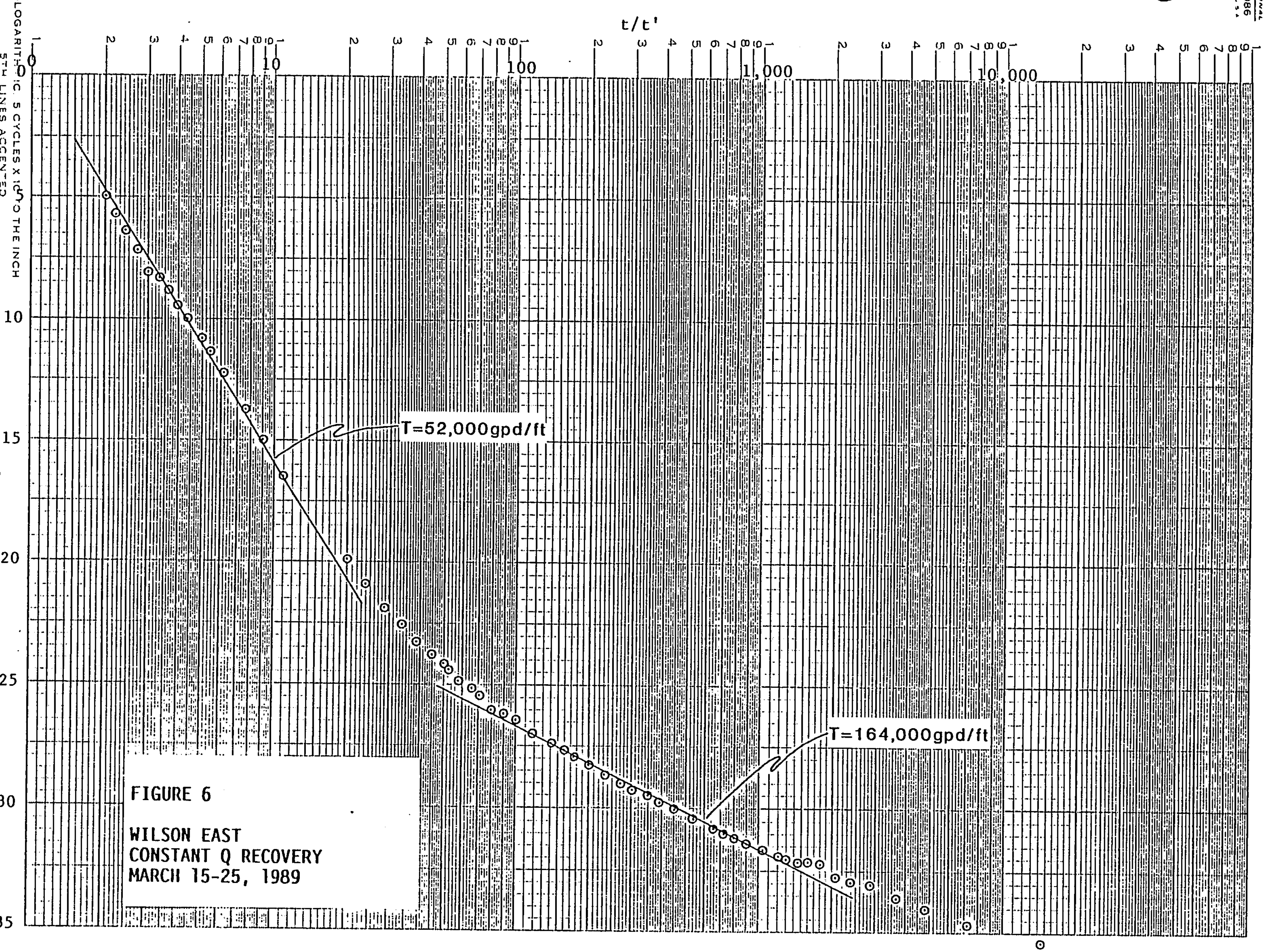


FIGURE 6

WILSON EAST
CONSTANT Q RECOVERY
MARCH 15-25, 1989

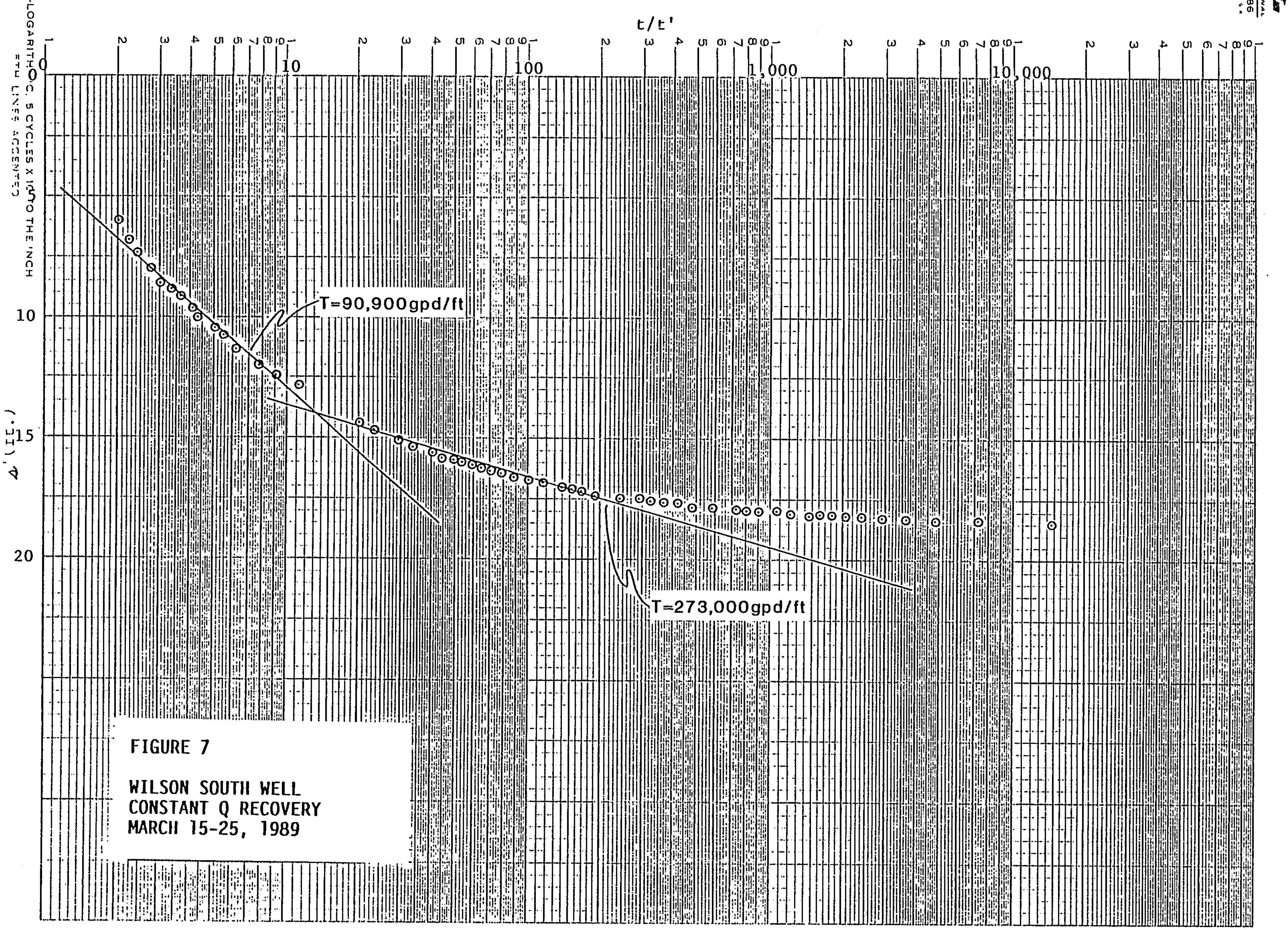


FIGURE 7

WILSON SOUTH WELL
CONSTANT Q RECOVERY
MARCH 15-25, 1989

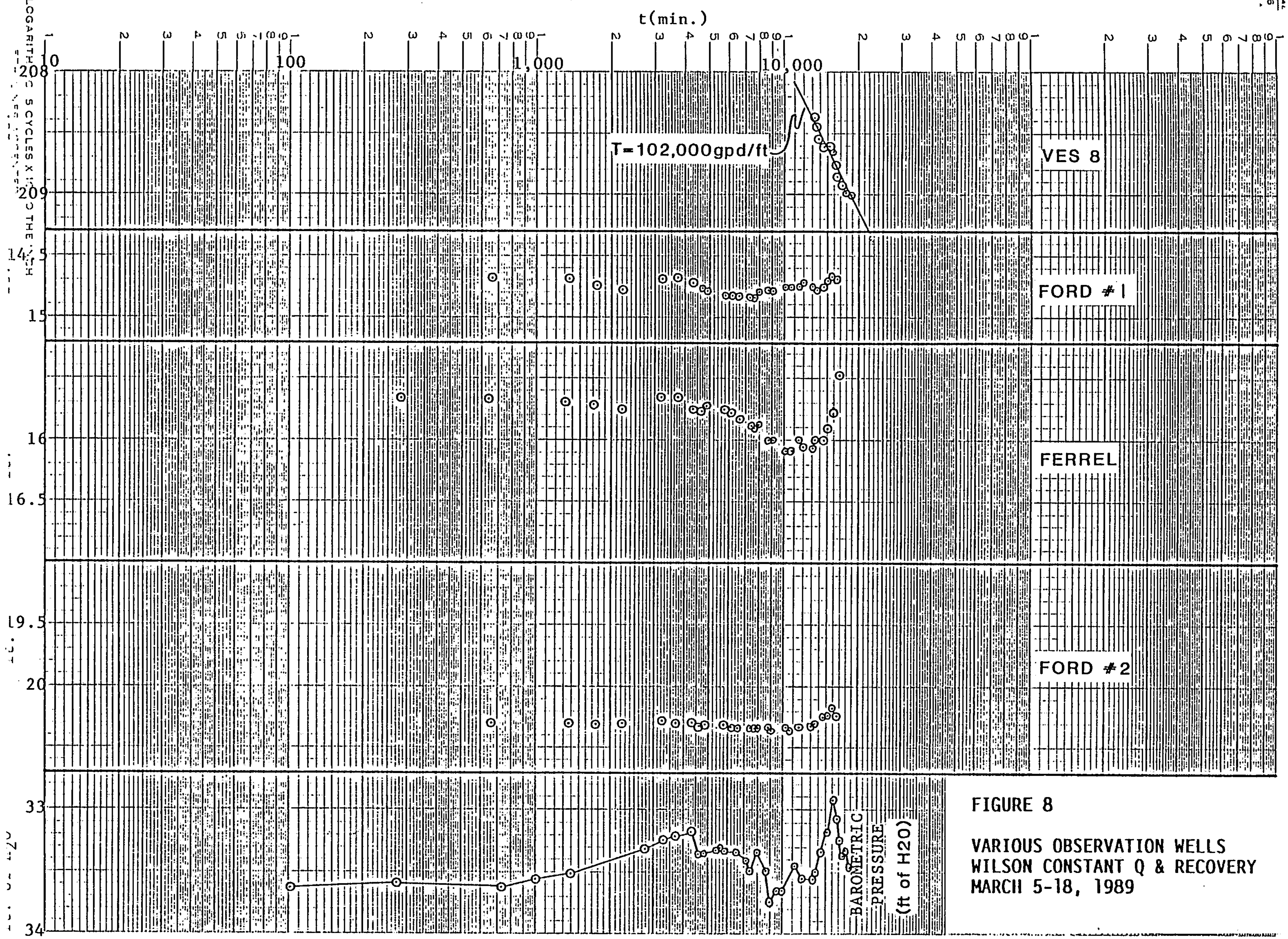


FIGURE 8

VARIOUS OBSERVATION WELLS
WILSON CONSTANT Q & RECOVERY
MARCH 5-18, 1989

with barometric data as well. It can be concluded that drawdown was occurring. The transmissivity is estimated at 102,000 gpd/feet. This well was drilled in volcanics to a depth of 1,336 feet. No drawdown was measured, as a result of pumping the Wilson Well, in the two Ford Wells or the Ferrel Well.

Table 2 lists the transmissivities and storage coefficients for the Wilson pumping tests. These estimates were derived using the "Well Hydraulic Interpretation Program (WHIP)" by Hydro Geo Chem, Inc. Comparing the WHIP estimates with the Jacob-Cooper Method (on Figures 2-7) there is generally good agreement. The average transmissivity at the Wilson Well (excluding Observation Well #2) is 125,800 gpd/foot with a storage coefficient equal to 0.007.

A few words about the boundary influenced (Bndy. Infl.) transmissivity values listed on Tables 2, 3, 4, 5 and 6. This terminology is used very loosely and is technically incorrect. In a confined aquifer a boundary does not physically change the aquifer transmissivity. A physical change in the hydraulic conductivity occurs at the boundary. This influences the flow of groundwater across that boundary towards the well. In the case of a negative boundary the pumping well is influenced by an increase in the rate of drawdown of the pumping level. This rate of decline can be described as a transmissivity value in order to 1) verify a boundary by comparing the changes in slope and 2) predict long term pumping levels in the vicinity of the pumping well. The values listed in tables and figures should be limited in usage to this discussion.

TABLE 2

WILSON TRANSMISIVITIES AND STORATIVITIES

WELL	T VALUE (GPD/FT)	BNDY. INFL. T VALUE (GPD/FT)	STORAGE COEFFICIENT
Wilson (p)	102,600	67,300	0.0015
Obs #1 (p)	135,600	66,500	0.003
Obs #2 (p)	124,000	73,000	0.016
Wilson (r)	92,200	56,900	
Obs #1 (r)	116,800	52,100	
Obs #2 (r)	84,234	64,200	

Headquarters Well

The Headquarters production well was pumped for seven days at two pumping rates. The initial pumping rate was 3,080 gpm. At t=9100 min. (6.3 days) the rate was reduced to 2,500 gpm. After seven days the well was turned off as it was felt that no additional information could be obtained with three additional days of pumping at the lower level. The reduction in flow was probably caused initially by debris clogging the pump intake.

Figures 9, 10 and 11 are the drawdown curves for the Headquarters Production, Observation #1 (rock aquifer), and Observation #2 (alluvial aquifer) wells, respectively. Figure 9 basically displays a straightline curve with a transmissivity of 273,000 gpd/foot. This well produces water from an alluvial aquifer and a rock aquifer. At the contact of these two lithologies is a 15 foot thick rubble zone.

Figures 10 and 11 display the effects of pumping on the individual aquifers. These show that greater drawdown occurred in the rock aquifer (17.5 feet) than in the alluvial aquifer (5 feet) and the production well (12.5 feet). This indicates that not only are well and formation losses minimal, but that the alluvial aquifer offsets (by 5 feet) the drawdown effects caused from pumping soley the rock aquifer. Flow to the production well occurs from both aquifers, but it is not known at what flow rates.

Figure 11 shows a constant rate of decline in the alluvial observation well from t=30 min. Figure 10 shows a near constant rate of decline in the rock observation well until t=300 minutes. This curve displays dual porosity behavior. The late time data represent the aquifer transmissivity.

