2.1.2

EG&G Idaho

INTEROFFICE CORRESPONDENCE

date September 19, 1978

to J. H. Ramsthaler

from R. C. Stoker

subject RRGE-2 TESTING AND PRODUCTION ESTIMATES - RCSt-51-78

Attached is a paper concerning the data derived from reservoir tests conducted at RRGE-2.

With the current pump inlet setting depth of 800 feet (a bubbler setting of 790 feet), a well shut-in bubbler pressure of 450 psi, and a minimum pump inlet pressure of 52 psi; the maximum predicted well pumping rate is 540 gpm. This estimate is based on the data (Figure 9) presented in the attached paper. It considers interference from other wells and two detected hydrologic boundaries. Undetected hydrologic boundaries present the greatest hazard in extrapolating the data over a five year period. A major undetected boundary would cause the well to be less productive than estimated here.

la

Attachment:
As Stated

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FORM EG&G-954
(Rev 2-77)

SUMMARY OF PUMP TEST RESULTS ON RRGE-2

AS OF AUGUST 16, 1978

David W. Allman

Purpose ?

Several production tests have been performed on RRGE-2. One of the most significant tests was performed at a steady production rate of 225 gpm on September 12 and 13, 1975, during which the H-P downhole pressure probe was used. The use of this probe results in accurate drawdown data. The data can be interpreted as implying the presence of barrier boundaries near the well as indicated by the straight line segmented nature of the drawdown data (Figure 1). The first break in slope, after approximately 15 minutes (900 seconds) of pumping results in a straight-line segment having a slope approximately double that of data prior to 15 minutes. This can be interpreted as indicating the presence of a linear impermeable barrier boundry located 50 feet from RRGE-2. The affects on the potentiometric head in RRGE-2 of a linear impermeable barrier boundry can be mathematically modeled using an imaginary pumping well at a distance of 100 feet from RRGE-2, pumping at the same rate as RRGE-2. The mathematical model would result in a doubling of the slope as observed.

The third linear segment of the drawdown plot begins at approximately 333 minutes (20,000 seconds). The slope of this segment is approximately 4 times greater than the linear segment prior to 15 minutes. This can be interpreted as another linear impermeable barrier boundry perpendicular to the first hypothesized barrier boundry. This second barrier boundry is estimated to be 275 feet from RRGE-2. The influence on RRGE-2 potentiometric heads of the impermeable barrier boundry can be mathematically represented by 2 pumping image wells at distances of 550 feet and 559 feet from RRGE-2. Because the image wells have near identical radii from RRGE-2, the impact of these two image wells on the potentiometric head in RRGE-2 occurs at essentially the same time. As result, the third straight line segment of the drawdown data plot has a slope approximately four times greater than the initial slope.

The expected relationships between drawdown after five years of pumping with and without interference with surrounding wells as a function of pumping rate are plotted in Figure 2. This plot results from extrapolating the September 12 and 13 data. The lower sloping line is the drawdown pumping rate relationship that would result with no well interference using the drawdown of 30 psi at 333 minutes and a Q/ΔS/ per cycle time of 11.25. The upper sloping line is the drawdown pumping rate relationship that would result from interference with the pumping wells. This interference was calculated assuming a reservoir kh of 100,000 md-ft, an S (storage coefficient) of 0.0005, a temperature of 300°F, equal production rates for RRGE-1, RRGE-4 and RRGE-5, a combined production rate of 2500 gpm, and radii from RRGE-2 of 3918 feet, 5280 feet, and 6160 feet for RRGE-1, RRGE-4 and RRGE-5 respectively. With no withdrawals from RRGE-2, interference of 66.68 psi would result because of pumping. The central line which depicts the expected well performance considers both the interference with the pumping wells and an estimated 20 psi of interference with the injection wells.

A series of relatively short drawdown tests of approximately one day duration have also been conducted RRGE-2. The results of these tests are plotted in Figure 3. The pressure declines are measured at the well head. As a result, considerable errors result in absolute drawdown. The changing specific gravity of the water in the wellbore as the temperature of the water in the wellbore increases as a result of discharging the well, can result in absolute drawdowns up to approximately 35 psi greater than those indicated in Figure 3. However, once thermal equilibrium is reached in the wellbore, relative temporally dependent declines in drawdown data can be determined with what is believed to be an acceptable degree of accuracy. However, it must be recognized that it may be possible that all the parameters describing these plots have errors of such a magnitude that the conclusions based on these data are completely erroneous.