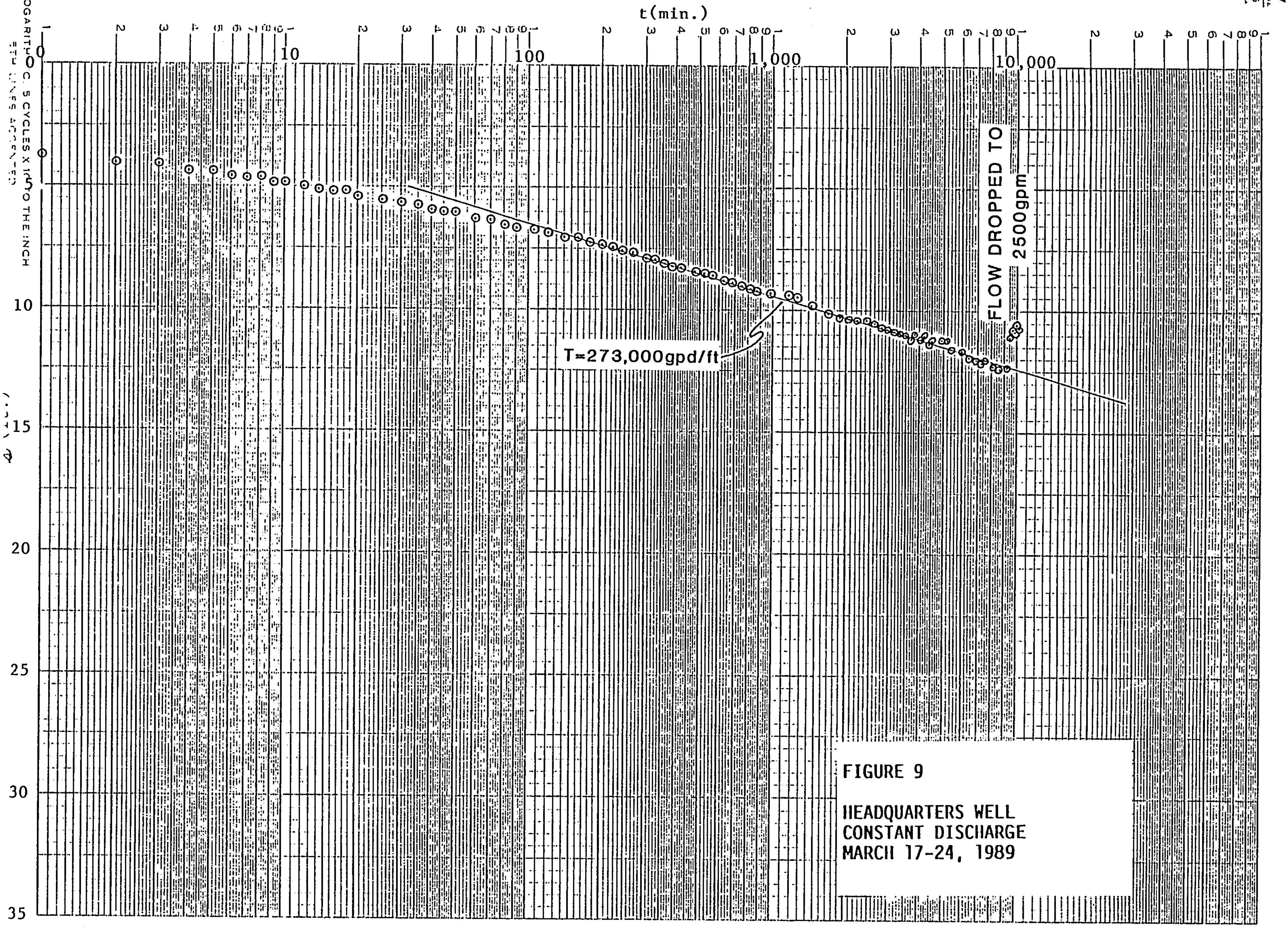


FIGURE 9

HEADQUARTERS WELL
CONSTANT DISCHARGE
MARCH 17-24, 1989

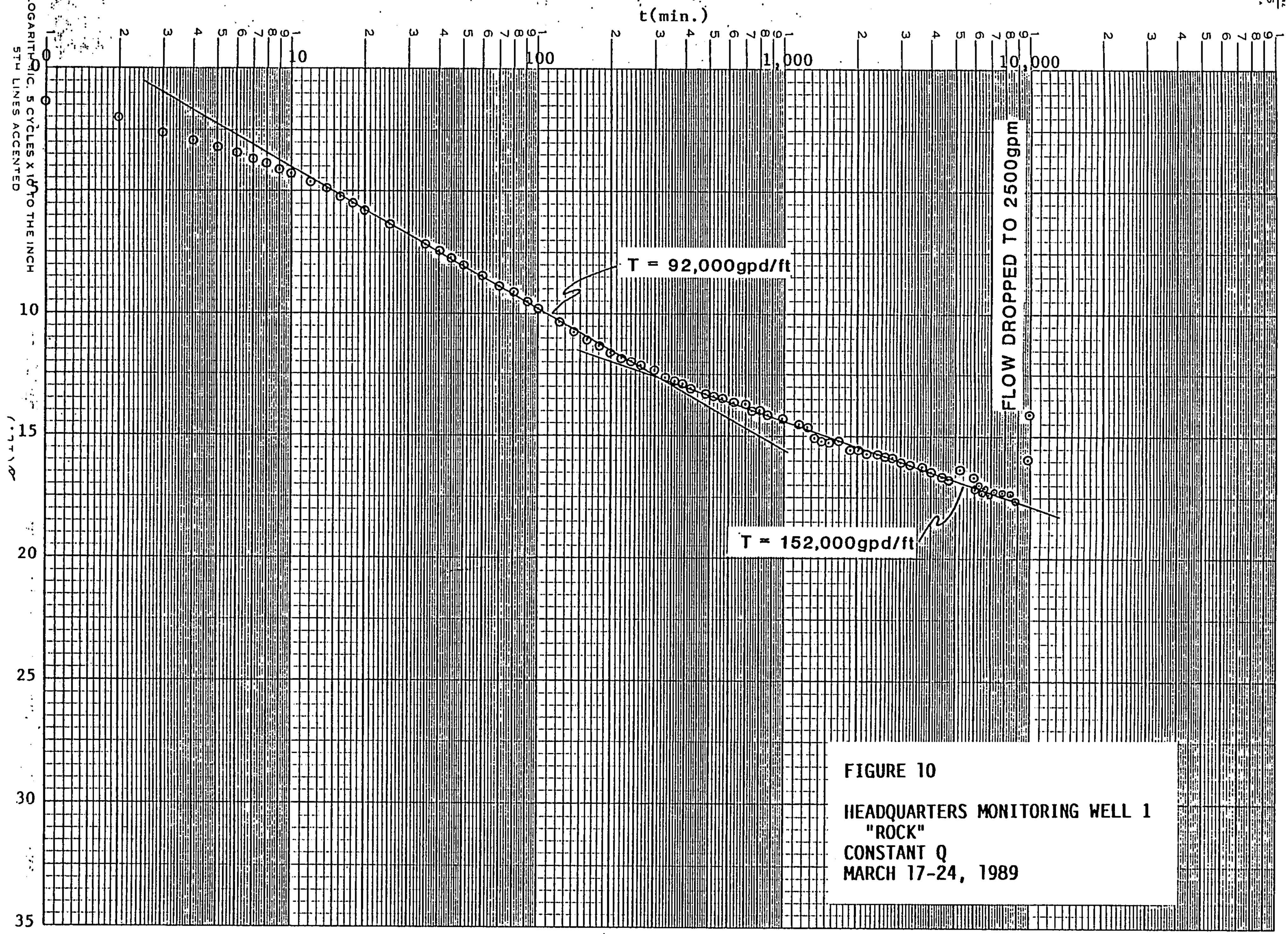


FIGURE 10

HEADQUARTERS MONITORING WELL 1
"ROCK"
CONSTANT Q
MARCH 17-24, 1989

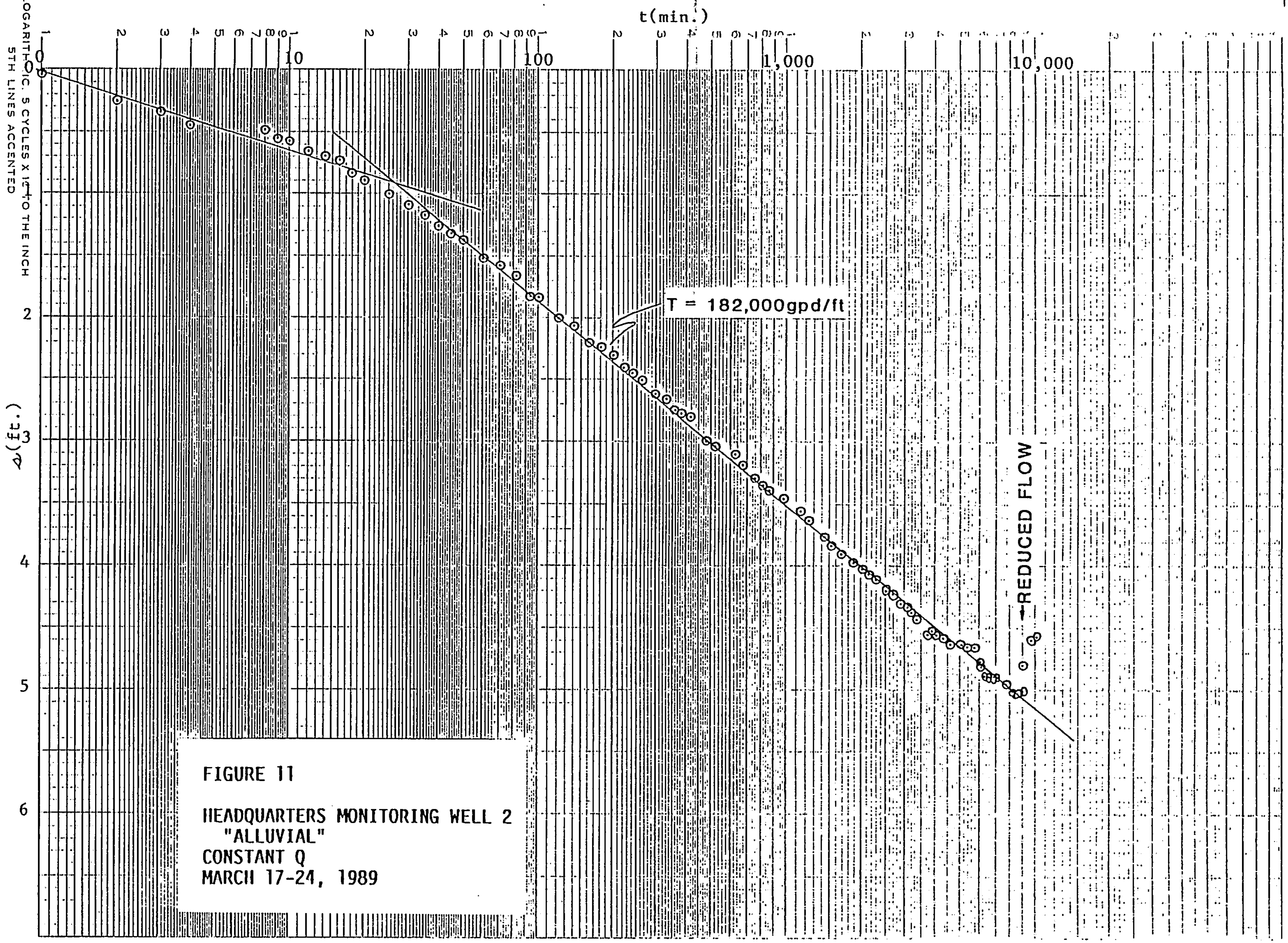


FIGURE 11

HEADQUARTERS MONITORING WELL 2
"ALLUVIAL"
CONSTANT Q
MARCH 17-24, 1989

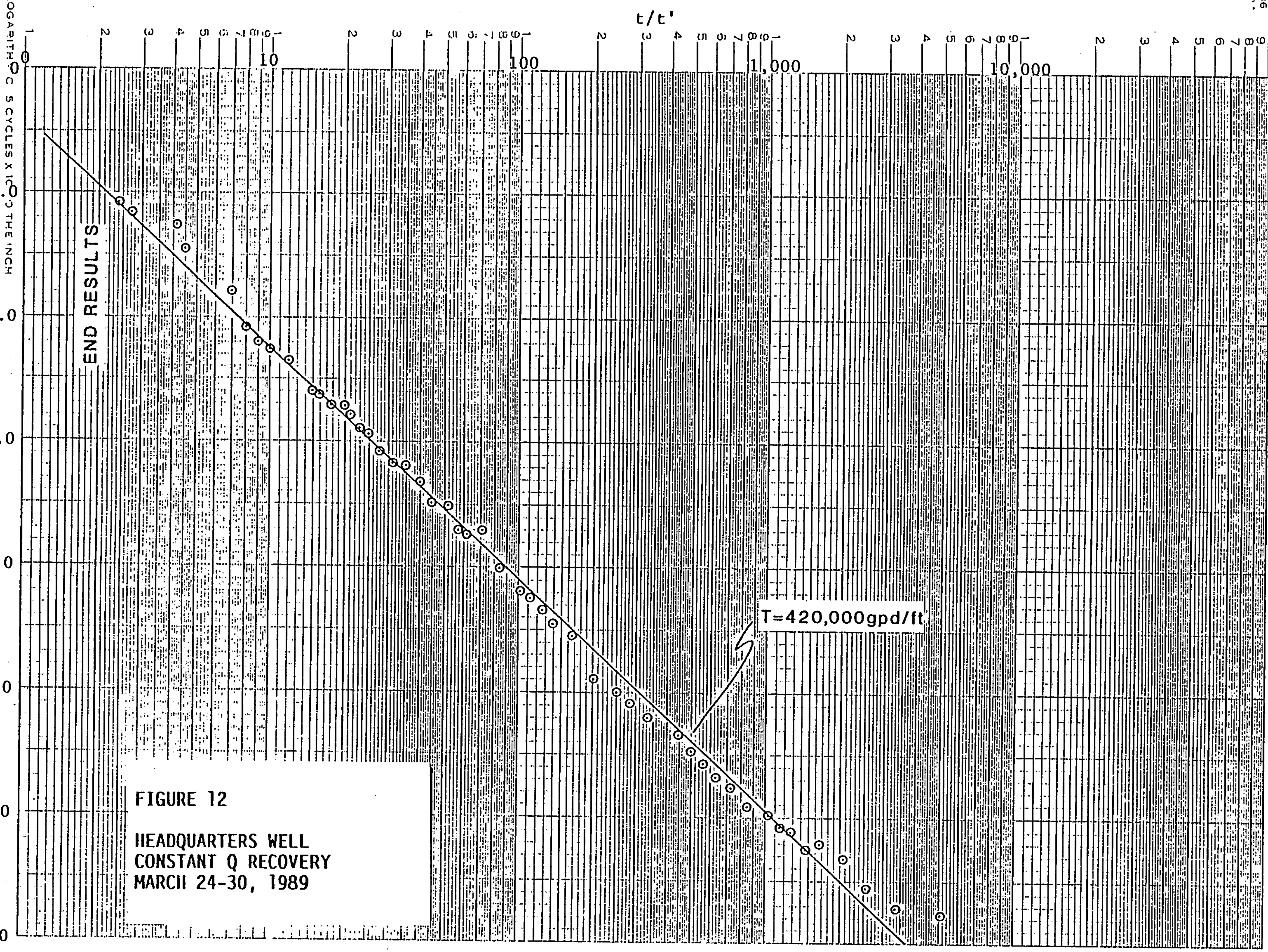


FIGURE 12

HEADQUARTERS WELL
CONSTANT Q RECOVERY
MARCH 24-30, 1989

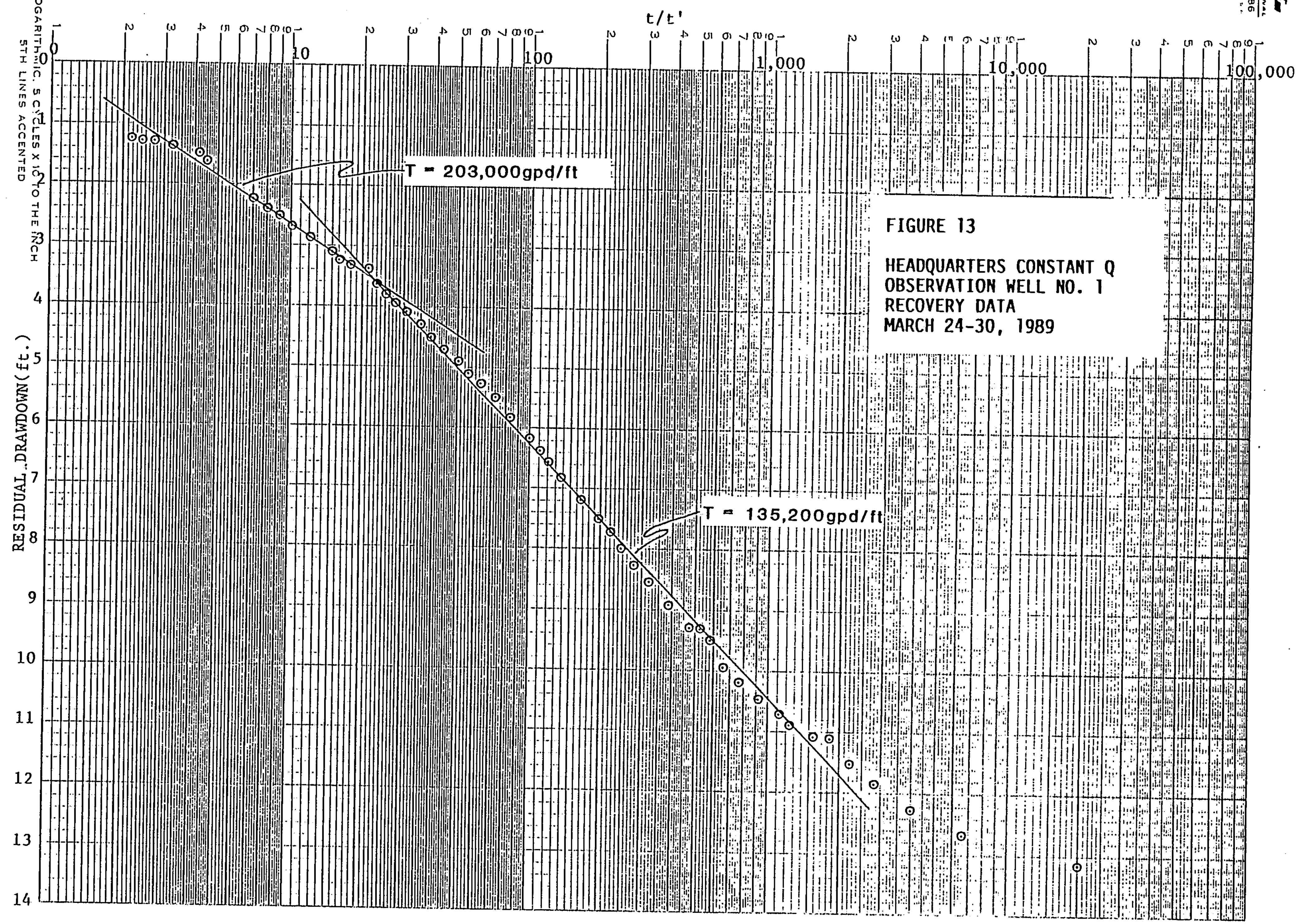
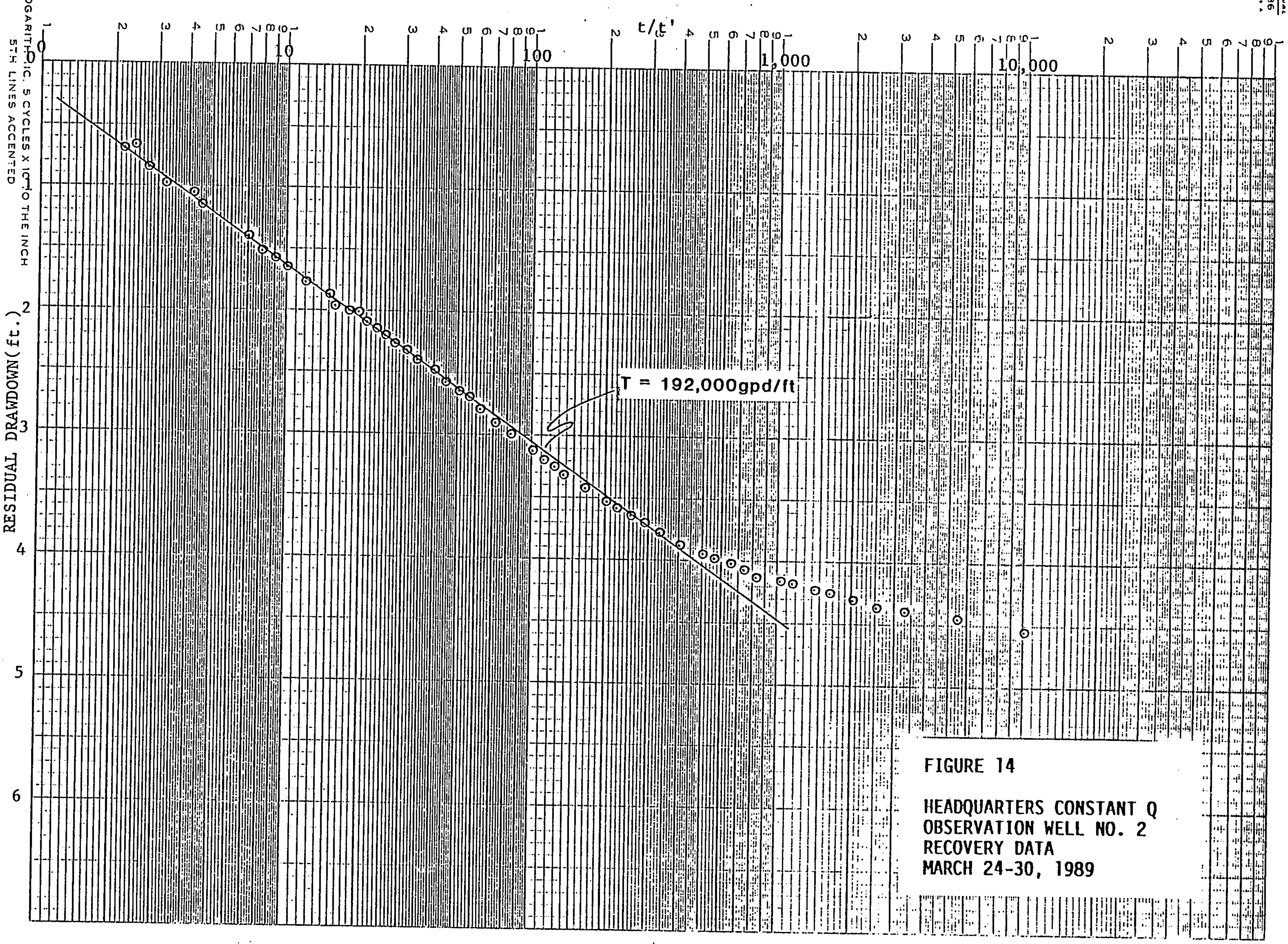


FIGURE 13
HEADQUARTERS CONSTANT Q
OBSERVATION WELL NO. 1
RECOVERY DATA
MARCH 24-30, 1989
T = 203,000gpd/ft
T = 135,200gpd/ft
t/t'
RESIDUAL DRAWDOWN(ft.)
10
100
1,000
10,000
100,000
SEMI-LOGARITHMIC, 5 CYCLES X 10 TO THE INCH
5TH LINES ACCENTED



t/t'
RESIDUAL DRAWDOWN(ft.)
T = 192,000gpd/ft
FIGURE 14
HEADQUARTERS CONSTANT Q
OBSERVATION WELL NO. 2
RECOVERY DATA
MARCH 24-30, 1989
SEMI-LOGARITHMIC. 5 CYCLES X 10 TO THE INCH
5TH LINES ACCENTED

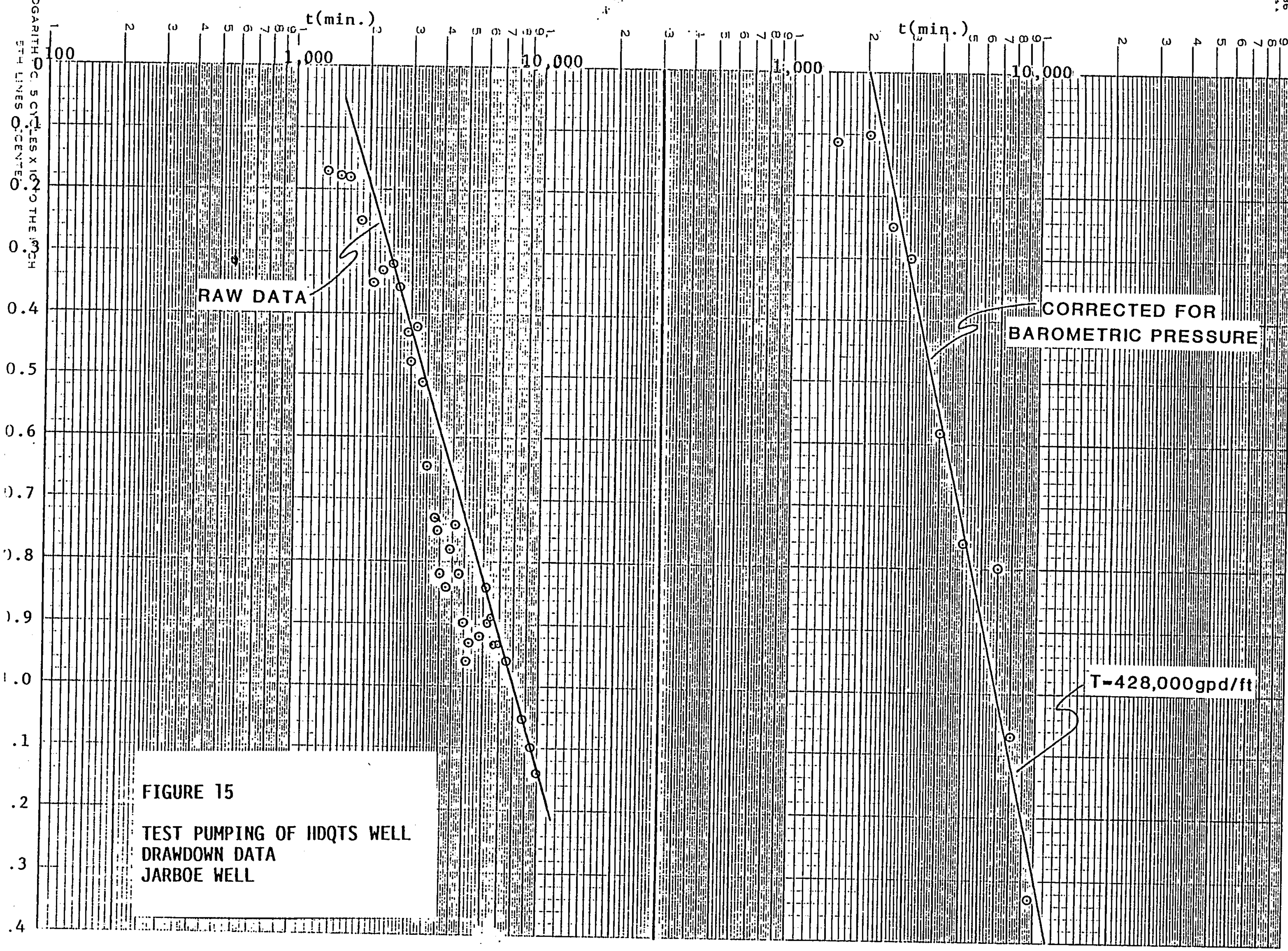


FIGURE 15

TEST PUMPING OF HDQTS WELL
DRAWDOWN DATA
JARBOE WELL

In determining transmissivities for these aquifers the individual discharges must be known and obviously is not. Discharges, and the resulting transmissivities, were adjusted and compared to the production well transmissivity. If the discharge from the rock aquifer was 2,000 gpm then the transmissivity would be 152,000 gpd/foot and within the expected range of values. The transmissivity of the alluvial aquifer would be 182,000 gpd/feet, which seems high given the clay content. However, the rubble zone is represented in the alluvial aquifer and could account for the anomalously high figure as rubble zones frequently have high transmissivities. For comparison, the transmissivities of the Hodges and Wilson wells (in alluvial aquifers) are 165,000 gpd/feet and 110,000 gpd/feet respectively.

Figures 12, 13 and 14 are the recovery curves for the Headquarters production, Observation #1 and Observation #2 Wells, respectively. Basically, these recovery curves duplicate the results from pumping although the transmissivities are higher, especially at the production well. The production well recovery curve indicates a transmissivity of 420,000 gpd/feet (3020 gpm). Figure 13 indicates a rock aquifer transmissivity of 203,000 gpd/foot (2000 gpm) and Figure 14 indicates a transmissivity of 192,000 gpd/foot for the alluvial aquifer (1020 gpm).

Figure 15 shows the drawdown curve measured in the Jarboe Production Well from pumping the Headquarters Well. This shows 1.33 feet of drawdown and a transmissivity value of 428,000 gpd/feet which considers barometric effects (otherwise an erroneous figure of 600,000 gpd/feet is calculated). This value coincides with the Headquarters recovery value and is indicative of this area of influence (approximately one mile). Table 3 lists proposed transmissivities and storativities for the Headquarters wells.

TABLE 3

HEADQUARTERS WELL TRANSMISSIVITIES AND STORATIVITIES

WELL	T-VALUES GPD/FOOT	STORAGE COEFFICIENT	DISCHARGE GPM
HQ (p)	273,000		3020
HQ #1 (p)	152,000	0.0017	2000
HQ #2 (p)	182,000	0.012	1020
Jarboe	428,000	0.007	3020
HQ (r)	420,000	-	3020
HQ #1 (r)	203,000	-	2000
HQ #2 (r)	192,000	-	1020

Ferrel Well

The Ferrel Production Well is believed to be completed in volcanics overlain by approximately 70 feet of alluvium. This is based on the lithology encountered from drilling the Ferrel Observation Well #1 150 feet to the south. However, the "Well Drillers Report" filed with the State Engineer's Office in 1975 on the Ferrel Production Well indicates 240 feet of alluvium. The Ferrel Observation Well #2, located 1,500 feet to the west is completed to a depth of 210 feet in alluvium. Figures 16 through 20 are plots of the pumping test data.

Cascading water prevented accurate monitoring of the Ferrel well during pumping. Consequently, no drawdown curve was generated for the Ferrel Well. After 51 hours of pumping at 1,500 gpm the flow was reduced to 1,360 gpm due to the pumping level nearing the pump intake. Figure 16 depicts the drawdown level in the Ferrel Observation Well #1. At 2,000 minutes a change in the slope occurs. This is due to a recharge boundary or from leakage. The apparent transmissivity increases two fold from 73,300 gpd/feet to 138,100 gpd/feet. Figure 17 depicts the drawdown data from the Ferrel Observation Well #2. A constant rate of drawdown occurs after 50 minutes of pumping with a transmissivity of approximately 198,000 gpd/feet based on a pumping rate of 1,500 gpm.

An explanation for Figures 16 and 17 is that the bedrock aquifer is characterized in the first 2,000 minutes at Observation Well #1. Observation Well #2 characterizes the alluvial aquifer and it is this aquifer that provides the "leakage" or change in transmissivity at t=2,000 minutes on Figure 16. This could physically be accomplished two ways. First the alluvial aquifer thins eastward and overlays the bedrock aquifer providing horizontal leakage once adequate pressure differentials are obtained. The lithologic log at Observation Well #1 does not necessarily support this, as only a 5 foot lense

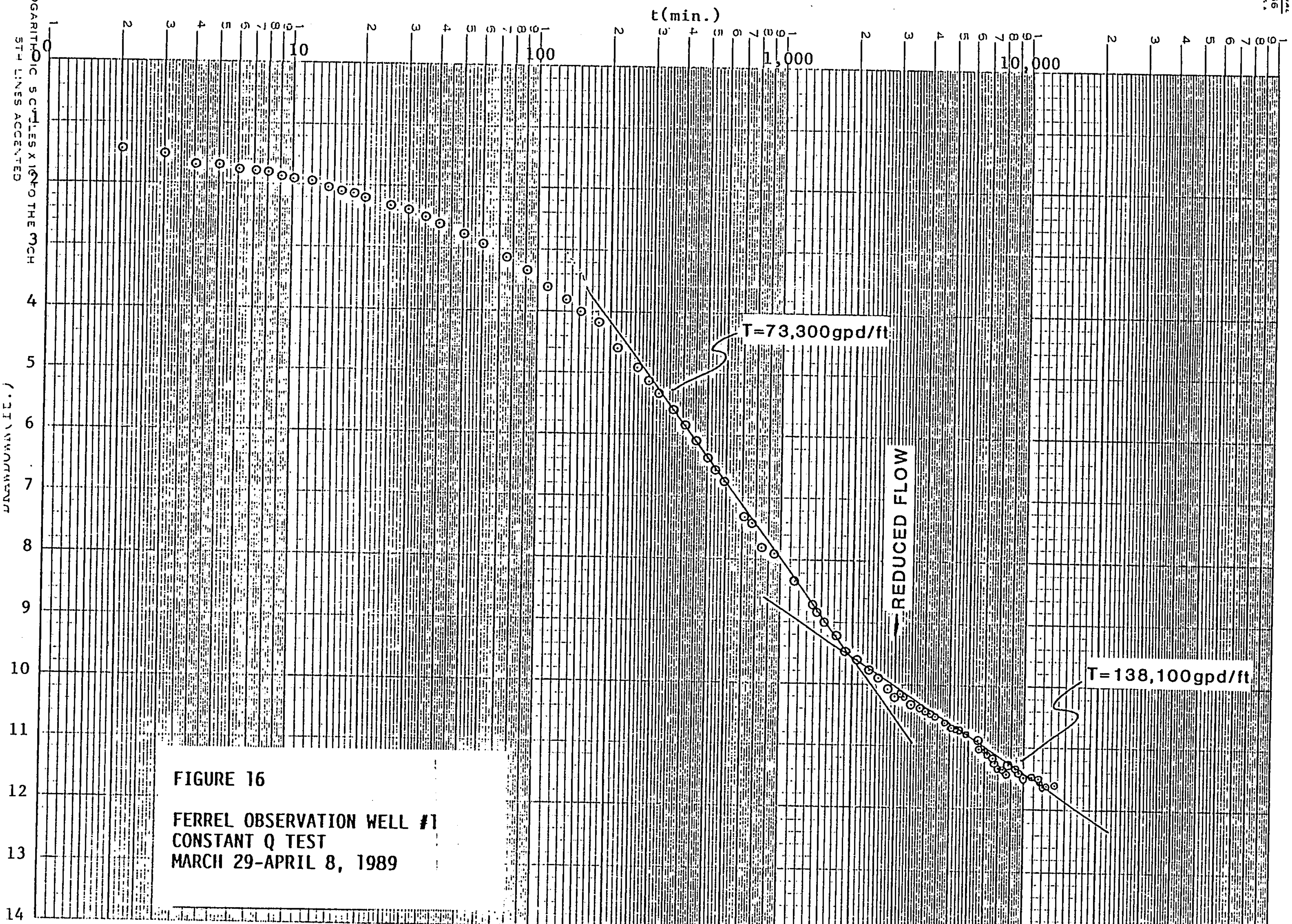


FIGURE 16

FERREL OBSERVATION WELL #1
CONSTANT Q TEST
MARCH 29-APRIL 8, 1989

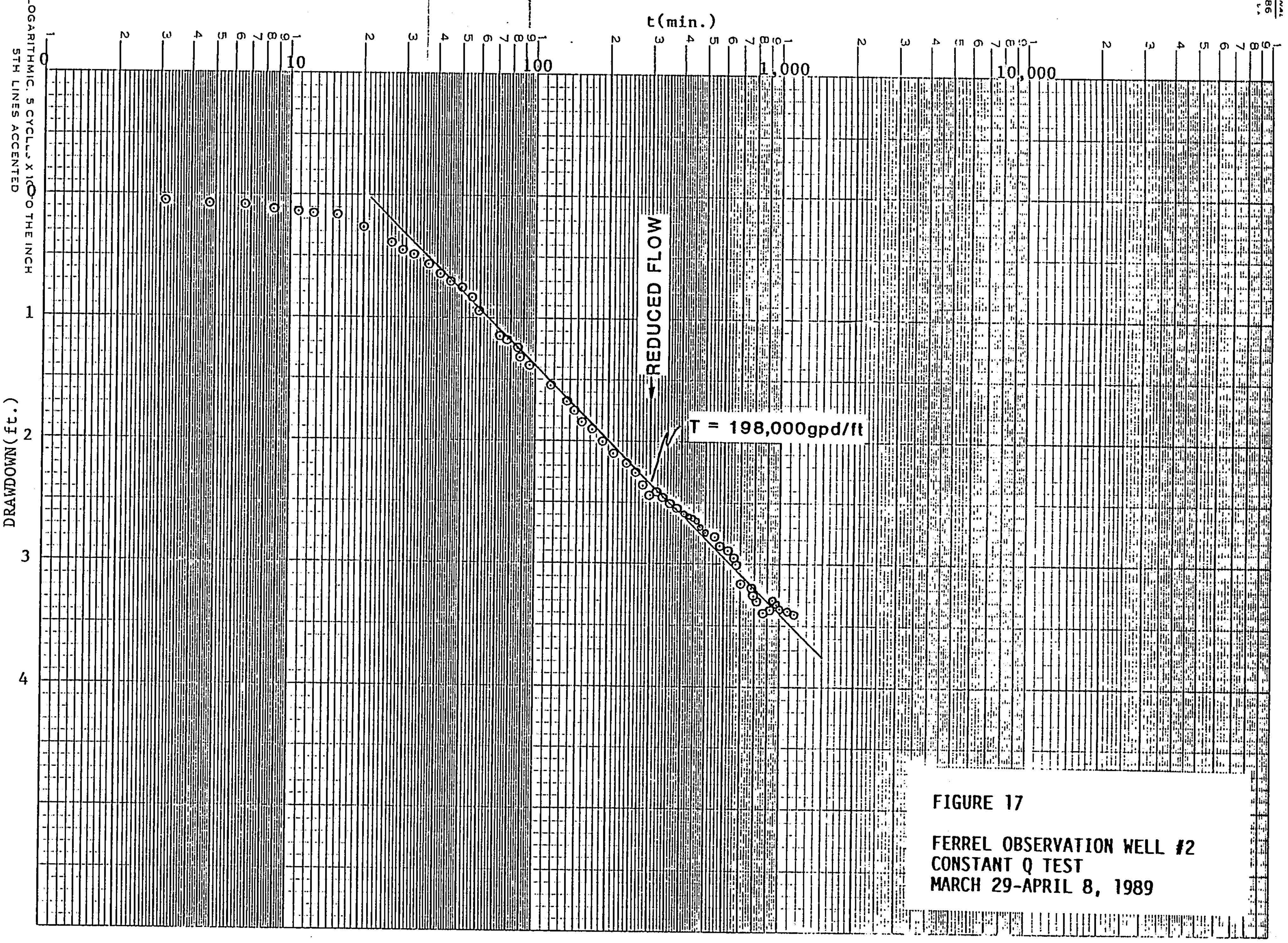


FIGURE 17

FERREL OBSERVATION WELL #2
CONSTANT Q TEST
MARCH 29-APRIL 8, 1989

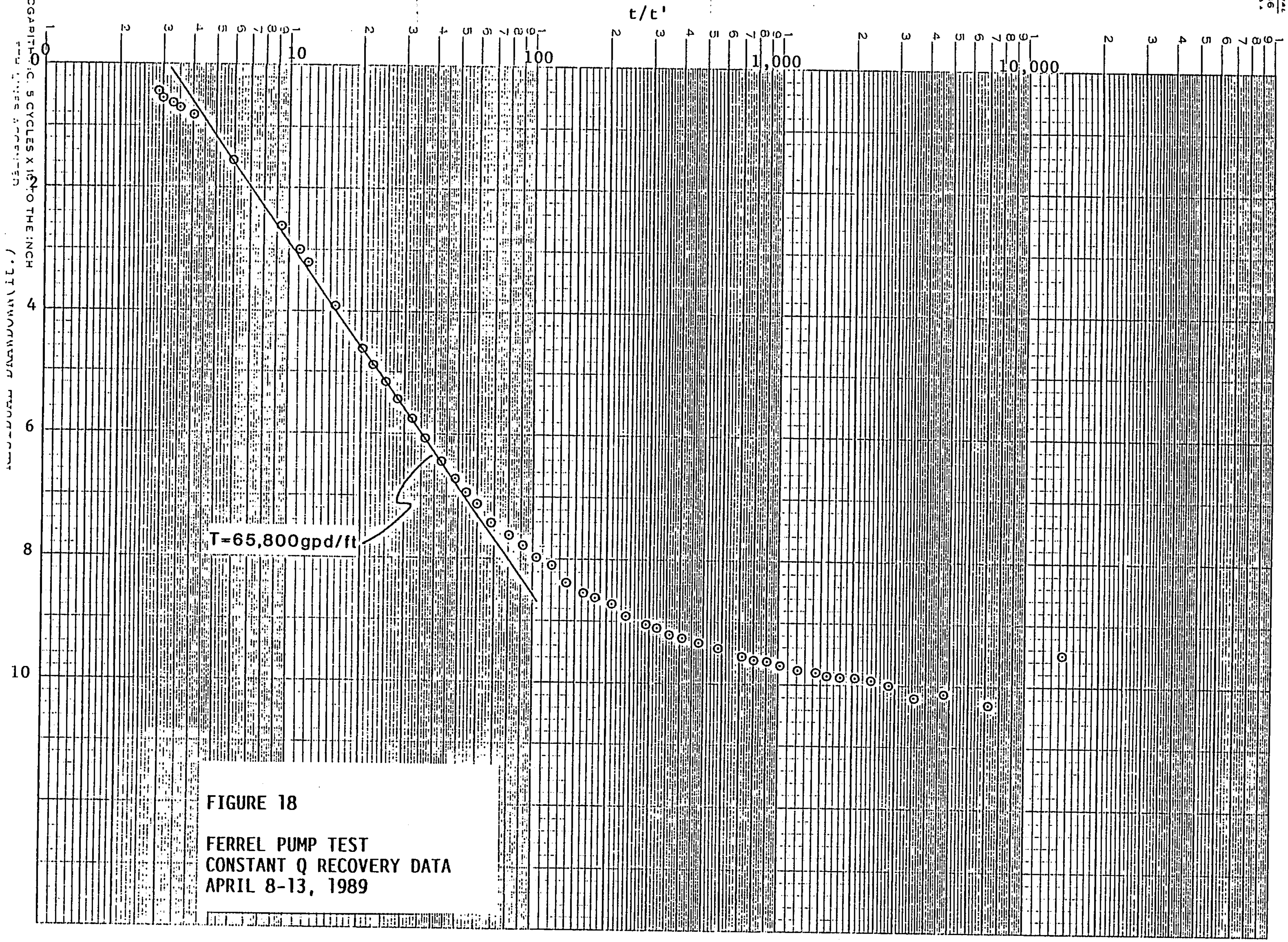


FIGURE 18

FERREL PUMP TEST
CONSTANT Q RECOVERY DATA
APRIL 8-13, 1989

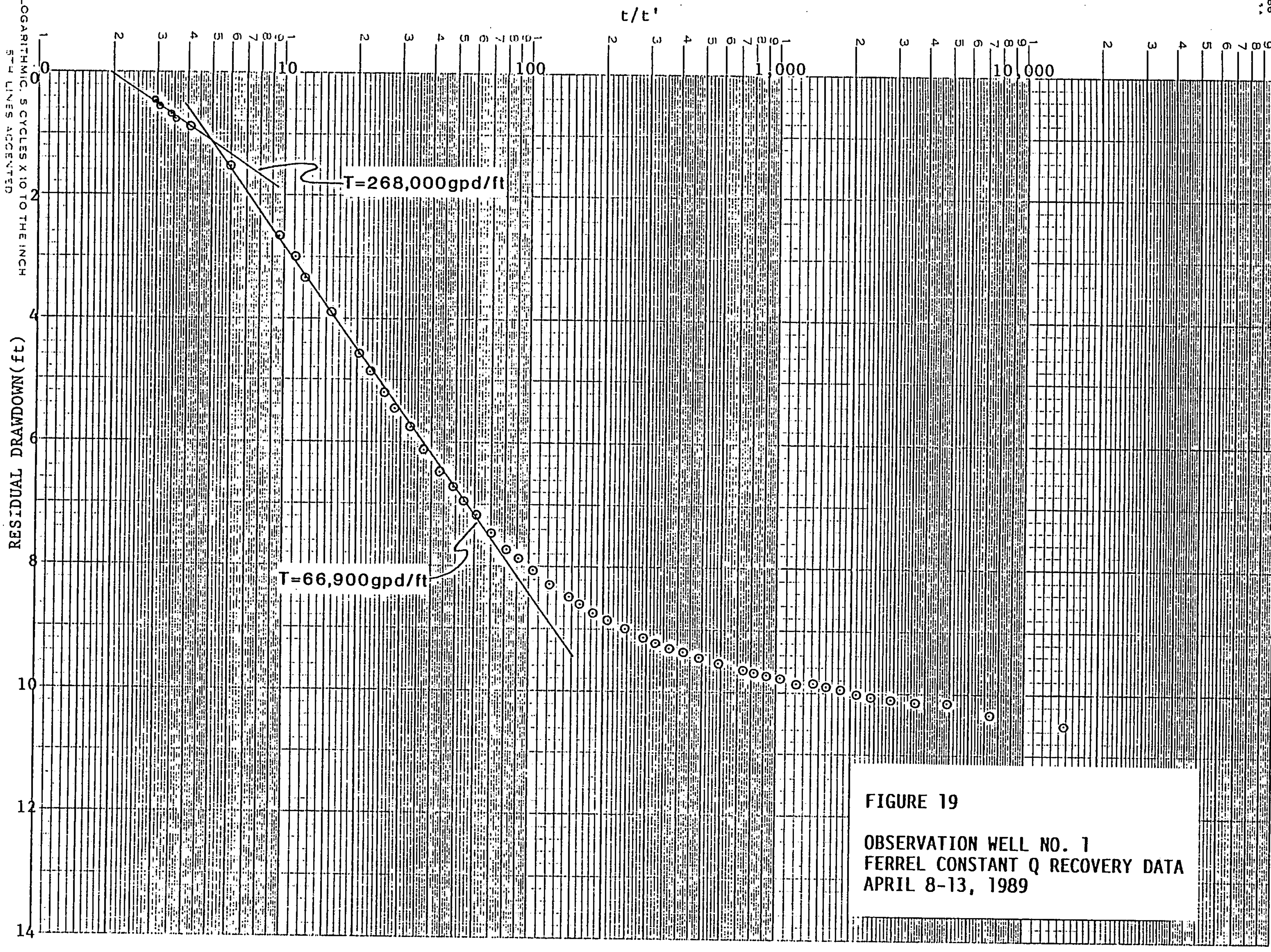


FIGURE 19

OBSERVATION WELL NO. 1
FERREL CONSTANT Q RECOVERY DATA
APRIL 8-13, 1989

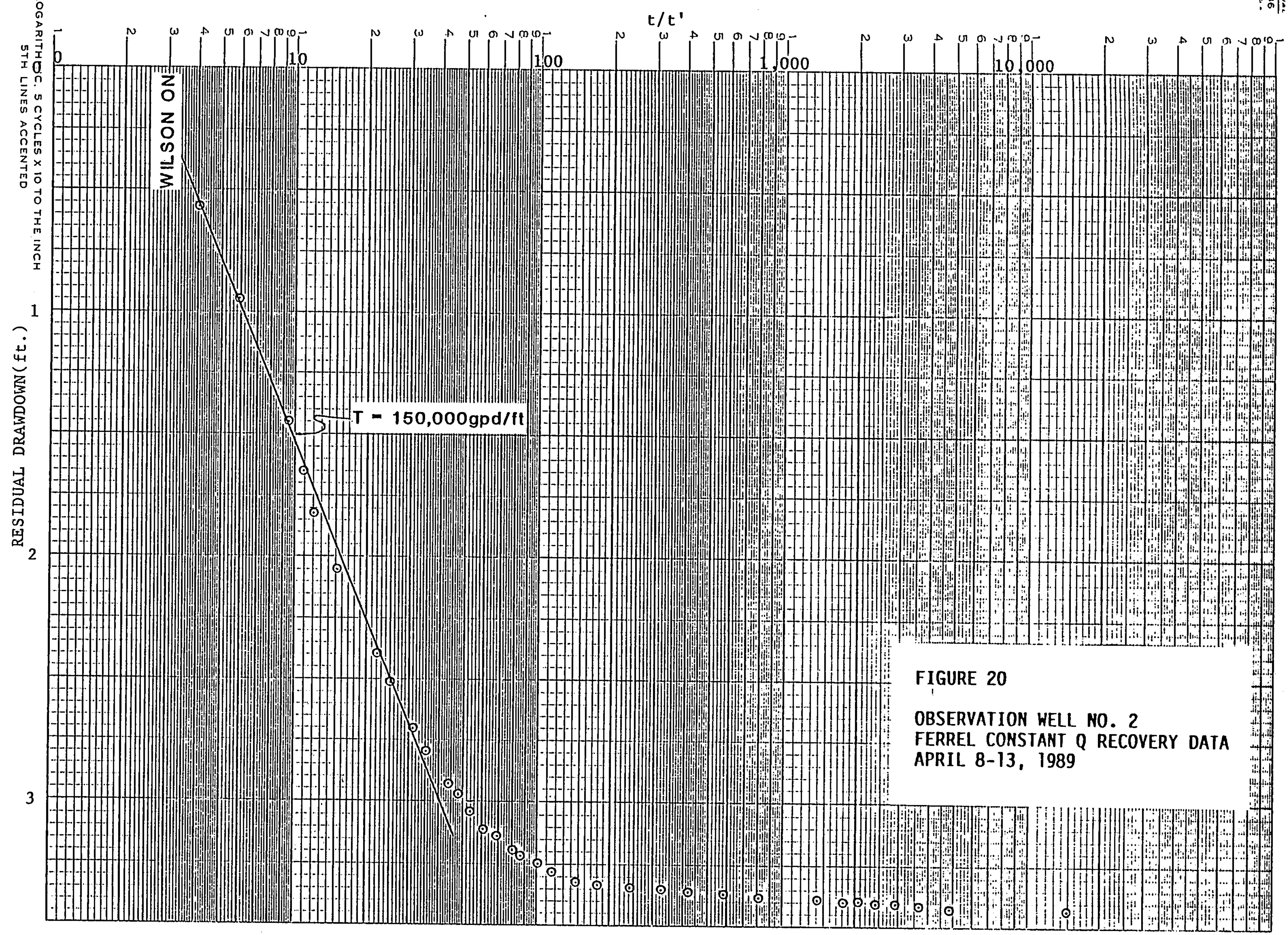


FIGURE 20

OBSERVATION WELL NO. 2
FERREL CONSTANT Q RECOVERY DATA
APRIL 8-13, 1989

of gravel was discovered in a 60 feet sequence of clays and altered volcanics (see Figure A3). A second concept is that a steeply dipping fault occurs between the two aquifers so that leakage between the two aquifers may occur laterally. This is depicted in Plate 1. A more accurate assessment could be made if the lithology and aquifer characteristics at the Ferrel production well were known. Contribution of flow from the coarse sands at the second observation well to the Ferrel Production Well can be estimated. If the transmissivity of the "Wilson aquifer" is averaged at 126,000 gpd/ft, then the flux rate is 950 gpm at the Ferrel Observation Well #2.

$$T = \frac{264.Q}{S} \qquad (1)$$

$$126{,}000 \text{ gpd/ft} = \frac{264\ (950 \text{ gpm})}{2 \text{ ft}} \qquad (2)$$

Figures 18, 19 and 20 are the recovery curves at the Ferrel, the Ferrel Observation #1 and the Ferrel Observation #2 Wells, respectively. Figures 18 and 19 are identical and reflect the drawdown curve of Figure 16, Observation Well #1. This supports the belief that the lithology at the Ferrel Well is the same as at the Observation Well #1. Figure 20 is the recovery curve of Observation Well #2 and duplicates the drawdown curve.

Table 4 lists the transmissivities and storage coefficients as determined by W.H.I.P.

TABLE 4

FERREL TRANSMISSIVITIES

WELL	T-VALVES (GPD/FOOT)	BNDY INFL T (GPD/FOOT)	STORAGE COEFFICIENT	Cooper-Jacob STORATIVITY
Ferrel Obs #1 (p)	68,500	136,600	0.02	0.00003
Ferrel Obs #2 (p)	173,000	–	0.0036	0.00002
Ferrel (r)	63,600			
Ferrel Obs #1 (r)	64,600			
Ferrel Obs #2 (r)	156,400			

Jarboe Well

The Jarboe constant discharge test was essentially run for seven days after a faulty fuel pump interrupted the initial start (one day). Because of large well inefficiencies, cascading water and 10% fluctuations in flow, measurements in the Jarboe Well were poor and/or suspect. Figure 21 displays the data from the Jarboe Well during pumping. Data was not collected during the first 19 minutes, as one person started up the test and was concentrating on measuring the observation wells. From Figure 21 the flat slope from t=20 minutes to t=300 minutes cannot be satisfactorily explained. It could be that water in storage from small fractures were supplying the discharge. A transmissivity of 74,100 gpd/feet was estimated.

Because the well is completed in two aquifer systems (rock and alluvial) it is not easy to determine transmissivities of each aquifer. The contribution of flow from each aquifer is not apparent. Flow to the well from the alluvial aquifer can occur in two ways. Either from vertical leakage to the bedrock and then along fractures to the well or horizontally to the well. Figures 22 and 23 are drawdown curves for Observation Well #1 (rock aquifer) and Observation Well #2 (alluvial aquifer).

If vertical leakage was occurring from the alluvial aquifer to the rock aquifer, a positive change in slope should occur on Figure 22 and this did not occur. The slotted casing in the Jarboe Well begins at 95 feet and the alluvial-bedrock contact is approximately at 115 feet. The phreatic surface in the alluvium was at 49 feet prior to pumping. The pumping level in the Jarboe Well was always 150 feet below land surface so that an "alluvial" groundwater gradient to the well occurred. It is felt then that the alluvial aquifer supplies water to the well horizontally.

A response to pumping occurred in the alluvial Observation Well at t=70 minutes. The phreatic surface continued to decrease at a fairly constant rate

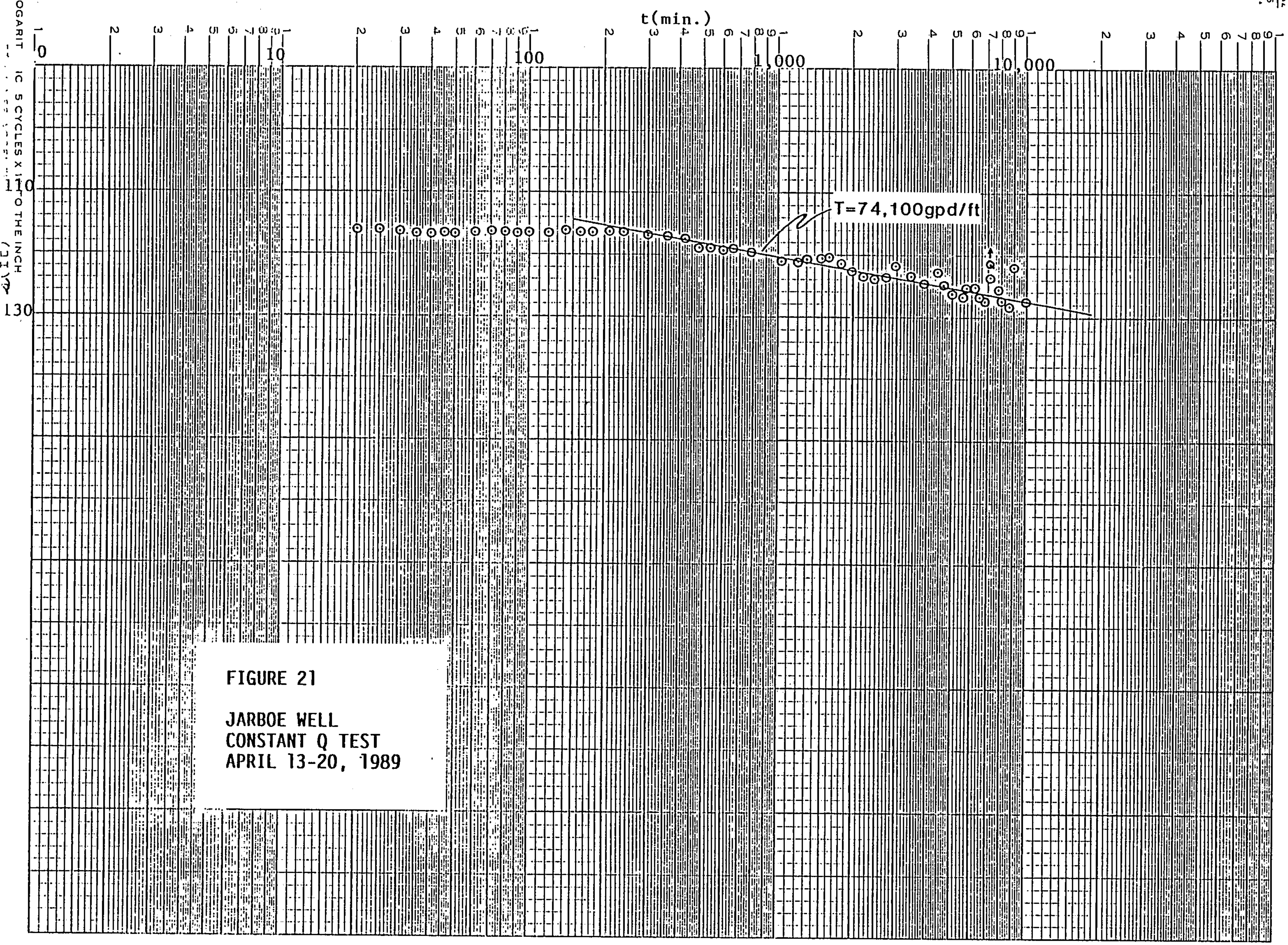


FIGURE 21

JARBOE WELL
CONSTANT Q TEST
APRIL 13-20, 1989

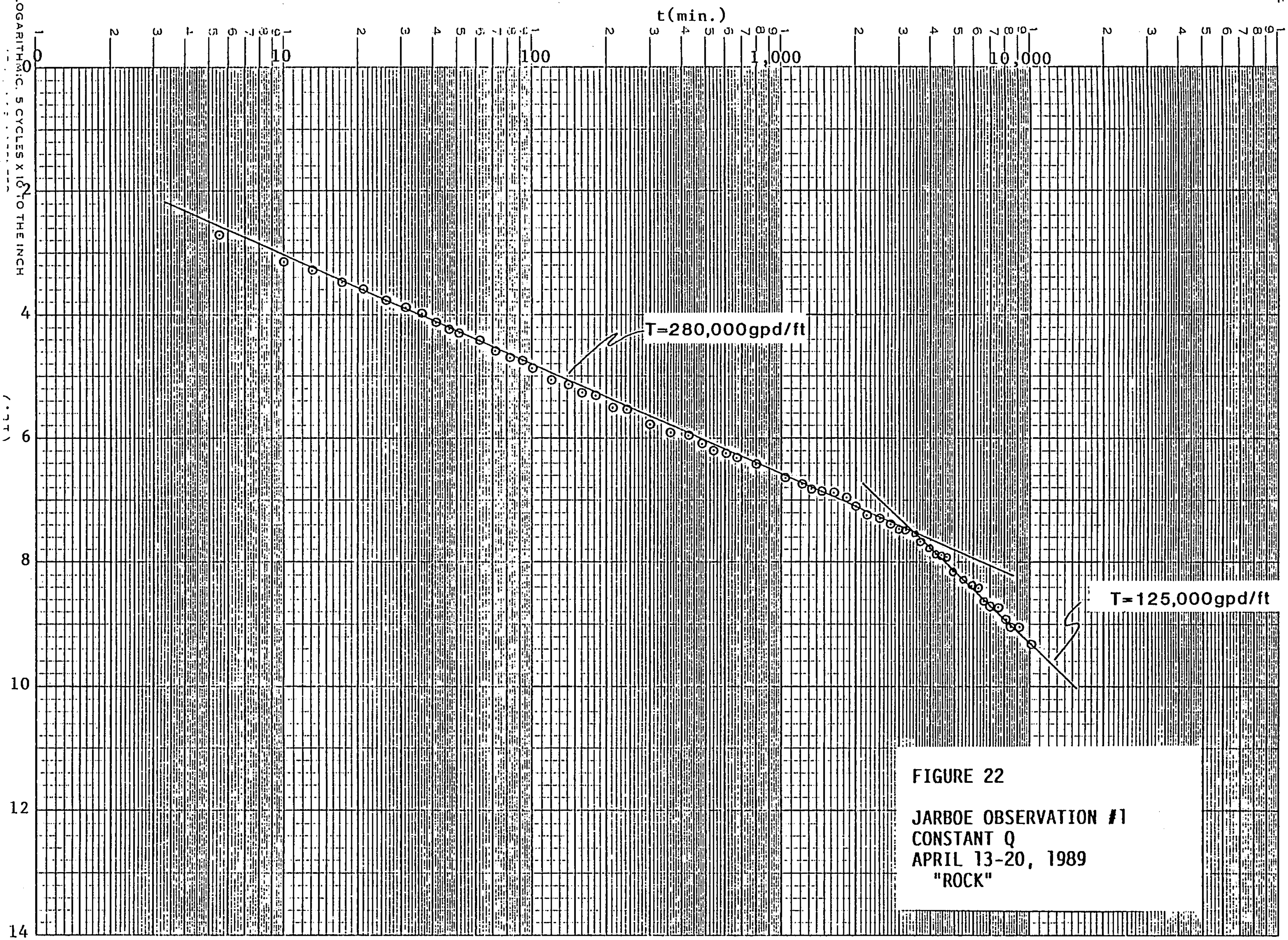


FIGURE 22

JARBOE OBSERVATION #1
CONSTANT Q
APRIL 13-20, 1989
"ROCK"

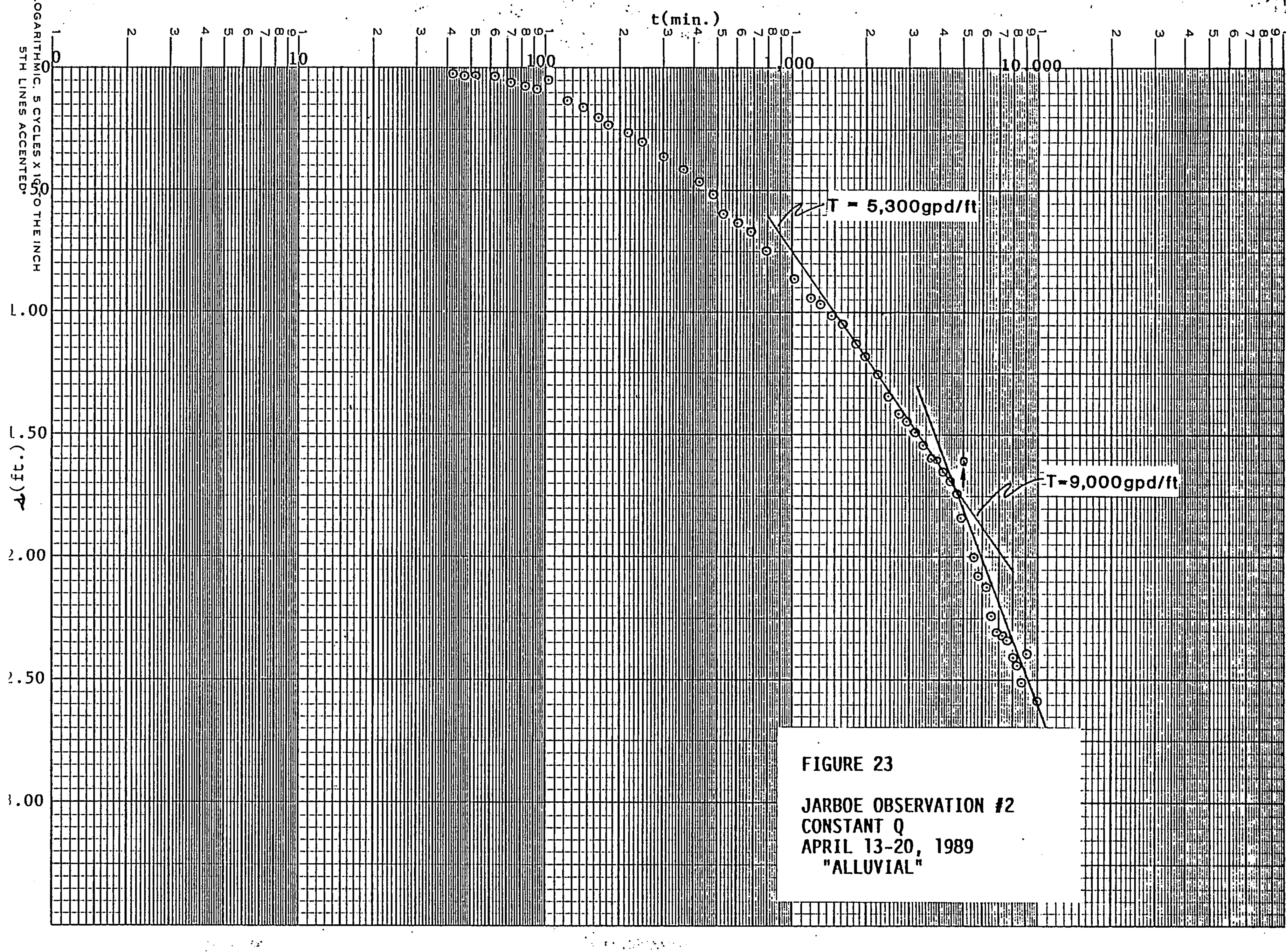


FIGURE 23

JARBOE OBSERVATION #2
CONSTANT Q
APRIL 13-20, 1989
"ALLUVIAL"

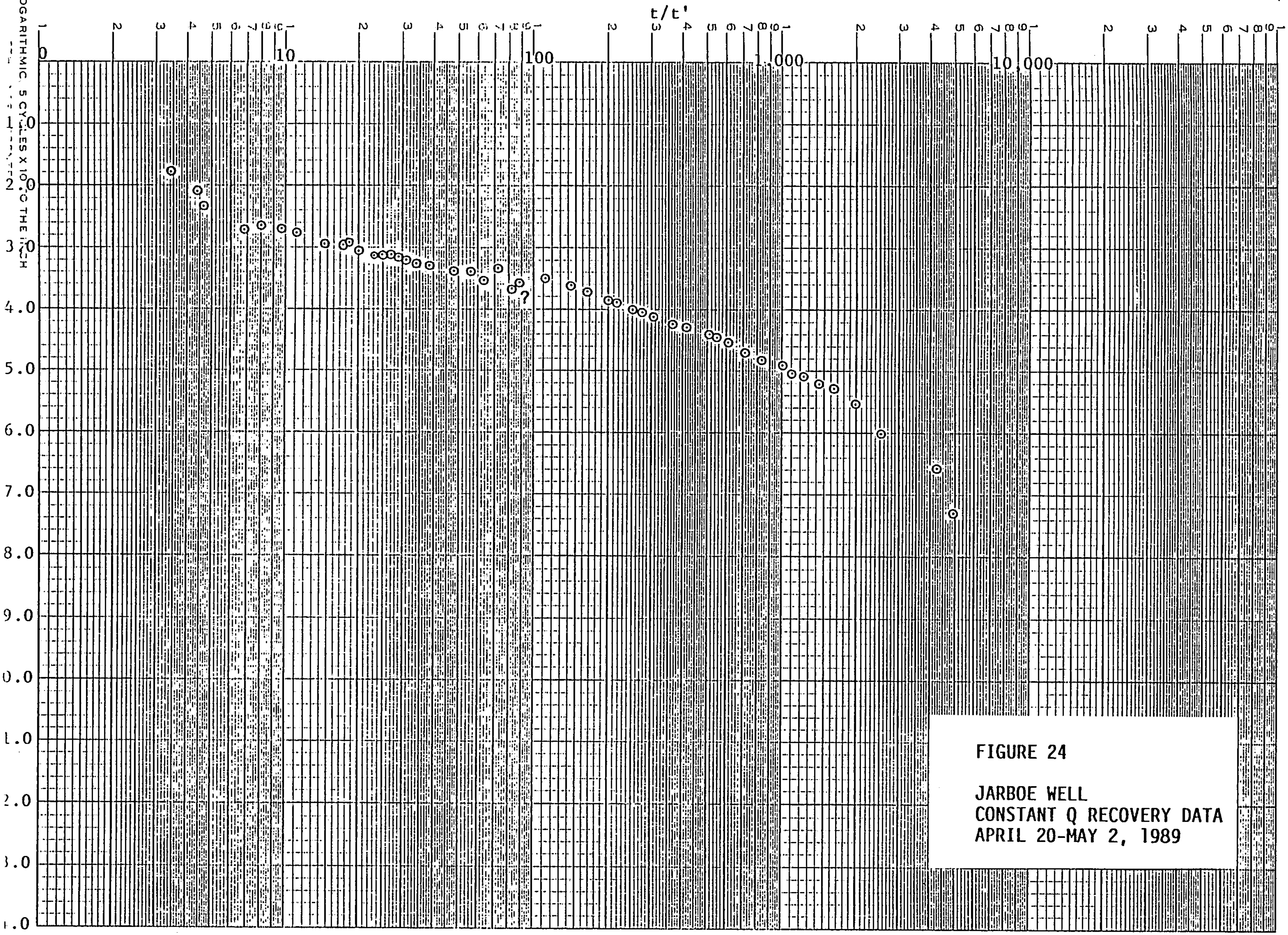


FIGURE 24

JARBOE WELL
CONSTANT Q RECOVERY DATA
APRIL 20-MAY 2, 1989

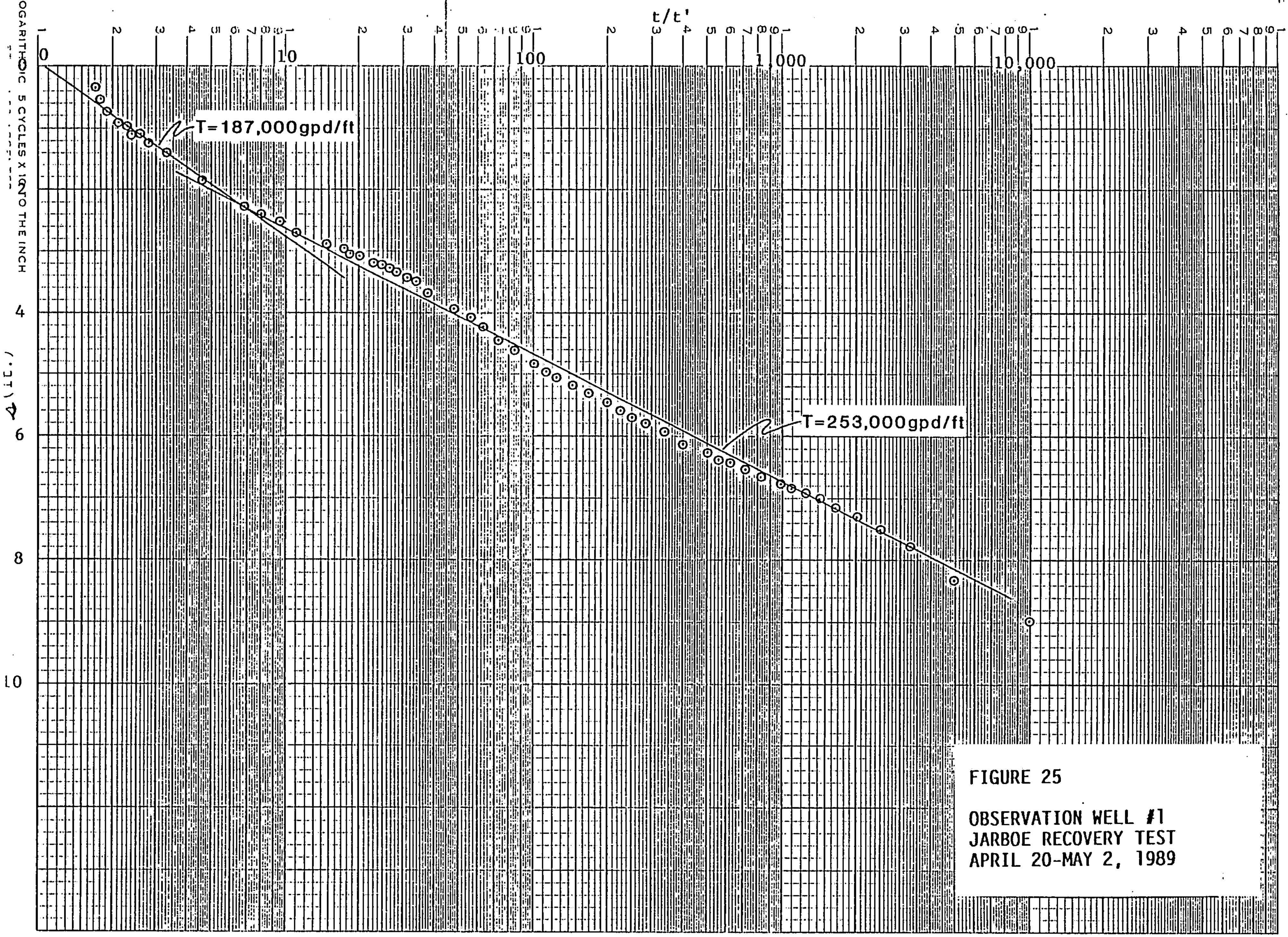


FIGURE 25

OBSERVATION WELL #1
JARBOE RECOVERY TEST
APRIL 20-MAY 2, 1989

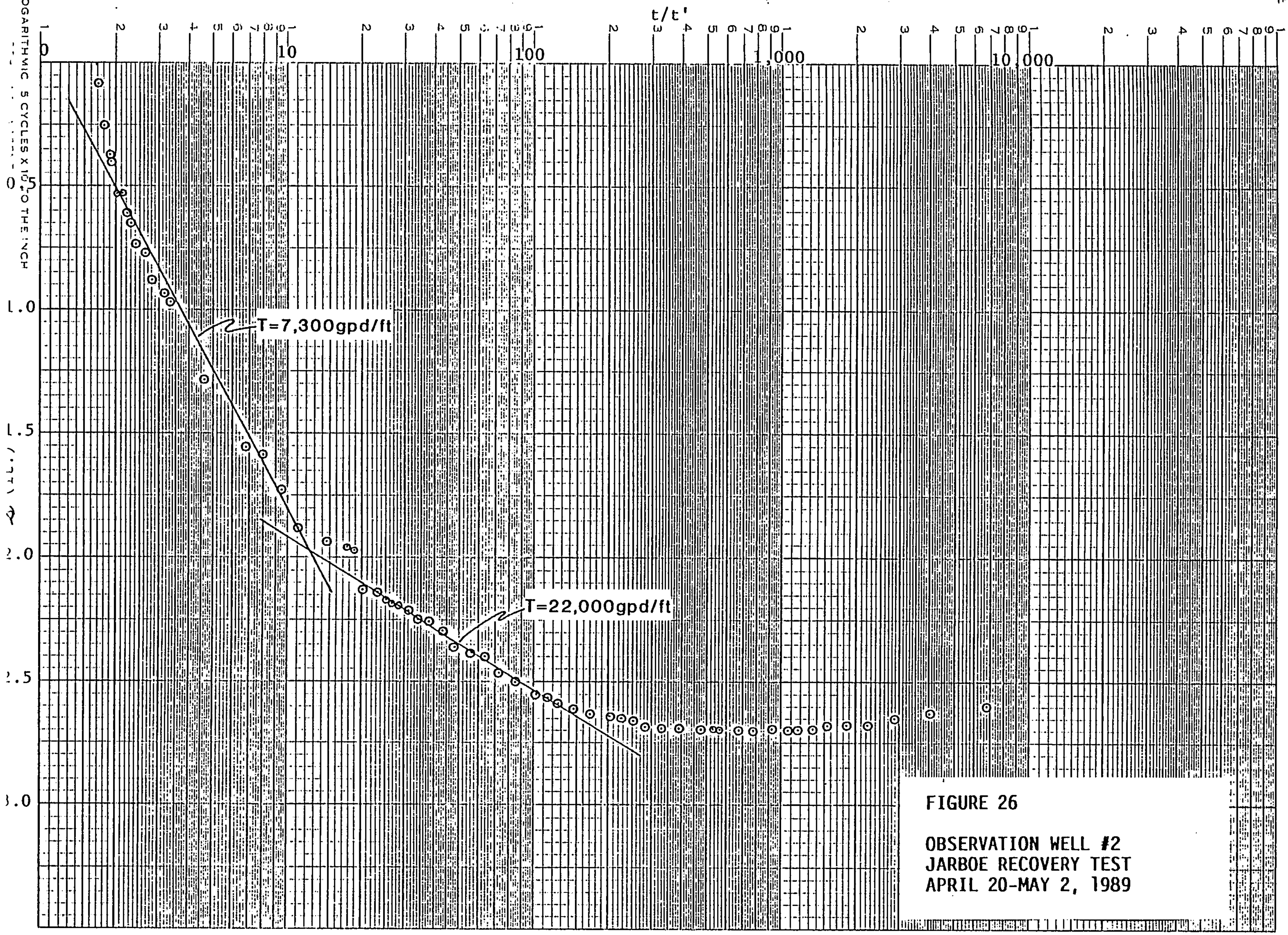


FIGURE 26

OBSERVATION WELL #2
JARBOE RECOVERY TEST
APRIL 20-MAY 2, 1989

until t=5000 minutes whereby the slope increased downward. On Figure 22 a negative slope change occurred at t=3,500 minutes. Two possible explanations can be speculated for this. It is possible that a boundary effect occurred in the rock aquifer and in the alluvial aquifer at a later time. The alluvial boundary effect may have been the volcanic hills to the southeast, but the distance (1,500 feet) seems too great, given the small alluvial radius of influence (360 feet). Another explanation is that either a boundary effect or dewatering of fractures occurred in the rock aquifer resulting in an increase in contributing flow from the alluvial aquifer in order to meet the 1960 gpm demand of the pumping well. This latter explanation is intuitively more reasonable.

In order to calculate the transmissivity of each aquifer the discharge rate from each must be known. If the volume of water removed from the alluvium can be determined from the cone of estimated depression, the discharge from the rock aquifer can be determined by difference. Assumptions must be made about the geometric dimensions of the cone of depression. It is estimated that the radius of influence is 360 feet and the maximum thickness ranges from 5 to 15 feet at the well-aquifer interface. Assuming that 10% of this volume is released groundwater, a range of 50 to 150 gpm is determined. Referring to Figure 23 a range of 9,000 to 26,000 gpd/feet can be calculated. These ranges of values are reasonable for this alluvial aquifer. Indeed, during development of the alluvial observation well, very little discharge from the well was attainable. This would indicate that the lower values of discharge and transmissivity should be used. From Figure 22 an aquifer transmissivity of 280,000 gpd/feet and boundary influenced transmissivity of 125,000 gpd/feet is derived. This is based on a rock aquifer discharge of 1,915 gpm.

Figures 24, 25 and 26 are recovery curves for the Jarboe, Observation Wells #1 and #2 respectively. The data from the Jarboe Well is not consistent or reliable because of floating oil in the well. Rapid recovery is apparent though. Figure 25 generally is the mirror image of the drawdown data from Figure 22, although the impermeable boundary is not as apparent. The apparent transmissivities are 253,000 and 187,000 gpd/feet. Figure 26 shows the recovery of the alluvial well and though peculiar in shape is easily explained. Recovery in the pumped well was initially rapid due primarily to large well losses and/or formation losses. During the initial recovery (t/t′) period between 7,000 and 300 the alluvial gradient due to pumping was still maintained at the Jarboe Well. This was approximately 30 minutes and includes a transition period towards recovery. From t/t′=300 to 2 normal recovery occurs in the alluvial aquifer. From t/t′=2 recovery is abnormally fast and probably reflects additional recovery due to the rock aquifer with the gravel pack as the conduit. Other factors are that the Jarboe Well was pumped for a day prior to the start of this test and full recovery was not attained and/or the use of a different well probe causing measurement error in the late stage of testing. Table 5 lists the transmissivities and storativities from the Jarboe pumping test.

TABLE 5

JARBOE PUMPING TEST TRANSMISSIVITIES AND STORATIVITIES

WELL		T VALVES GPD/FOOT	BNDY INFL T GPD/FOOT	STORAGE COEFFICIENT	PUMPING GPM
Jarboe	(p)	74,000 (?)			1965
Jarboe Obs #1	(p)	280,000	125,000	0.00005	1915
Jarboe Obs #2	(p)	10,000	10,000	0.008	50
Jarboe	(r)	324,000 (?)			1965
Jarboe #1	(r)	253,000	187,000		1915
Jarboe #2	(r)	22,000	7,300		50

Hodges Well

The Hodges Well is completed in coarse grained sediments. From the drilling operations it was undetermined as to where these gravels actually overlayed the broken volcanics. Figures 27-29 are semilog plots of drawdown for the Hodges Well, Observation #1 and Observation #2 respectively. These figures indicate that an impermeable boundary exists.

Figure 27 does not show delayed yield effects. At approximately t=2,000 minutes and 5,000 minutes the slope changes by factors of 2. In theory a boundary will change the slope by a factor of 2. Figure 28 shows a small delayed yield component for Observation Well #1 and a boundary effect at t=2,400 minutes. The change in slope is by a factor of 2 which is in line with theory. Figure 29 for Observation Well #2 shows two changes in slope at t=1,000 minutes and t=4,000 minutes. Slope changes were roughly by factors of 2.

Figures 30-32 are recovery curves for the Hodges, Observation #1 and #2 respectively. Because of irrigation needs the recovery was terminated at t/t′=6. It appears that this time was also when changes in slope were occurring, reflecting boundary conditions. The Observation Wells recovery plots are exact reciprocals of the drawdown curves. Figure 30 is a different scale than Figure 27, but basically reproduces the same hydraulic parameters as the drawdown data.

Table 6 lists transmissivities and storage coefficients. These figures were derived using Hydro Geo Chem, Inc. Well Hydraulic Interpretation Program (WHIP). The analysis was based on partial penetration effects of an unconfined, homogeneous aquifer. The average transmissivity for the aquifer is 164,400 gpd/feet and a storage coefficient of 0.0045. This storage value reflects semi-confined conditions. Transmissivities based on incorporation of boundary conditions average 89,200 gpd/feet. These should be used in

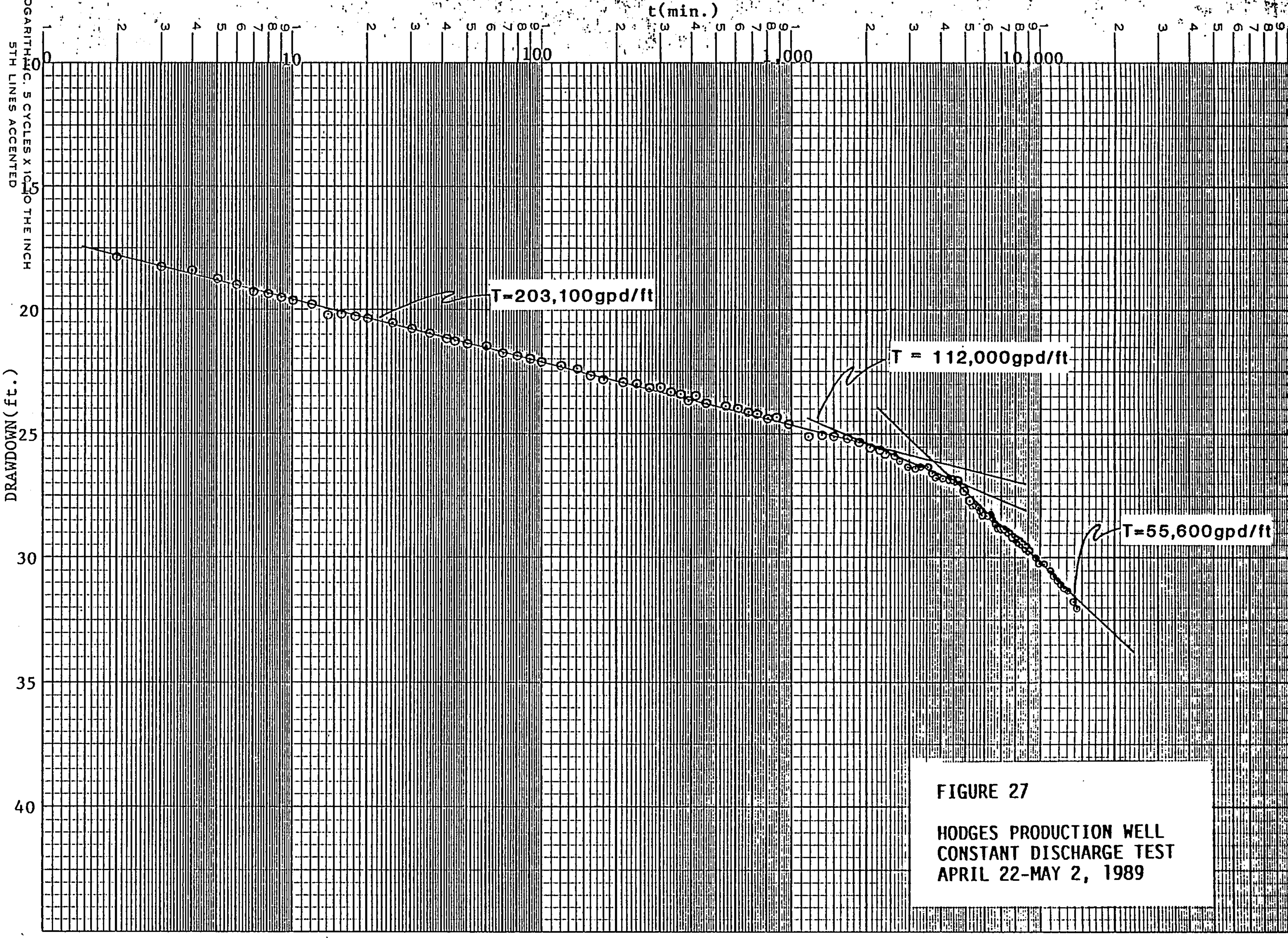


FIGURE 27

HODGES PRODUCTION WELL
CONSTANT DISCHARGE TEST
APRIL 22-MAY 2, 1989

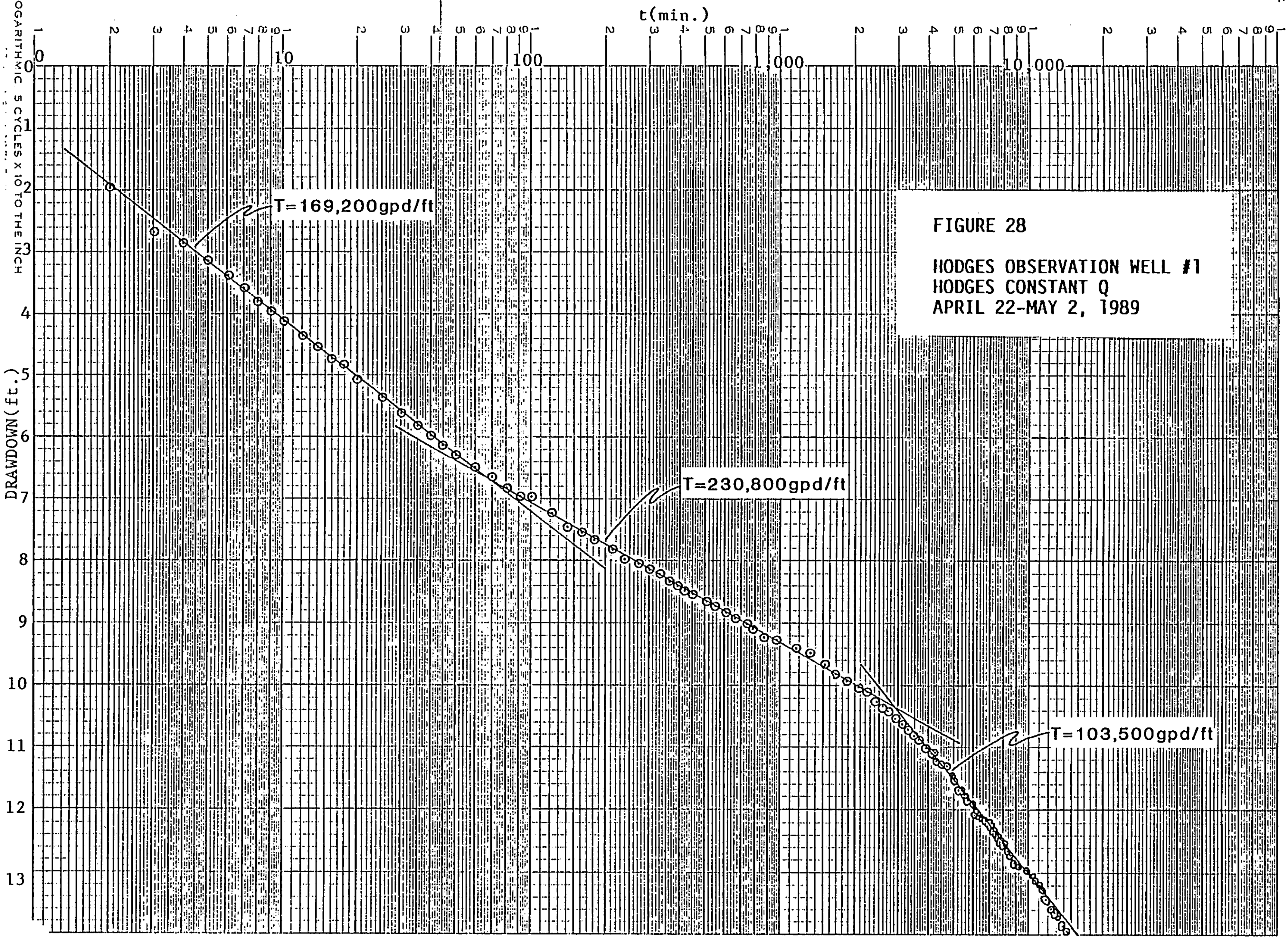


FIGURE 28
HODGES OBSERVATION WELL #1
HODGES CONSTANT Q
APRIL 22-MAY 2, 1989
t(min.)
DRAWDOWN(ft.)
T=169,200gpd/ft
T=230,800gpd/ft
T=103,500gpd/ft
SEMI-LOGARITHMIC 5 CYCLES X 10 TO THE INCH
12-086

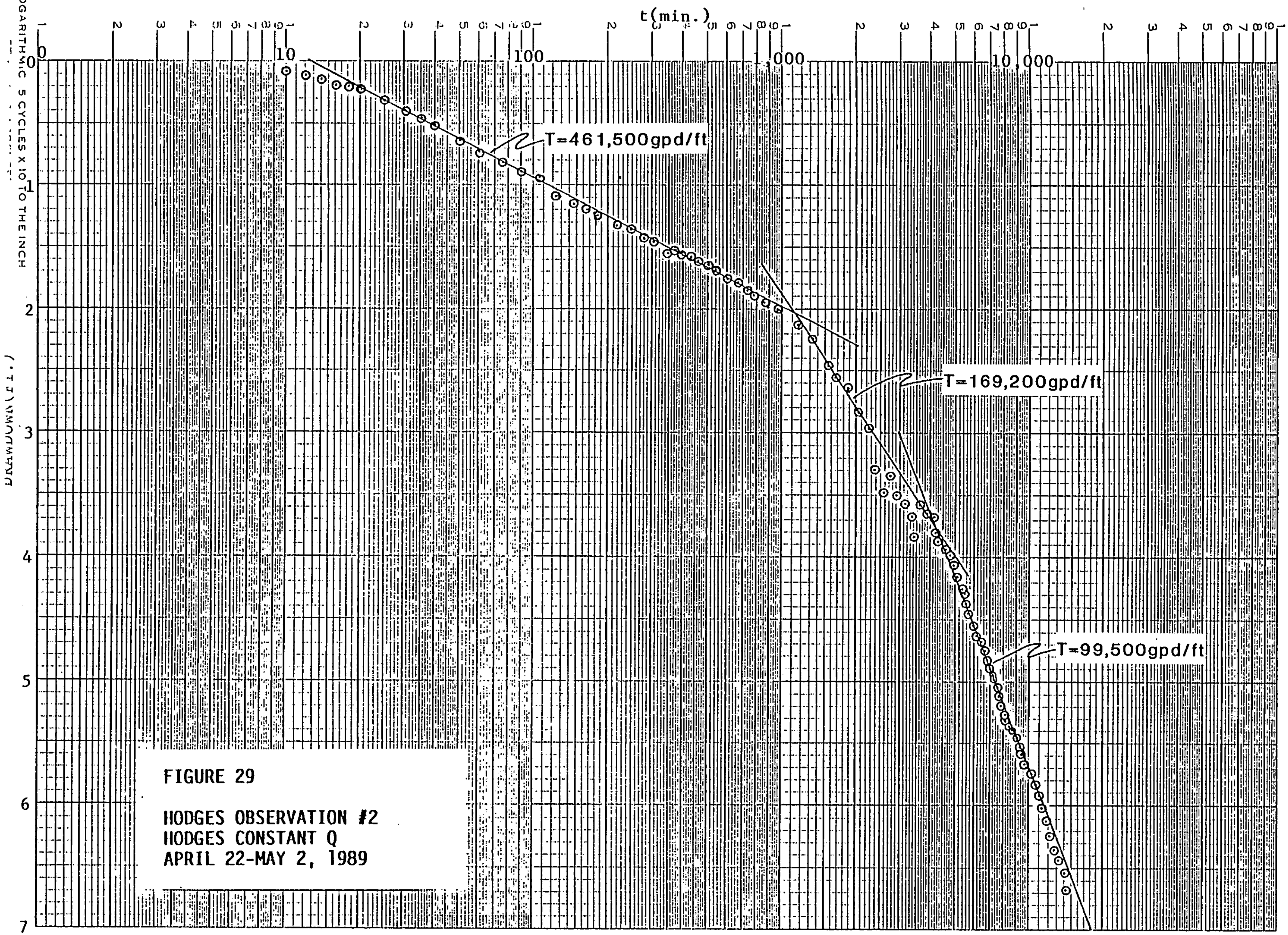


FIGURE 29

HODGES OBSERVATION #2
HODGES CONSTANT Q
APRIL 22-MAY 2, 1989

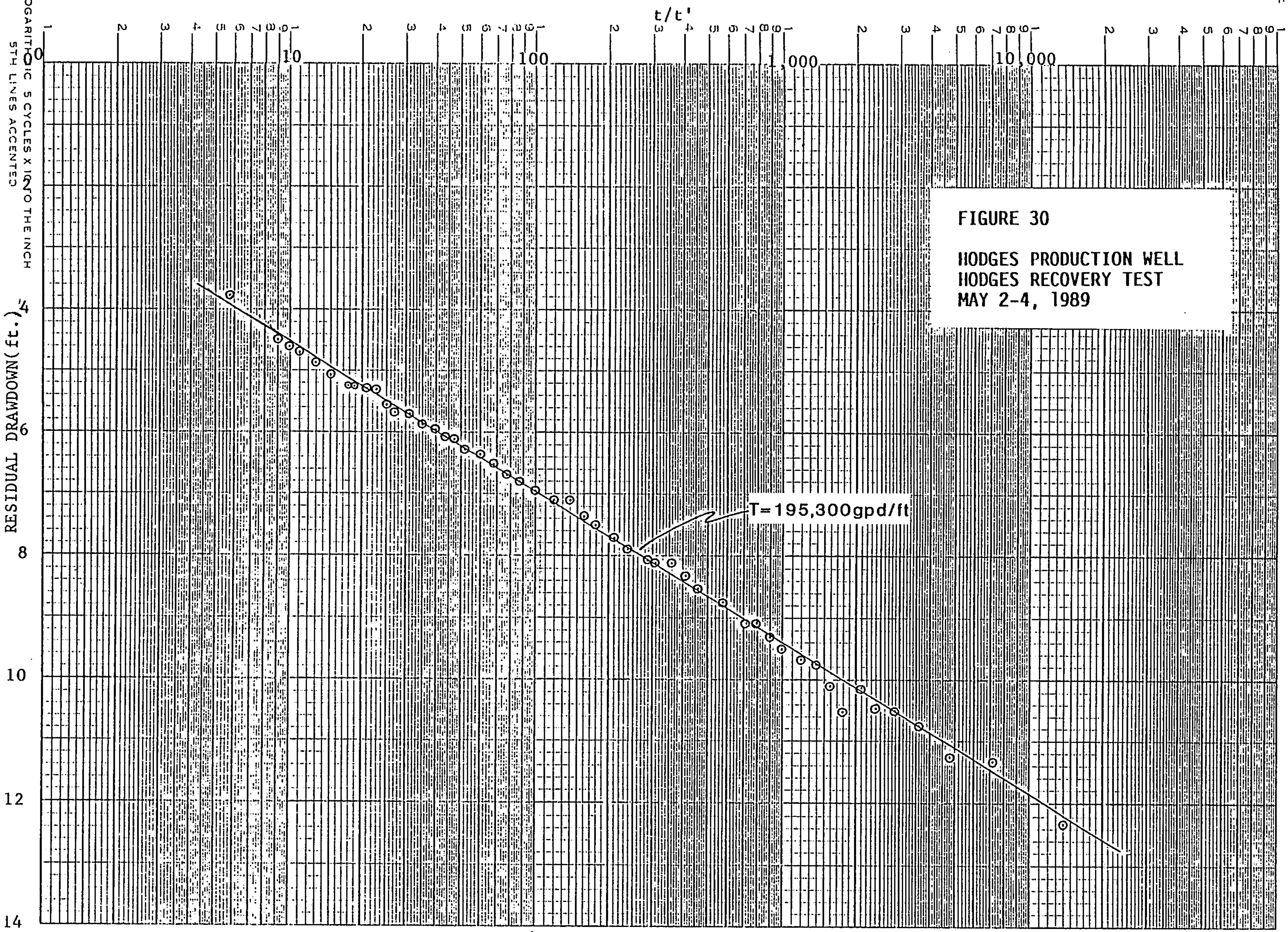


FIGURE 30
HODGES PRODUCTION WELL
HODGES RECOVERY TEST
MAY 2-4, 1989
T=195,300gpd/ft
t/t'
RESIDUAL DRAWDOWN(ft.)
SEMI-LOGARITHMIC 5 CYCLES X 10 TO THE INCH
5TH LINES ACCENTED

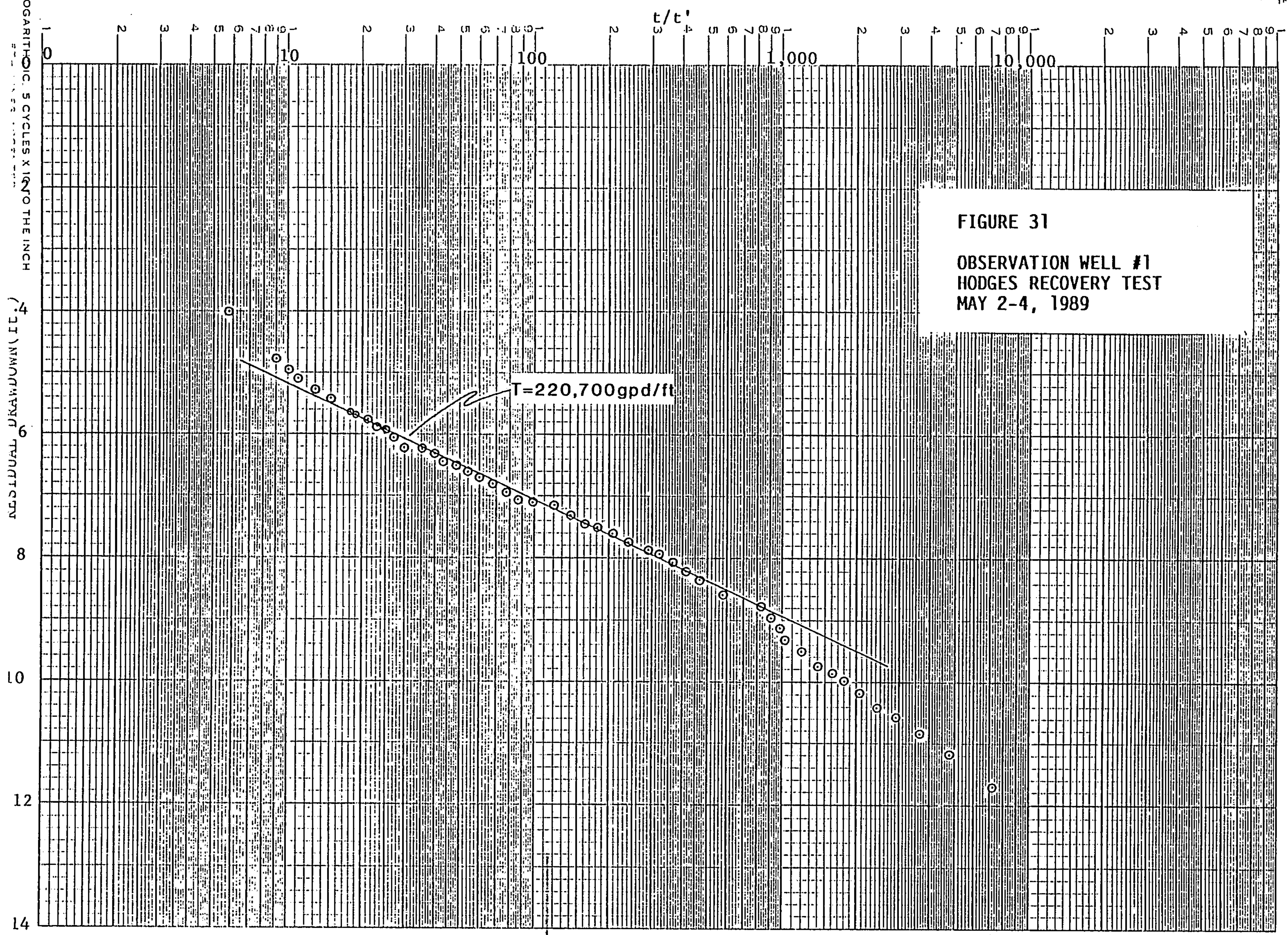


FIGURE 31
OBSERVATION WELL #1
HODGES RECOVERY TEST
MAY 2-4, 1989
T=220,700gpd/ft
t/t'
RESIDUAL DRAWDOWN(FT.)
0
10
100
1,000
10,000
0
2
4
6
8
10
12
14
SEMI-LOGARITHMIC, 5 CYCLES X 10 TO THE INCH

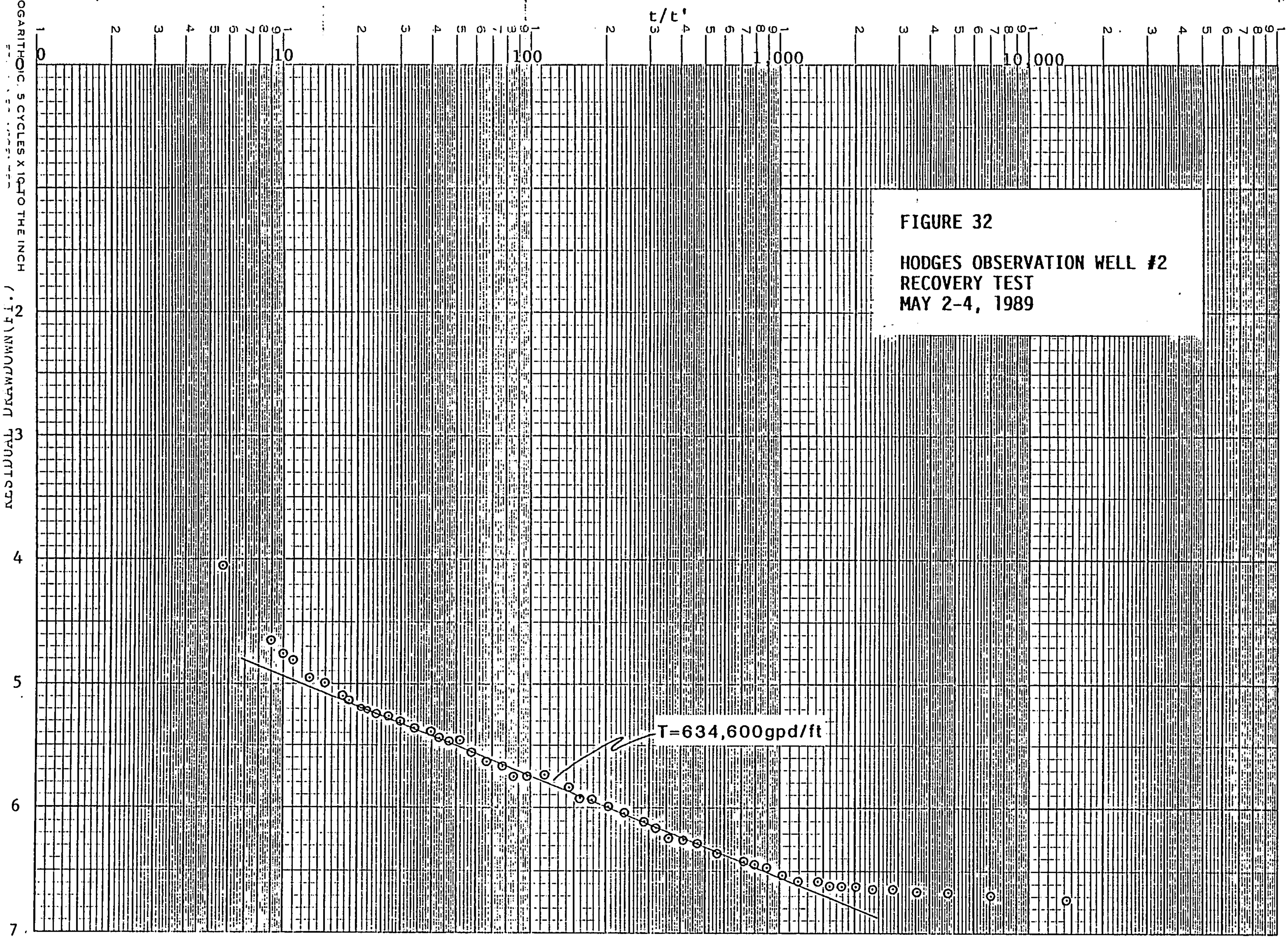


FIGURE 32
HODGES OBSERVATION WELL #2
RECOVERY TEST
MAY 2-4, 1989
T=634,600gpd/ft
t/t'
RESIDUAL DRAWDOWN(FT.)
SEMI-LOGARITHMIC, 5 CYCLES X 10 TO THE INCH
12-086

TABLE 6

HODGES TRANSMISSIVITIES

WELL	T VALUES (GPD/FOOT)	BNDY INFL T VALUES (GPD/FOOT)	STORAGE COEFFICIENT
Hodges (p)	137,800	55,600	0.004
Obs. #1 (p)	203,300	108,400	0.0005
Obs. #2 (p)	174,300	103,500	0.009
Hodges (r)	164,500		
Obs. #1 (r)	142,100		
Obs. #2 (r)	640,300		

estimating long term effects of pumping this aquifer. WHIP estimated a boundary to the east a distance of 8,600 feet. This would correspond to the fault blocked Virginia Range and/or the Cottonwood fault mapped by the Nevada Bureau of Mines (Grose, 1984).

CHEMISTRY

Water quality analyses were made on all five production wells at the Fish Springs Ranch. At least two analyses per well were made in order to verify the initial results and to document any quality trends.

Figure 33 is a trilinear diagram which describes the major ionic composition of each water. The lower left portion of the diagram displays, in percentages, the major cation composition. It can be seen that all five waters plot mostly as a sodium rich water. The lower right portion of the diagram shows that four waters plot as mostly bicarbonate anion waters and that the Wilson is predominately anionic in sulfate. The upper portion of the diagram then shows the total ionic make-up of these waters. The Wilson water can be described as a sodium-sulfate water, while the others are sodium-bicarbonate waters.

Table 7 lists the general chemisty of these waters. These represent averages of the analyses taken during the pumping tests. The Jarboe, Hodges, Ferrel and Headquarters water are considered low in total dissolved solids and generally excellent in quality. The Wilson water is high in sodium and sulfate with respect to the other waters, but is within the secondary standards of the state "Safe Drinking Water Act." Comparing the sodium and sulfate of all the waters indicates that the Ferrel water is in part derived from the Wilson area. This is supported from the pumping tests. Since sodium and sulfate are alkali, the likely source of these solubles in the Wilson Well water is the playa to the immediate north. It must also be mentioned that while pumping the Wilson well, hydrogen sulfide gas could be detected at the discharge.

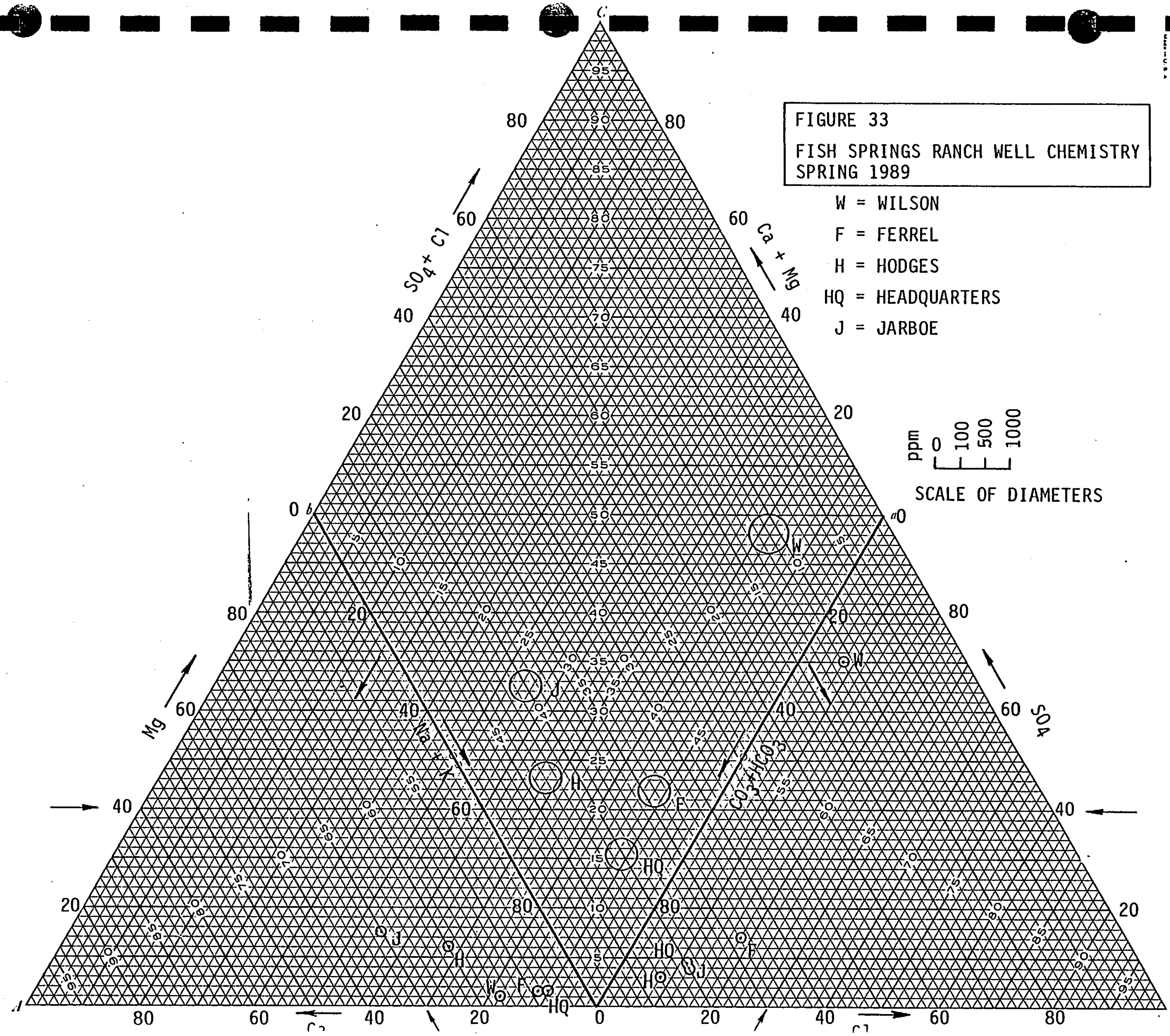


FIGURE 33

FISH SPRINGS RANCH WELL CHEMISTRY
SPRING 1989

TABLE 7

FISH SPRINGS AQUIFER CHEMISTRY (ppm)

	JARBOE	HODGES	FERREL	HQ	WILSON
TDS (units/mgl)	165	200	233	203	467
pH	8.3	8.0	8.5	8.4	8.2
CO_3	0	0	7	7	0
HCO_3	90	108	109	90	93
SO_4	6.5	6	16.5	8	226
Cl	8	7	17	7	20
N	5	3.3	5.1	4.8	0.3
F	0.1	0.1	0.3	0.1	1
Na	24.9	37.5	62	45.5	121
K	6.4	8.4	5.8	7.2	3.9
Ca	13.6	9.8	5.6	3.4	21
Mg	4.1	3.5	1.4	1.2	1.6
Fe	< 0.02	< .02	.04	< .02	0.04
Mn	< 0.02	< .02	< .02	< .02	0.03
As	< .003	< .003	.01	.015	.038
Color	< 5	< 5	< 5	< 5	< 5

Aquifer Productivity and Recharge Capture

The purpose of this section is to give an approximate assessment of aquifer productivity and what volume of groundwater Washoe County may expect to export. This assessment is based on the pumping tests and general hydrogeologic information. The ability to maximize groundwater capture is limited by the number of wells, well interference, water quality concerns and long term drawdown effects. Of most importance is that while these aquifers are highly transmissive, the groundwater must be physically and economically available on an annual basis virtually forever. Therefore, estimates of groundwater recharge must be accurate and thorough.

The "Wilson Aquifer" is confined, alluvial and limited in extent, though highly conductive. Groundwater production is limited by aquifer volume and water quality (see Water Quality Section). The aquifer should probably be pumped no more than it's current irrigation rate (3,000 gpm) with the pumping rate averaged to 365 days per year (1,000 gpm). Until better assessment is made towards 1) recharge to the aquifer from the south (volcanic highlands), 2) water quality migration from the north (playa) and 3) long term aquifer response (storage depletion) an estimate of 1,600 AF annually of pumpage is made.

The Hodges Well is located in the Cottonwood alluvial fan. The aquifer system of this sub-basin consists of an alluvial and a hard rock section of which little is known. This sub-basin probably has the greatest potential for groundwater capture than the Jarboe area and the Wilson area. The transmissivity is quite good in the alluvial aquifer and likewise should be good in the hardrock. Future exploration should continue in this sub-basin to delineate the alluvial aquifer and explore the hardrock areas. With three to four wells this area could possibly support 3,000-5,000 AF/A.

The Headquarters, Jarboe and Ferrel Wells mostly penetrate a hardrock aquifer in the same sub-basin (Jarboe). Production wells in this area would be limited by annual recharge and well interference effects. Exploration for new well sites should be west of the Jarboe Well and near the Ferrel Well. It seems plausible that an estimated 3,000-4,000 AF could be pumped annually from this sub-basin, but more work must be done to assess the recharge to the basin and potential poor quality water migration near the Ferrel Well.

Until the annual recharge and impacts on water quality are more clearly defined, the estimated yield from the Fish Springs Ranch area is 7,600-10,600 AF/YR. Adjustment will be made based on recharge estimates, chemistry analysis and exploratory drilling. Please keep in mind that estimating groundwater capture from pumping tests is unreliable and only preliminary at best. Pumping tests indicate the ability of the aquifers to transmit water and provide estimates of long term drawdowns in wells.

CONCLUSIONS

The aquifers at Fish Springs Ranch exhibit high transmissivity. This means that the aquifers or porous media are highly conductive of groundwater. Storativity values are moderate and generally represent confined aquifers. Management of the aquifers must ensure that future pumpage does not reduce aquifer pressures enough to cause land subsidence or unconfined water table conditions. Based on data collected to date 7,600-10,600 AF/YR could be pumped annually from the Fish Springs Area.

The water quality is generally excellent except in the aquifer system that the Wilson Well pumps from. Increased pumping from this area may cause quality degradation at the Wilson Well and to a lesser extent at the Ferrel Well.

The physical wells themselves range from poor to good condition. A water importation plan would necessarily require replacement of the Ferrel and the Jarboe Well. The Headquarters Well also needs rehabilitation. Additional wells are necessary to efficiently capture annual yield.

Future work with respect to the aquifer analysis at Fish Springs must include:

- recharge/discharge analysis with emphasis on water level declines and their relation to storativity and aquifer discharge.
- water quality analysis, especially in the vicinity of the Wilson and Ferrel Wells
- delineation of aquifers and boundaries
- well interference effects
- groundwater modelling

This report is only a partial examination of the aquifers and their characteristics at Fish Springs Ranch. The need for additional examination as given above is paramount. It is recommended that the next step is to commence an exploratory drilling program based on geophysical surveys and groundwater modelling. Concurrent work should address water quality concerns.

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APPENDICES

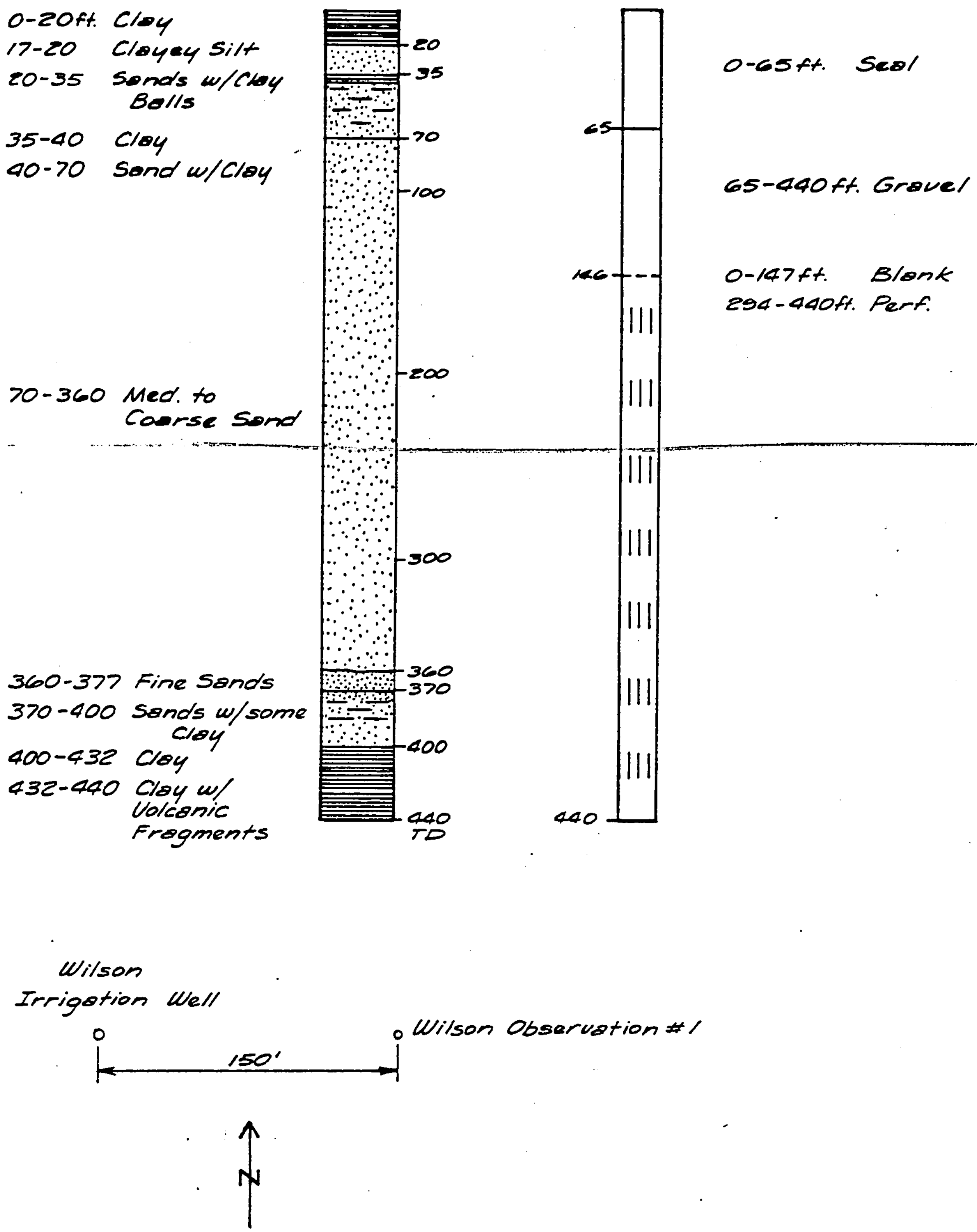

Figure A1. Observation Well #1, lithology and well construction.

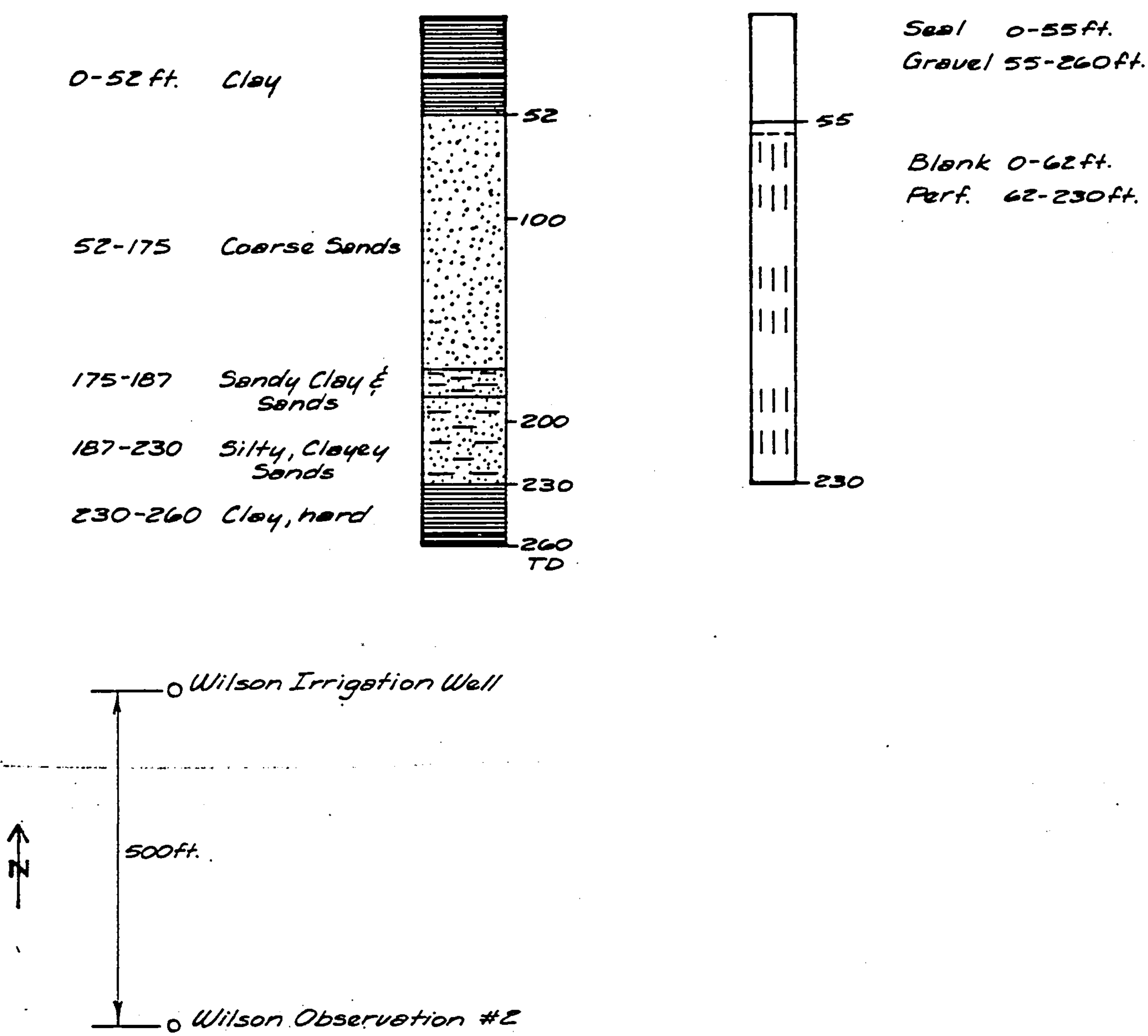

Figure A2. Wilson Observation Well #2, lithology and well construction.

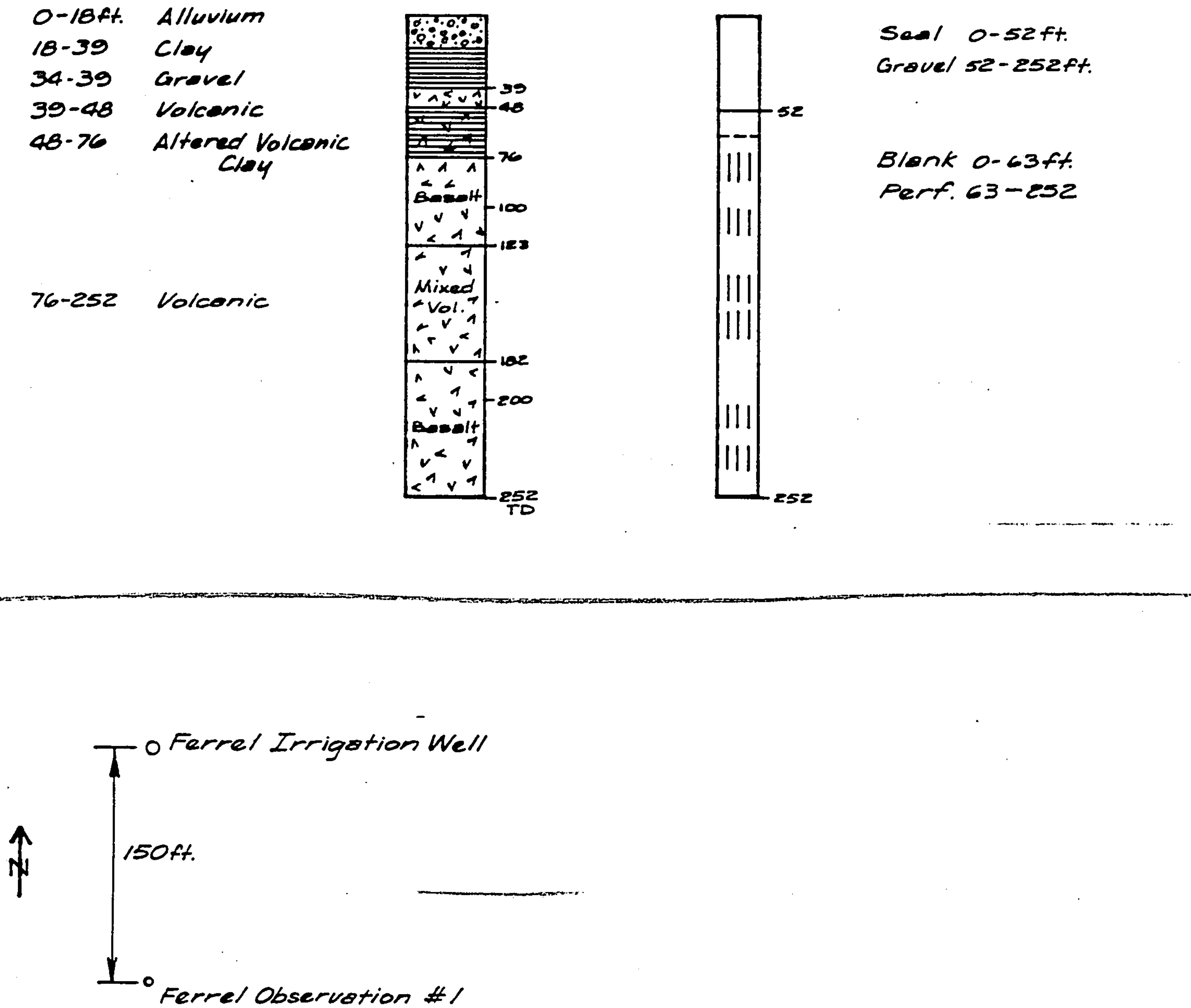

Figure A3. Ferrel Observation Well #1, lithology and well construction.

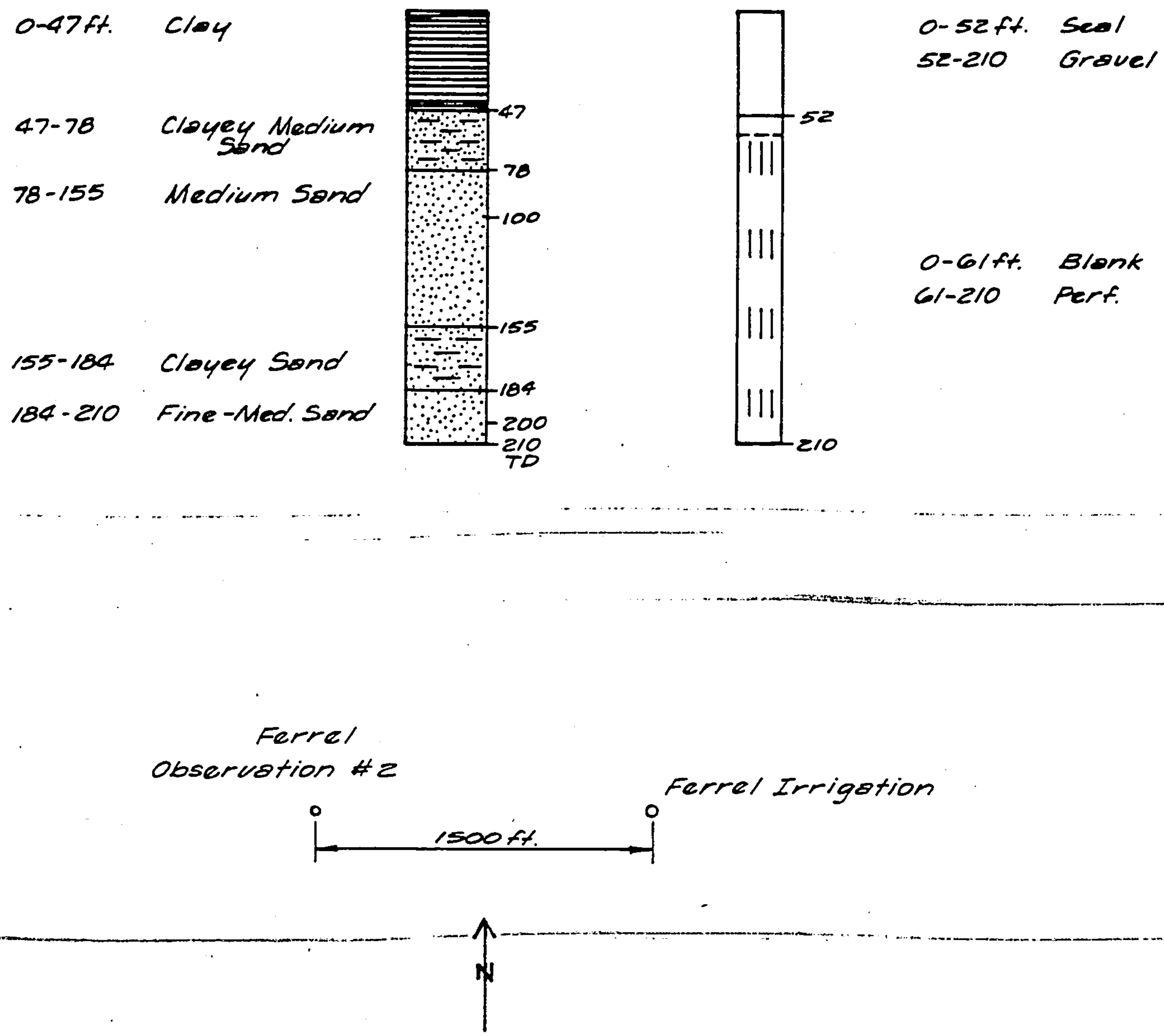

Figure A4. Ferrel Observation Well #2, lithology and well construction.

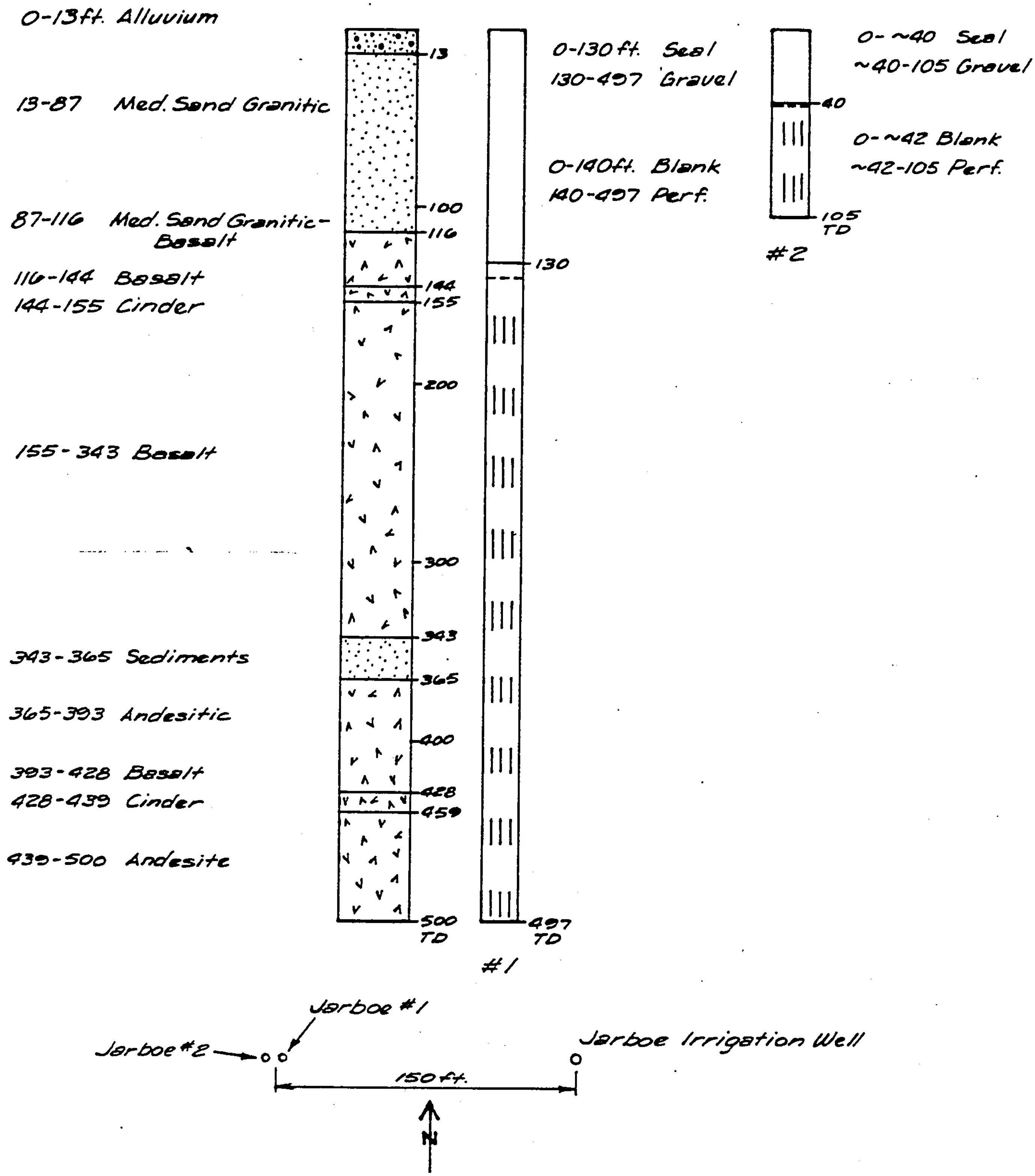

Figure A5. Jarboe Observation Wells #1 & 2, lithology and well construction.

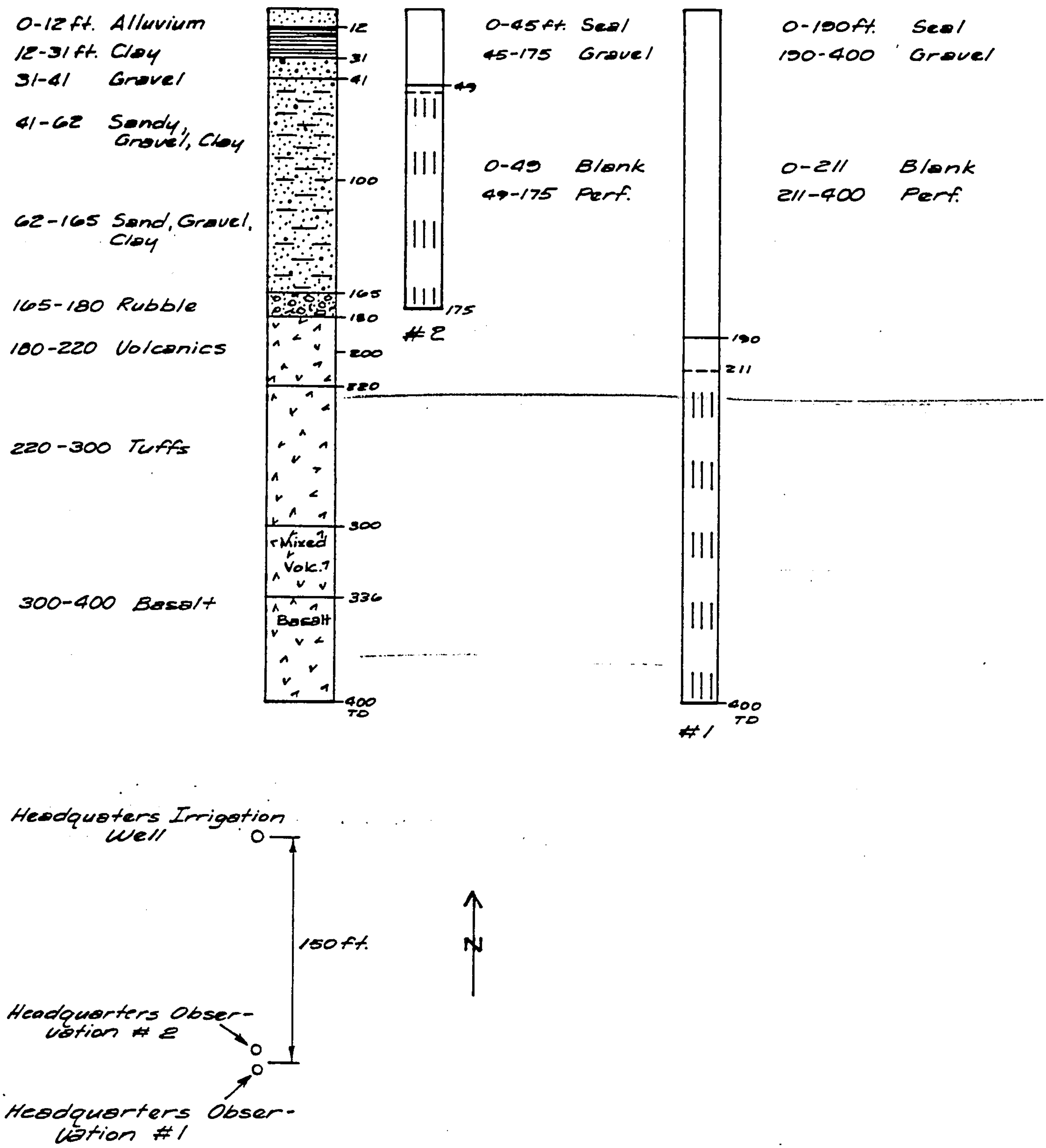

Figure A6. Headquarters Observation Wells #1 & 2, lithology and well construction.

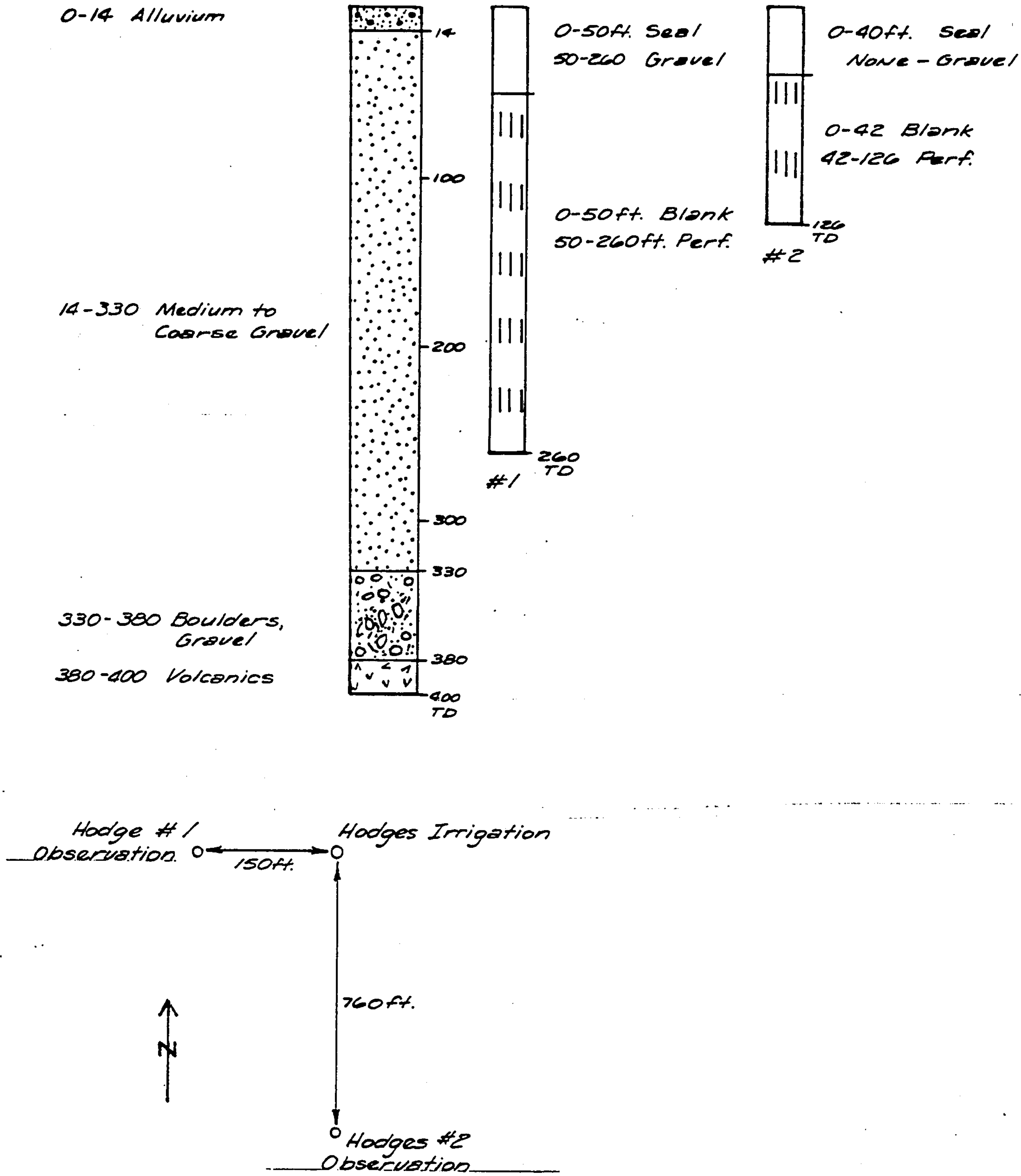

Figure A7. Hodges Observation Wells #1 & 2, lithology and well construction.

SIERRA ENVIRONMENTAL MONITORING

WATER QUALITY ANALYSIS RECORD

PROJECT NAME Washoe County Department of Public Works

J.N. WAS-314

Utilities Division P.O. Box 11130 Reno, Nv 89520

P.O. #91749

SAMPLE IDENTIFICATION			PARAMETER	PARAMETER	PARAMETER	PARAMETER	PARAMETER
Sample Collection Date	Time	Station ID.	pH	Alaklinity Carbonate	Alkalinity Bicarbonate	Total Dissol Solids	Color
MON DAY YR	0-2400		UNITS S.U.	UNITS mg/l $CaCO_3$	UNITS mg/l $CaCO_3$	UNITS mg/l	UNITS C.U.
3-14-89	9:00	Wilson # 4	8.2	∅	92	474	<5
3-15-89	8:30	Wilson # 5	8.2	∅	99	494	<5

Sample Collection Date	Time	Station ID.	Sulfate	Chloride	Nitrate	Fluoride	Sodium
			Units: mg/l	Units: mg/l	Units: mg/l NO_3	Units: mg/l	Units: mg/l
3-14-89	9:00	Wilson # 4	223	20	<0.1	1.1	125
-15-89	8:30	Wilson # 5	240	20	<0.1	1.1	121

Sample Collection Date	Time	Station ID.	Potassium	Calcium	Magnesium	Iron	Manganese
			Units: mg/l	Units: mg/l	Units: mg/l	Units: mg/l	Units: mg/l
3-14-89	9:00	Wilson # 4	3.9	21	1.6	0.04	0.03
-15-89	8:30	Wilson # 5	3.9	21	1.6	0.03	0.02

Sample Collection Date	Time	Station ID.	Arsenic
			Units: mg/l
3-14-89	9:00	Wilson # 4	0.036
-15-89	8:30	Wilson # 5	0.038

SAMPLES BY: Washoe County

ANALYSIS BY: SEM - G.Gross/J.Mantravadi/A.Moos

APPROVED BY: [signature]

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SIERRA ENVIRONMENTAL MONITORING

ATER QUALITY ANALYSIS RECORD

ROJECT NAME Washoe County Department of Public Works

Utilities Division P.O. Box 11130 Reno, Nv 89520

J.N. WAS-314

P.O. # 97149

SAMPLE IDENTIFICATION			PARAMETER	PARAMETER	PARAMETER	PARAMETER	PARAMETER
ample Collection Date	Time	Station ID.	pH	Alkalinity Carbonate	Alkalinity Bicarbonate	Total Dissol Solids	Color
MON DAY YR	0-2400		UNITS S.U.	UNITS mg/l $CaCO_3$	UNITS mg/l $CaCO_3$	UNITS mg/l	UNITS C.U.
3-5-89	10:00	Wilson	8.2	Ø	91	464	<5
3-8-89	13:45	Wilson#2	8.2	Ø	93	429	<5
3-10-89	10:30	Wilson#3	8.2	Ø	91	472	<5

			Sulfate	Chloride	Nitrate	Fluoride	Sodium
			Units: mg/l	Units: mg/l	Units: mg/l NO_3	Units: mg/l	Units: mg/l
3-5-89	10:00	Wilson	217	20	< 0.1	1.0	116
3-8-89	13:45	Wilson#2	223	20	< 0.1	1.0	124
3-10-89	10:30	Wilson#3	227	20	1.1	0.9	120

			Potassium	Calcium	Magnesium	Iron	Manganese
			Units: mg/l	Units: mg/l	Units: mg/l	Units: mg/l	Units: mg/l
3-5-89	10:00	Wilson	3.9	20	1.6	0.04	0.03
3-08-89	13:45	Wilson#2	3.9	21	1.6	0.04	0.03
3-10-89	10:30	Wilson#3	4.0	21	1.6	0.04	0.03

AMPLES BY: Washoe County

NALYSIS BY: SEM - G. Gross/J.Mantravadi/A. Moos

APPROVED BY:

SIERRA ENVIRONMENTAL MONITORING

WATER QUALITY ANALYSIS RECORD

PROJECT NAME
Washoe County Department of Public Works — J.N. WAS-314

Utilities Division P.O. Box 1130 Reno, Nv 89520

P.O. # 97149

SAMPLE IDENTIFICATION			PARAMETER	PARAMETER	PARAMETER	PARAMETER	PARAMETER
Sample Collection Date	Time	Station ID.	Arsenic				
MON DAY YR	0-2400		UNITS mg/l	UNITS	UNITS	UNITS	UNITS
3-5-89	10:00	Wilson	0.038				
-8-89	13:45	Wilson#2	0.041				
3-10-89	10:30	Wilson#3	0.039				

AMPLES BY: Washoe County
N YSIS BY: SEM - G. Gross

APPROVED BY: [signature]

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ROJECT NAME
Washoe County Department of Public Works — J.N. WAS-314

Utilities Division, P.O. Box 11130 Reno, Nv 89520

P.O. #97623

SAMPLE IDENTIFICATION			PARAMETER	PARAMETER	PARAMETER	PARAMETER	PARAMETER
Sample Collection Date	Time	Station ID.	pH	Alkalinity Carbonate	Alkalinity Bicarbonate	Total Dissol Solids	Color
MON DAY YR	0-2400		UNITS S.U.	UNITS mg/l $CaCO_3$	UNITS mg/l $CaCO_3$	UNITS mg/l	UNITS C.U.
3-18-89	10:45	HQ #1	8.4	6	90	204	<5
-24-89	10:50	FishSpgs Ranch	8.4	8	90	202	<5
			Sulfate	Chloride	Nitrate	Fluoride	Sodium
			Units: mg/l	Units: mg/l	Units: mg/l NO_3	Units: mg/l	Units: mg/l
3-18-89	10:45	HO #1	8	7	4.8	0.1	45
-24-89	10:50	FishSpgs Ranch	8	7	4.9	0.1	46
			Potassium	Calcium	Magnesium	Iron	Manganese
			Units: mg/l	Units: mg/l	Units: mg/l	Units: mg/l	Units: mg/l
3-18-89	10:45	HQ #1	7.2	2.7	1.2	< 0.02	<0.02
-24-89	10:50	FishSpgs Ranch	7.3	4	1.3	< 0.02	<0.02
			Arsenic	Interesting!			
			Units: mg/l				
3-18-89	10:45	HW #1	0.005				
-24-89	10:50	FishSpgs Ranch	0.025	After 6 more days of	pumping —		ANOTHER SYMPTOM

AMPLES BY: Washoe County - D. Dragon
NALYSIS BY: SEM - G.Gross/J.Mantravadi/A.Moos

APPROVED BY: [signature]

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ATER QUALITY ANALYSIS RECORD

ROJECT NAME
Washoe County Department of Public Works

Utilities Division, P.O. Box 11130 Reno, Nv 89520

J.N. WAS-314

P.O. #97623

SAMPLE IDENTIFICATION			PARAMETER	PARAMETER	PARAMETER	PARAMETER	PARAMETER
Sample Collection Date	Time	Station ID.	pH	Alkalinity Carbonate	Alkalinity Bicarbonate	Total Dissol Solids	Color
MON DAY YR	0-2400		UNITS S.U.	UNITS mg/l $CaCO_3$	UNITS mg/l $CaCO_3$	UNITS mg/l	UNITS C.U.
3-18-89	10:45	HQ #1	8.4	6	90	204	<5
-24-89	10:50	FishSpgs. Ranch	8.4	8	90	202	< 5
			Sulfate	Chloride	Nitrate	Fluoride	Sodium
			Units: mg/l	Units: mg/l	Units: mg/l NO_3	Units: mg/l	Units: mg/l
3-18-89	10:45	HQ #1	8	7	4.8	0.1	45
-24-89	10:50	FishSpgs. Ranch	8	7	4.9	0.1	46
			Potassium	Calcium	Magnesium	Iron	Manganese
			Units: mg/l	Units: mg/l	Units: mg/l	Units: mg/l	Units: mg/l
3-18-89	10:45	HQ #1	7.2	2.7	1.2	< 0.02	<0.02
-24-89	10:50	FishSpgs. Ranch	7.3	4	1.3	< 0.02	< 0.02
			Arsenic				
			Units: mg/l				
3-18-89	10:45	HW #1	0.005				
24-89	10:50	FishSpgs. Ranch	0.025				

MPLES BY: Washoe County - D. Dragon

AYSIS BY: SEM - G.Gross/J.Mantravadi/A.Moos

APPROVED BY: [signature]

SIERRA ENVIRONMENTAL MONITORING

WATER QUALITY ANALYSIS RECORD

PROJECT NAME
Washoe County Department of Public Works

J.N. WAS-314

Utilities Division P.O. Box 11130 Reno, NV 89520

P.O. #97625

SAMPLE IDENTIFICATION: Sample Collection Date (MON DAY YR)	Time (0-2400)	Station ID.	PARAMETER: pH (UNITS S.U.)	PARAMETER: Alkalinity Carbonate (UNITS mg/l $CaCO_3$)	PARAMETER: Alkalinity Bicarbonate (UNITS mg/l $CaCO_3$)	PARAMETER: Total Dissol Solids (UNITS mg/l)	PARAMETER: Color (UNITS C.U.)
3-30-89	12:08	Ferrel #1	8.5	10	105	235	<5
4-[illegible]8-89	07:30	Ferrel Well	8.5	4	113	232	<5

Date	Time	Station ID.	Sulfate (Units: mg/l)	Chloride (Units: mg/l)	Nitrate (Units: mg/l NO_3)	Fluoride (Units: mg/l)	Sodium (Units: mg/l)
3-30-89	12:08	Ferrel #1	16	17	5.1	0.3	61
4-[illegible]8-89	07:30	Ferrel Well	17	17	5.2	0.3	63

Date	Time	Station ID.	Potassium (Units: mg/l)	Calcium (Units: mg/l)	Magnesium (Units: mg/l)	Iron (Units: mg/l)	Manganese (Units: mg/l)
3-30-89	12:08	Ferrel #1	5.8	5.5	1.4	< 0.02	< 0.02
4-[illegible]-89	07:30	Ferrel Well	5.8	5.7	1.4	0.07	< 0.02

Date	Time	Station ID.	Arsenic (Units: mg/l)	Lead (Units: mg/l)	Silver (Units: mg/l)	Chromium (Units: mg/l)	Cadmium (Units: mg/l)
3-30-89	12:08	Ferrel #1	0.010	< 0.05	< 0.02	< 0.02	< 0.01
[illegible]-89	07:30	Ferrel Well	0.011	< 0.05	< 0.02	< 0.02	< 0.01

SAMPLES BY: Washoe County - D. Dragon

ANALYSIS BY: SEM - G. Gross/A. Moos/J. Mantravadi

APPROVED BY: [signature]

SIERRA ENVIRONMENTAL MONITORING

WATER QUALITY ANALYSIS RECORD

PROJECT NAME Washoe County Department of Public Works

Utilities Division P.O. Box 11130 Reno, NV 89520

J.N. WAS-314

P.O. #97624

SAMPLE IDENTIFICATION			PARAMETER	PARAMETER	PARAMETER	PARAMETER	PARAMETER
Sample Collection Date	Time	Station ID.	Copper	Zinc	Barium	Mercury	Selenium
MON DAY YR	0-2400		UNITS mg/l	UNITS mg/l	UNITS mg/l	UNITS mg/l	UNITS mg/l
3-30-89	12:08	Ferrel #1	<0.02	0.01	<0.4	<0.0005	<0.005
[illegible]8-89	07:30	Ferrel Well	<0.02	0.01	<0.4	<0.0005	*

* - Result to Follow

SAMPLES BY: Washoe County - D. Dragon

ANALYSIS BY: SEM - G. Gross

APPROVED BY: [signature]

SIERRA ENVIRONMENTAL MONITORING

RECEIVED MAY 1989 WASHOE COUNTY UTILITY DIVISION

WATER QUALITY ANALYSIS RECORD

PROJECT NAME
Washoe County Department of Public Works
Utilities Division P.O. Box 11130 Reno, NV 89520

J.N. WAS-314

P.O. #98127

SAMPLE IDENTIFICATION			PARAMETER	PARAMETER	PARAMETER	PARAMETER	PARAMETER
Sample Collection Date	Time	Station ID.	pH	Alkalinity Carbonate	Alkalinity Bicarbonate	Total Dissol Solids	Color
MON DAY YR	0-2400		UNITS S.U.	UNITS mg/l $CaCO_3$	UNITS mg/l $CaCO_3$	UNITS mg/l	UNITS C.U.
4-14-89	12:30	Jarboe #1	8.3	Ø	89	169	< 5
4-20-89	09:30	Jarboe	8.3	Ø	90	162	< 5
4-23-89	09:00	Hodges Prod.Well	8.1	Ø	107	191	< 5
			Sulfate	Chloride	Nitrate	Fluoride	Sodium
			Units: mg/l	Units: mg/l	Units: mg/l NO_3	Units: mg/l	Units: mg/l
4-14-89	12:30	Jarboe #1	7	8	4.9	0.1	24.9
4-20-89	09:30	Jarboe	6	8	5.0	0.1	24.9
4-23-89	09:00	Hodges ProdWell	6	7	3.1	0.1	38.9
			Potassium	Calcium	Magnesium	Iron	Manganese
			Units: mg/l	Units: mg/l	Units: mg/l	Units: mg/l	Units: mg/l
4-14-89	12:30	Jarboe #1	6.4	14.4	4.2	< 0.02	< 0.02
4-20-89	09:30	Jarboe	6.5	12.8	4.1	< 0.02	< 0.02
4-23-89	09:00	Hodges ProdWell	8.6	9.5	3.4	< 0.02	< 0.02

SAMPLES BY: Washoe County

ANALYSIS BY: SEM - G. Gross/S. Poole/A.M. Moos

APPROVED BY: [signature]

SIERRA ENVIRONMENTAL MONITORING

WATER QUALITY ANALYSIS RECORD

PROJECT NAME

Washoe County Department of Public Works

Utilities Division P.O. Box 1130 Reno, NV 89520

J.N. WAS-314

SAMPLE IDENTIFICATION			PARAMETER	PARAMETER	PARAMETER	PARAMETER	PARAMETER
Sample Collection Date	Time	Station ID.	Arsenic				
MON DAY YR	0-2400		UNITS mg/l	UNITS	UNITS	UNITS	UNITS
4-14-89	12:30	Jarboe #1	<0.003				
4-20-89	09:30	Jarboe	<0.003				
4-23-89	09:00	Hodges ProdWell	<0.003				

SAMPLES BY: Washoe County

ANALYSIS BY: SEM - G. Gross

APPROVED BY: [signature]

SIERRA ENVIRONMENTAL MONITORING

WATER QUALITY ANALYSIS RECORD

PROJECT NAME Washoe County Department of Public Works | J.N. WAS-314

Utilities Division P.O. Box 11130 Reno, NV 89520

P.O. #98395

SAMPLE IDENTIFICATION			PARAMETER	PARAMETER	PARAMETER	PARAMETER	PARAMETER
Sample Collection Date	Time	Station ID.	pH	Alkalinity Carbonate	Alkalinity Bicarbonate	Total Dissol Solids	Color
MON DAY YR	0-2400		UNITS S.U.	UNITS mg/l $CaCO_3$	UNITS mg/l $CaCO_3$	UNITS mg/l	UNITS C.U.
5-1-89	15:00	Hodges #2	7.8	0	110	209	< 5
			Sulfate	Chloride	Nitrate	Fluoride	Sodium
			Units: mg/l	Units: mg/l	Units: mg/l NO_3	Units: mg/l	Units: mg/l
5-1-89	15:00	Hodges #2	6	6	3.5	0.1	36.1
			Potassium	Calcium	Magnesium	Iron	Manganese
			Units: mg/l	Units: mg/l	Units: mg/l	Units: mg/l	Units: mg/l
5-1-89	15:00	Hodges #2	8.1	10	3.7	< 0.02	< 0.02
			Arsenic				
			Units: mg/l				
5-1-89	15:00	Hodges #2	< 0.003				

SAMPLES BY: Washoe County

ANALYSIS BY: SEM - G. Gross/A.M. Moos/S. Poole

APPROVED BY: [signature]

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety

OFFICE USE ONLY
Log No.
Permit No.
Basin.

PRINT OR TYPE ONLY

NOTICE OF INTENT NO. 11840

1. OWNER WASHOE CO.
MAILING ADDRESS P.O. BOX 11130
RENO NV. 89520

ADDRESS AT WELL LOCATION 150' EAST of Irrigation well

2. LOCATION NW 1/4 SE 1/4 Sec. 26 T. 26 N/S R. 18 E WASHOE County
PERMIT NO. 49268-49269 Issued by Water Resources | Parcel No. | Wilson EAST Subdivision Name

3. TYPE OF WORK
New Well ☒ Recondition ☐ Deepen ☐ Other ☐

4. PROPOSED USE OBSERVATION
Domestic ☐ Irrigation ☐ Test ☒ Municipal ☐ Industrial ☐ Stock ☐

5. TYPE WELL
Cable ☐ Rotary ☒ Other ☐

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Clay		0	20	20
Sand with clay		20	35	15
Clay		35	40	5
Sand with clay		40	70	30
Med To Coarse Sand		70	360	290
Fine Sand		360	377	17
Sand with clay		370	400	30
Clay		400	432	32
Clay with some Volcanic cuttings		432	440	8

Date started FEB 27, 19 89
Date completed 4-18-, 19 89

7. WELL TEST DATA

Pump RPM	G.P.M.	Draw Down	After Hours Pump
Air Lift.		NO SPM.	

BAILER TEST
G.P.M. .... Draw down .... feet .... hours
G.P.M. .... Draw down .... feet .... hours
G.P.M. .... Draw down .... feet .... hours

8. WELL CONSTRUCTION
Diameter 6 3/4 inches Total depth 440 feet
.... inches
.... inches
Casing record 2" gALV. A 120
Weight per foot .... Thickness ....

Diameter	From	To
2 inches	+ 2 feet	440' feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet

Surface seal: Yes ☒ No ☐ Type CEMENT
Depth of seal 65 feet
Gravel packed: Yes ☒ No ☐
Gravel packed from 65 feet to 440 feet

Perforations:
Type perforation mill cuts.
Size perforation 1/8 x 2 1/2
From 146 feet to 440 feet
From .... feet to .... feet
From .... feet to .... feet
From .... feet to .... feet
From .... feet to .... feet

9. WATER LEVEL
Static water level 28.53 feet below land surface
Flow .... G.P.M. .... P.S.I.
Water temperature cool °F Quality O.K.

10. DRILLER'S CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.
Name OASIS Drilling Inc. Contractor
Address P.O. BOX 21421 CARSON City NV. Contractor
Nevada contractor's license number issued by the State Contractor's Board 0023129
Nevada contractor's driller's number issued by the Division of Water Resources ....
Nevada driller's license number issued by the Division of Water Resources, the on-site driller 1539
Signed [signature] By driller performing actual drilling on site or contractor
Date June 30, 1989

(Rev. 11-85) USE ADDITIONAL SHEETS IF NECESSARY (O)-627

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety

OFFICE USE ONLY
Log No.
Permit No.
Basin

PRINT OR TYPE ONLY

NOTICE OF INTENT NO. 11840

1. OWNER WASHOE CO.
MAILING ADDRESS PO. BOX 11130 RENO NV. 89520

ADDRESS AT WELL LOCATION 500' South of Irrigation well

2. LOCATION NW 1/4 SE 1/4 Sec. 26 T. 26 N/S R. 18 E WASHOE County
PERMIT NO. 49268-49269
Issued by Water Resources
Parcel No.
Wilson South Subdivision Name

3. TYPE OF WORK
New Well ☒ Recondition ☐
Deepen ☐ Other ☐

4. PROPOSED USE OBSERVATION
Domestic ☐ Irrigation ☐ Test ☒
Municipal ☐ Industrial ☐ Stock ☐

5. TYPE WELL
Cable ☐ Rotary ☒
Other ☐

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Clay		0	52	52
Coarse Sand		52	175	123
Sandy Clay & Sand		175	187	12
Silty Clayey Sands		187	230	43
Hard Clay		230	260	30

Date started FEB 27 , 1989
Date completed 4 18 , 1989

7. WELL TEST DATA

Pump RPM	G.P.M.	Draw Down	After Hours Pump
AIR Lift	10 GPM		

BAILER TEST
G.P.M. .... Draw down .... feet .... hours
G.P.M. .... Draw down .... feet .... hours
G.P.M. .... Draw down .... feet .... hours

8. WELL CONSTRUCTION
Diameter 6 3/4 inches Total depth 260 feet
.... inches
.... inches
Casing record 2" GALV. A120
Weight per foot .... Thickness ....

Diameter	From	To
[redacted] inches	[redacted] feet	[redacted] feet
2 inches	+2 feet	230 feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet

Surface seal: Yes ☒ No ☐ Type Cement
Depth of seal 55 feet
Gravel packed: Yes ☒ No ☐
Gravel packed from 55 feet to 260 feet

Perforations:
Type perforation mill cuts
Size perforation 1/8 x 2 1/2
From 62 feet to 230 feet
From .... feet to .... feet
From .... feet to .... feet
From .... feet to .... feet
From .... feet to .... feet

9. WATER LEVEL
Static water level 33.25 feet below land surface
Flow .... G.P.M. .... P.S.I.
Water temperature Cool °F Quality OK.

10. DRILLER'S CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.
Name OASIS DRILLING INC.
Contractor
Address PO. BOX 21421 CARSON City NV.
Contractor
Nevada contractor's license number issued by the State Contractor's Board 0023129
Nevada contractor's driller's number issued by the Division of Water Resources ....
Nevada driller's license number issued by the Division of Water Resources, the on-site driller 1539
Signed [signature]
By driller performing actual drilling on site or contractor
Date June 30, 1989

(Rev. 11-85) USE ADDITIONAL SHEETS IF NECESSARY (O)-627

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety

OFFICE USE ONLY
Log No.
Permit No.
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PRINT OR TYPE ONLY

NOTICE OF INTENT NO. 10377

1. OWNER Washoe Co.
MAILING ADDRESS PO Box 11130
Reno NV. 89520

ADDRESS AT WELL LOCATION 150 South of Irrigation well

2. LOCATION NW ¼ NW ¼ Sec. 29 T. 26 N/S R. 19 E Washoe County
PERMIT NO. 48380(1)(2)(3) Issued by Water Resources | Parcel No. | HQ #1 Subdivision Name

3. TYPE OF WORK
New Well ☒ Recondition ☐
Deepen ☐ Other ☐

4. PROPOSED USE OBSERVATION
Domestic ☐ Irrigation ☐ Test ☒
Municipal ☐ Industrial ☐ Stock ☐

5. TYPE WELL
Cable ☐ Rotary ☒
Other ☐

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Alluvium		0	12	12
Clay		12	31	19
gravel		31	41	10
Sand & gravel with clay		41	62	21
Sand gravel & clay		62	165	103
Rubble		165	180	15
volc.		180	220	40
Tuffs		220	300	80
basalt.		300	400	100

Date started FEB 27, 19 89
Date completed 4 18, 19 89

7. WELL TEST DATA

Pump RPM	G.P.M.	Draw Down	After Hours Pump
AIR Lift 10+ GPM			

BAILER TEST

G.P.M. ______ Draw down ______ feet ______ hours
G.P.M. ______ Draw down ______ feet ______ hours
G.P.M. ______ Draw down ______ feet ______ hours

8. WELL CONSTRUCTION

Diameter 6 3/4 inches Total depth 400 feet
______ inches
______ inches
Casing record 2" galv. A120
Weight per foot ______ Thickness ______

Diameter	From	To
2 inches	+2 feet	400 feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet

Surface seal: Yes ☒ No ☐ Type Cement
Depth of seal 190 feet
Gravel packed: Yes ☒ No ☐
Gravel packed from 190 feet to 400 feet

Perforations:
Type perforation mill cuts
Size perforation 1/8 x 2½
From 211 feet to 400 feet
From ______ feet to ______ feet
From ______ feet to ______ feet
From ______ feet to ______ feet
From ______ feet to ______ feet

9. WATER LEVEL

Static water level 36.19 feet below land surface
Flow ______ G.P.M. ______ P.S.I.
Water temperature cool °F Quality ok

10. DRILLER'S CERTIFICATION

This well was drilled under my supervision and the report is true to the best of my knowledge.

Name OASIS Drilling Inc. (Contractor)
Address PO. Box 21421 Carson City NV. (Contractor)
Nevada contractor's license number issued by the State Contractor's Board ______
Nevada contractor's driller's number issued by the Division of Water Resources 0023129
Nevada driller's license number issued by the Division of Water Resources, the on-site driller 1539
Signed T. Amer
By driller performing actual drilling on site or contractor
Date Jun 30 1989

(Rev. 11-85)

USE ADDITIONAL SHEETS IF NECESSARY

(O)-627

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety

PRINT OR TYPE ONLY

OFFICE USE ONLY
Log No. ______
Permit No. ______
Basin ______

NOTICE OF INTENT NO. 10377

1. OWNER Washoe Co.
MAILING ADDRESS Po. Box 11130 Reno NV. 89520

ADDRESS AT WELL LOCATION 150' South of Irrigation well

2. LOCATION NW ¼ NW ¼ Sec. 29 T. 26 N/S R. 19 E Washoe County
PERMIT NO. 48380(11O)(3) (Issued by Water Resources) | Parcel No. | HQ #2 Subdivision Name

3. TYPE OF WORK
New Well ☒ Recondition ☐
Deepen ☐ Other ☐

4. PROPOSED USE OBSERVATION
Domestic ☐ Irrigation ☐ Test ☒
Municipal ☐ Industrial ☐ Stock ☐

5. TYPE WELL
Cable ☐ Rotary ☒
Other ☐

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Alluvium		0	12	12
Clay		12	31	19
gravel		31	41	10
Sand gravel clay		41	62	21
" " "		62	165	103
Rock		165	175	10

Date started Feb 22, 1989
Date completed 4-18-, 1989

7. WELL TEST DATA

Pump RPM	G.P.M.	Draw Down	After Hours Pump
AIR Lift	10 GPM		

BAILER TEST

G.P.M. ______ Draw down ______ feet ______ hours
G.P.M. ______ Draw down ______ feet ______ hours
G.P.M. ______ Draw down ______ feet ______ hours

8. WELL CONSTRUCTION
Diameter 6 3/4 inches Total depth 175 feet
______ inches
______ inches
Casing record 2" galv. 14120
Weight per foot ______ Thickness ______

Diameter	From	To
2" inches	+2 feet	175 feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet

Surface seal: Yes ☒ No ☐ Type Cement
Depth of seal 45 feet
Gravel packed: Yes ☒ No ☐
Gravel packed from 45 feet to 175 feet

Perforations:
Type perforation mill cuts
Size perforation 1/8 x 2 1/2
From 49 feet to 175 feet
From ______ feet to ______ feet
From ______ feet to ______ feet
From ______ feet to ______ feet
From ______ feet to ______ feet

9. WATER LEVEL
Static water level 34.77 feet below land surface
Flow ______ G.P.M. ______ P.S.I.
Water temperature 60.1 °F Quality ______

10. DRILLER'S CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.
Name Oasis Drilling Inc. (Contractor)
Address P.O. Box 21421 Carson City NV. (Contractor)
Nevada contractor's license number issued by the State Contractor's Board 0023129
Nevada contractor's driller's number issued by the Division of Water Resources ______
Nevada driller's license number issued by the Division of Water Resources, the on-site driller 1539
Signed T. [illegible] (By driller performing actual drilling on site or contractor)
Date June 30 1989

(Rev. 11-85) USE ADDITIONAL SHEETS IF NECESSARY (01-627

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety

OFFICE USE ONLY
Log No.
Permit No.
Basin

PRINT OR TYPE ONLY

NOTICE OF INTENT NO. 11841

1. OWNER Washoe Co.
MAILING ADDRESS Po Box 11130 Reno NV 89520

ADDRESS AT WELL LOCATION 150 South of Irrigation well

2. LOCATION NE ¼ SW ¼ Sec. 25 T. 26 N/S R. 18 E. Washoe County
PERMIT NO. (49373) (49376) (49378) Issued by Water Resources — Parcel No. — Ferrel South Subdivision Name

3. TYPE OF WORK
New Well ☒ Recondition ☐
Deepen ☐ Other ☐

4. PROPOSED USE OBSERVATION
Domestic ☐ Irrigation ☐ Test ☒
Municipal ☐ Industrial ☐ Stock ☐

5. TYPE WELL
Cable ☐ Rotary ☒
Other ☐

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Alluvium		0	18	18
Clay		18	39	21
volcanic clay		39	48	9
Altered volcanic clay		48	76	28
volcanic rock		76	252	176

Date started Feb 22, 1989
Date completed 4-18-, 1989

8. WELL CONSTRUCTION
Diameter 6¾ inches Total depth 252 feet
.......inches
.......inches
Casing record 2 gal. A120
Weight per foot .... Thickness ....

Diameter	From	To
2 inches	+2 feet	252 feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet

Surface seal: Yes ☒ No ☐ Type Cement
Depth of seal 52' feet
Gravel packed: Yes ☒ No ☐
Gravel packed from 52 feet to 252 feet

Perforations:
Type perforation mill cuts
Size perforation ⅛ x 2½
From 63 feet to 252 feet
From .... feet to .... feet
From .... feet to .... feet
From .... feet to .... feet
From .... feet to .... feet

9. WATER LEVEL
Static water level 18.06 feet below land surface
Flow .... G.P.M. .... P.S.I.
Water temperature Cool °F Quality ok

7. WELL TEST DATA

Pump RPM	G.P.M.	Draw Down	After Hours Pump
Air	Lift	30 GPM	

BAILER TEST
G.P.M. .... Draw down .... feet .... hours
G.P.M. .... Draw down .... feet .... hours
G.P.M. .... Draw down .... feet .... hours

10. DRILLER'S CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.
Name Oasis Drilling Inc. (Contractor)
Address Po Box 21471 Carson City NV. (Contractor)
Nevada contractor's license number issued by the State Contractor's Board 0023129
Nevada contractor's driller's number issued by the Division of Water Resources ....
Nevada driller's license number issued by the Division of Water Resources, the on-site driller 1539
Signed [signature]
By driller performing actual drilling on site or contractor
Date June 30, 1989

(Rev. 11-85) USE ADDITIONAL SHEETS IF NECESSARY (O)-627

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety

OFFICE USE ONLY
Log No.
Permit No.
Basin

PRINT OR TYPE ONLY

NOTICE OF INTENT NO. 11841

1. OWNER Washoe Co.
MAILING ADDRESS P.O. Box 11130 Reno NV. 89520

ADDRESS AT WELL LOCATION 1500' West of Irrigation

2. LOCATION NE ¼ SW ¼ Sec. 25 T. 26 N/S R. 18 E. Washoe County
PERMIT NO. 49323-49326-49328 (Issued by Water Resources) Parcel No. Ferrel West (Subdivision Name)

3. TYPE OF WORK
New Well ☒ Recondition ☐ Deepen ☐ Other ☐

4. PROPOSED USE Observation
Domestic ☐ Irrigation ☐ Test ☒ Municipal ☐ Industrial ☐ Stock ☐

5. TYPE WELL
Cable ☐ Rotary ☒ Other ☐

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Clay		0	47	47
Clayey med sand		47	78	31
Med sand		78	155	63
Clayey sand		155	184	29
fine med sand		184	210	26

Date started Feb 27, 1989
Date completed 4-18-, 1989

7. WELL TEST DATA

Pump RPM	G.P.M.	Draw Down	After Hours Pump
10	GPM	Air Lift	

BAILER TEST
G.P.M. .... Draw down .... feet .... hours
G.P.M. .... Draw down .... feet .... hours
G.P.M. .... Draw down .... feet .... hours

8. WELL CONSTRUCTION
Diameter 6 3/4 inches Total depth 210 feet
.... inches
.... inches
Casing record 2 gals. A120
Weight per foot .... Thickness ....

Diameter	From	To
2 inches	+ 2 feet	210 feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet

Surface seal: Yes ☒ No ☐ Type Cement
Depth of seal 52 feet
Gravel packed: Yes ☒ No ☐
Gravel packed from 61 feet to 210 feet

Perforations:
Type perforation mill cuts
Size perforation 1/8 x 2 1/2
From 61 feet to 210 feet
From .... feet to .... feet
From .... feet to .... feet
From .... feet to .... feet
From .... feet to .... feet

9. WATER LEVEL
Static water level 24.65 feet below land surface
Flow .... G.P.M. .... P.S.I.
Water temperature 60 °F Quality OK

10. DRILLER'S CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.
Name Oasis Drilling Inc. (Contractor)
Address P.O. 21421 Carson City NV. 89721 (Contractor)
Nevada contractor's license number issued by the State Contractor's Board 0023129
Nevada contractor's driller's number issued by the Division of Water Resources
Nevada driller's license number issued by the Division of Water Resources, the on-site driller 1539
Signed .... By driller performing actual drilling on site or contractor
Date June 30 1989

(Rev. 11-85) USE ADDITIONAL SHEETS IF NECESSARY (O)-627

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety

OFFICE USE ONLY
Log No.
Permit No.
Basin

PRINT OR TYPE ONLY

NOTICE OF INTENT NO. 10374

1. OWNER WAShoe Co.
MAILING ADDRESS P.O. Box 11130 Reno NV. 89520

ADDRESS AT WELL LOCATION 150 West of Irrigation Well

2. LOCATION SE ¼ SE ¼ Sec. 30 T. 26 N/S R. 19 E. WAShoe County

PERMIT NO. 48380 48381 (Issued by Water Resources) | Parcel No. | Jarboe #1 (Subdivision Name)

3. TYPE OF WORK
New Well ☒ Recondition ☐
Deepen ☐ Other ☐

4. PROPOSED USE Observation
Domestic ☐ Irrigation ☐ Test ☒
Municipal ☐ Industrial ☐ Stock ☐

5. TYPE WELL
Cable ☐ Rotary ☒
Other ☐

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Alluvium		0	13	13
med sand granitic		13	87	74
med sand granitic basalt		87	116	29
basalt		116	144	28
Cinders.		144	155	11
basalt		155	343	188
Sediments		343	365	22
Andesite		365	393	28
basalt		393	428	35
Cinders		428	439	11
Andesite		439	500	61

Date started FEB 27, 1989
Date completed 4 18, 1989

7. WELL TEST DATA

Pump RPM	G.P.M.	Draw Down	After Hours Pump
AIR	Lift	20 GPM.	

BAILER TEST
G.P.M. ____ Draw down ____ feet ____ hours
G.P.M. ____ Draw down ____ feet ____ hours
G.P.M. ____ Draw down ____ feet ____ hours

8. WELL CONSTRUCTION
Diameter 6 3/4 inches Total depth 500 feet
____ inches
____ inches
Casing record 2" gal. A120
Weight per foot ____ Thickness ____

Diameter	From	To
2 inches	+2 feet	497 feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet

Surface seal: Yes ☒ No ☐ Type Cement
Depth of seal 130 feet
Gravel packed: Yes ☒ No ☐
Gravel packed from 130 feet to 497 feet

Perforations:
Type perforation mill cuts
Size perforation 1/8 x 2½
From 140 feet to 497 feet
From ____ feet to ____ feet
From ____ feet to ____ feet
From ____ feet to ____ feet
From ____ feet to ____ feet

9. WATER LEVEL
Static water level 52.01 feet below land surface
Flow ____ G.P.M. ____ P.S.I.
Water temperature Cool °F Quality OK.

10. DRILLER'S CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.
Name OASIS DRILLING INC. (Contractor)
Address P.O. Box 21421 Carson City NV. (Contractor)
Nevada contractor's license number issued by the State Contractor's Board 0023129
Nevada contractor's driller's number issued by the Division of Water Resources ____
Nevada driller's license number issued by the Division of Water Resources, the on-site driller 1539
Signed T. Amsler (By driller performing actual drilling on site or contractor)
Date June 20 1989

(Rev. 11-85) USE ADDITIONAL SHEETS IF NECESSARY (O)-627

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety

OFFICE USE ONLY
Log No.
Permit No.
Basin

PRINT OR TYPE ONLY

NOTICE OF INTENT NO. 10374

1. OWNER WASHOE CO.
MAILING ADDRESS PO Box 11130 RENO NV 89520

ADDRESS AT WELL LOCATION 150' WEST of Irrigation Well

2. LOCATION SE 1/4 SE 1/4 Sec. 30 T. 26 N/S R. 19 E. WASHOE County
PERMIT NO. 48380 48381 (Issued by Water Resources) Parcel No. Jarboe #2 Subdivision Name

3. TYPE OF WORK
New Well ☒ Recondition ☐
Deepen ☐ Other ☐

4. PROPOSED USE OBSERVATION
Domestic ☐ Irrigation ☐ Test ☒
Municipal ☐ Industrial ☐ Stock ☐

5. TYPE WELL
Cable ☐ Rotary ☒
Other ☐

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Alluvium		0	13	13
med sand granitic		13	87	74
med sand " and basalt.		87	105	18

Date started FEB 27, 1989
Date completed 4-18, 1988

7. WELL TEST DATA

Pump RPM	G.P.M.	Draw Down	After Hours Pump
AIR LIFT	10 GPM		

BAILER TEST
G.P.M. Draw down feet hours
G.P.M. Draw down feet hours
G.P.M. Draw down feet hours

8. WELL CONSTRUCTION
Diameter 6 3/4 inches Total depth 105 feet
inches
inches
Casing record 2" galv. A120
Weight per foot Thickness

Diameter	From	To
2 inches	+2 feet	105 feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet

Surface seal: Yes ☒ No ☐ Type Cement
Depth of seal 40 feet
Gravel packed: Yes ☒ No ☐
Gravel packed from 40 feet to 105 feet

Perforations:
Type perforation mill cuts.
Size perforation 8 x 2½
From 40 feet to 105 feet
From feet to feet
From feet to feet
From feet to feet
From feet to feet

9. WATER LEVEL
Static water level 48.55 feet below land surface
Flow G.P.M. P.S.I.
Water temperature Cool °F Quality OK

10. DRILLER'S CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.
Name OASIS DRILLING INC. (Contractor)
Address PO BOX 21421 CARSON City NV. (Contractor)
Nevada contractor's license number issued by the State Contractor's Board 0023129
Nevada contractor's driller's number issued by the Division of Water Resources
Nevada driller's license number issued by the Division of Water Resources, the on-site driller 1539
Signed L. Amger
By driller performing actual drilling on site or contractor
Date JUNE 30, 1989

(Rev. 11-85) USE ADDITIONAL SHEETS IF NECESSARY (O)-627

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety

OFFICE USE ONLY
Log No.
Permit No.
Basin

PRINT OR TYPE ONLY

NOTICE OF INTENT NO. 10375

1. OWNER Washoe Co.
MAILING ADDRESS P.O. Box 11130
Reno NV 89520

ADDRESS AT WELL LOCATION 150' South West of Irrigation Well

2. LOCATION SW ¼ SW ¼ Sec. 10 T. 26 N/S R. 19 E Washoe County

PERMIT NO. 39899-45024 (Issued by Water Resources) Parcel No. Subdivision Name Teri Hodges EAST

3. TYPE OF WORK
New Well [X] Recondition [ ]
Deepen [ ] Other [ ]

4. PROPOSED USE OBSERVATION
Domestic [ ] Irrigation [ ] Test [X]
Municipal [ ] Industrial [ ] Stock [ ]

5. TYPE WELL
Cable [ ] Rotary [X]
Other [ ]

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Alluvium		0	14	14
Med To Corse gravel		14	260	246

Date started Feb 07, 1989
Date completed 4-18, 1989

7. WELL TEST DATA

Pump RPM	G.P.M.	Draw Down	After Hours Pump
Air Lift 10 GPM			

BAILER TEST
G.P.M. .... Draw down .... feet .... hours
G.P.M. .... Draw down .... feet .... hours
G.P.M. .... Draw down .... feet .... hours

8. WELL CONSTRUCTION
Diameter 6 3/4 inches Total depth 260 feet
.... inches
.... inches
Casing record 2" galv A120
Weight per foot .... Thickness ....

Diameter	From	To
2 inches	+2 feet	260 feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet

Surface seal: Yes [X] No [ ] Type CEMENT
Depth of seal 50 feet
Gravel packed: Yes [X] No [ ]
Gravel packed from 50 feet to 260 feet

Perforations:
Type perforation mill cuts
Size perforation 1/8 x 2½
From 50 feet to 260 feet
From .... feet to .... feet
From .... feet to .... feet
From .... feet to .... feet
From .... feet to .... feet

9. WATER LEVEL
Static water level 52.01 feet below land surface
Flow .... G.P.M. .... P.S.I.
Water temperature Cool °F Quality OK

10. DRILLER'S CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.
Name OASIS DRILLING INC. (Contractor)
Address P.O. Box 21421 Carson City NV (Contractor)
Nevada contractor's license number issued by the State Contractor's Board 0023129
Nevada contractor's driller's number issued by the Division of Water Resources
Nevada driller's license number issued by the Division of Water Resources, the on-site driller 1539
Signed T. [signature] By driller performing actual drilling on site or contractor
Date June 30 1989

(Rev. 11-85) USE ADDITIONAL SHEETS IF NECESSARY (O)-627

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety

OFFICE USE ONLY
Log No.
Permit No.
Basin

PRINT OR TYPE ONLY

NOTICE OF INTENT NO. 10325

1. OWNER WASHOE CO.
MAILING ADDRESS P.O. BOX 11130 RENO NV. 89520

ADDRESS AT WELL LOCATION 770 South of Irrigation Well

2. LOCATION SW ¼ SW ¼ Sec. 10 T. 26 N/S R. 19 E WASHOE County
PERMIT NO. 39899-45024 (Issued by Water Resources) Parcel No. Hodges South (Subdivision Name)

3. TYPE OF WORK: New Well [X] Recondition [ ] Deepen [ ] Other [ ]

4. PROPOSED USE OBSERVATION: Domestic [ ] Irrigation [ ] Test [X] Municipal [ ] Industrial [ ] Stock [ ]

5. TYPE WELL: Cable [ ] Rotary [X] Other [ ]

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Alluvium		0	14	14
med to coarse gravel		14	330	316
Bolders & gravel		330	380	50
Volcanics.		380	400	20

Date started FEB 27, 1989
Date completed 4-18-, 1989

7. WELL TEST DATA

Pump RPM	G.P.M.	Draw Down	After Hours Pump
Air	lift	10 GPM.	

BAILER TEST

G.P.M. ____ Draw down ____ feet ____ hours
G.P.M. ____ Draw down ____ feet ____ hours
G.P.M. ____ Draw down ____ feet ____ hours

8. WELL CONSTRUCTION

Diameter 6 3/4 inches Total depth 400 feet
____ inches
____ inches
Casing record 2" galv A120
Weight per foot ____ Thickness ____

Diameter	From	To
2 inches	+ 2 feet	126 feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet
inches	feet	feet

Surface seal: Yes [X] No [ ] Type CEMENT
Depth of seal 42 feet
Gravel packed: Yes [X] No [ ]
Gravel packed from 42 feet to 400 feet

Perforations:
Type perforation 1/8 x 2 1/2 mill cuts
Size perforation
From 42 feet to 126 feet
From ____ feet to ____ feet
From ____ feet to ____ feet
From ____ feet to ____ feet
From ____ feet to ____ feet

9. WATER LEVEL

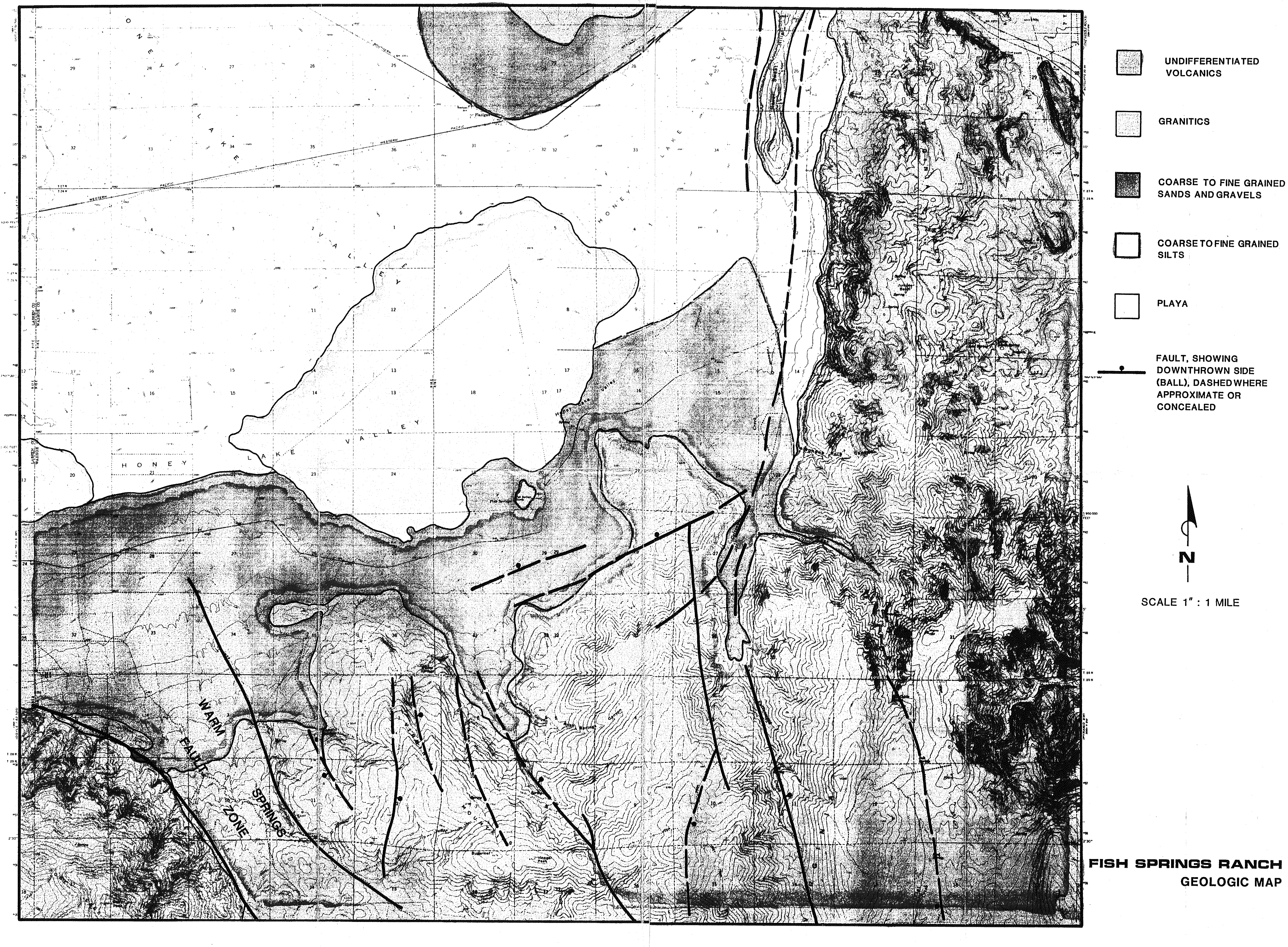
Static water level 45.82 feet below land surface
Flow ____ G.P.M. ____ P.S.I.
Water temperature Cool °F Quality ok

10. DRILLER'S CERTIFICATION

This well was drilled under my supervision and the report is true to the best of my knowledge.

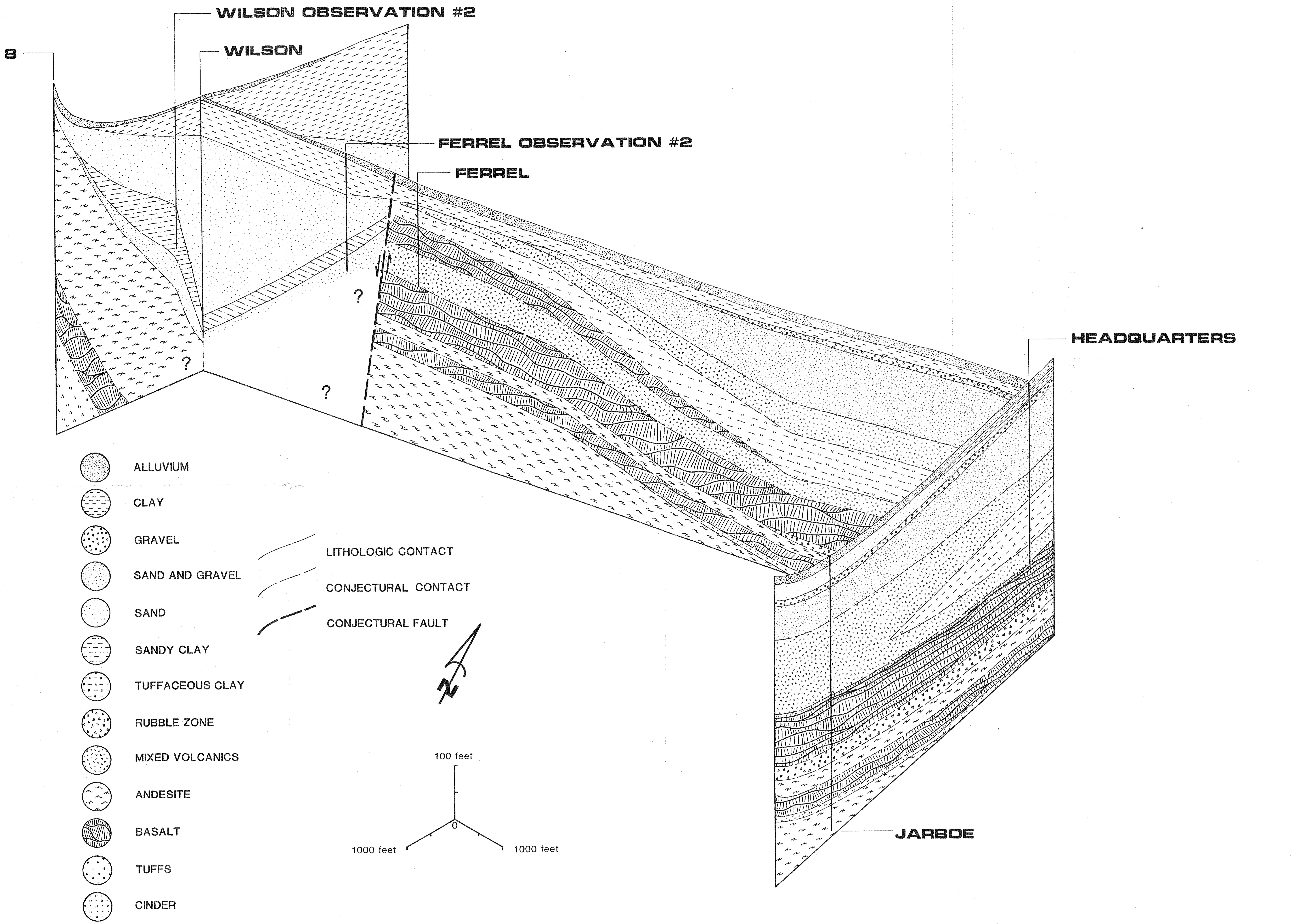
Name OASIS Drilling INC. (Contractor)
Address P.O. Box 21421 CARSON City NV. (Contractor)
Nevada contractor's license number issued by the State Contractor's Board 0023129
Nevada contractor's driller's number issued by the Division of Water Resources
Nevada driller's license number issued by the Division of Water Resources, the on-site driller 1539
Signed [signature]
By driller performing actual drilling on site or contractor
Date Jun 30, 1989

(Rev. 11-85) USE ADDITIONAL SHEETS IF NECESSARY (O)-627



FISH SPRINGS RANCH

GEOLOGIC MAP



FENCE DIAGRAM

FISH SPRINGS R