The data in Figure 3 exhibits some non-ideal characteristics. The data from the time pumping began to approximately 333 minutes appear to have significant errors because of temporally dependent borehold fluid density changes as suggested by the lack of distinct changes in slope of the data as presumed boundary affects influence the drawdown data. Since the data collected after approximately 333 minutes exhibits well defined linear trends for approximately 0.64 of a log cycle, some credence can be placed on the wellhead drawdown data being indicative of the drawdowns occurring in the wellbore fluid adjacent to the production zone(s). The slopes expressed as psi/log cycle of time (ΔS/log cycle time), of the linear trend from approximately 333 minutes until termination of the test, are listed in Table 1 as a function of the flow rate used during the test. In addition, the value of the ratio Q/ΔS/log cycle time is also listed in Table 1 along with the observed drawdown after flowing the well for 333 minutes.

Data for two additional tests at 800 and 740 gpm (Figure 4 and 5), have also been examined. The drawdown data for the 800 gpm test do not exhibit a distinct change in slope over the 725 minutes of pumping. However, the drawdown data for the 740 gpm test exhibit an abrupt change in slope after pumping 500 minutes. The reason for the absence of a slope change in Figure 4 is not known. The drawdown after pumping 333 minutes as well as the slope of the drawdown data after 333 minutes are listed in Table 1.

The estimated drawdowns after pumping 333 minutes appear to be predictable. Figure 6 is a plot of the drawdown versus Q for the data listed in Table 1. The coefficient of determination r^2, indicates that 98.5% of the variation in the drawdown after pumping 333 minutes is accounted for by the regression.

Contrary to that which would result with an ideal well, the value of Q/ΔS/log cycle time is dependent on Q. Figure 7 is a plot of ΔS/log cycle time versus Q. The best fitting linear regression between these variables indicates that the rates of Q/ΔS log cycle time is not a constant since there is a non zero interrupt. Figure 8 is a graph of Q/ΔS/log cycle time versus Q. The non-linearity of this relationship is readily apparent. An ideal well would have a Q/ΔS/log cycle time value independent of Q. The dashed line is the relationship between these two variables as obtained from the best fitting linear regression based on the data plotted in Figure 6.

The dependent relationship between the ratio Q/ΔS/log cycle time and Q is significant in that it indicates the greater the rate of withdrawal from the wall, the poorer the well performs. This dependent relationship also indicates that significant errors in predicting drawdown can be expected unless: (a) the test pumping rate is fortuitously close to the pumping rate being used for projection purposes, (b) the ratio Q/ΔS/log cycle time is not dependent on Q, or (c) the relationship between Q/ΔS/log cycle time and Q can be defined.

The expected relationships between drawdown after five years of pumping with and without interference with surrounding wells as a function of pumping rate Q are plotted in Figure 9. The lower sloping solid line is the drawdown pumping rate relationship that would result with no well interference using the drawdown at 333 minutes as obtained from the relationship in Figure 6 and the values for ΔS/log cycle time as obtained from the linear relationship in Figure 7. The upper sloping solid line is the drawdown-pumping rate relationship that would result from interference with the pumping wells. This interference was calculated using identical assumptions as those used for Figure 2. The central solid line depicts the expected well performance with both injection well and pumping well interference.

The comparison of the drawdown-pumping rate relationship using the 225 gpm test data only and all the available data indicates that above approximately 280 gpm, the data based on the 225 gpm test underestimate the resulting drawdowns. For convenience, the dashed line in Figure 9 is the expected well performance based on the 225 gpm test data as per Figure 2. Below approximately 280 gpm, the data based on the 225 gpm test overestimate the resulting drawdowns. Based on these results, the projection of drawdown-pumping rate relationships beyond the range of pumping rate data available can result in rather larger errors in estimated drawdown.

CONCLUSION:

(1) To eliminate the significant affects of temporally dependent borehole fluid density changes on the hypothesized drawdown data, drawdown data should be collected with a downhole pressure probe.

(2) Based on the 225 gpm test, the drawdown data can apparently be duplicated by assuming one real pumping well and 3 pumping image wells.

(3) Estimated drawdowns after pumping 333 minutes are apparently not linearly dependent on the pumping rate.

(4) The changes in drawdown (ΔS) per log cycle time appear to be linearly dependent on the pumping rate.

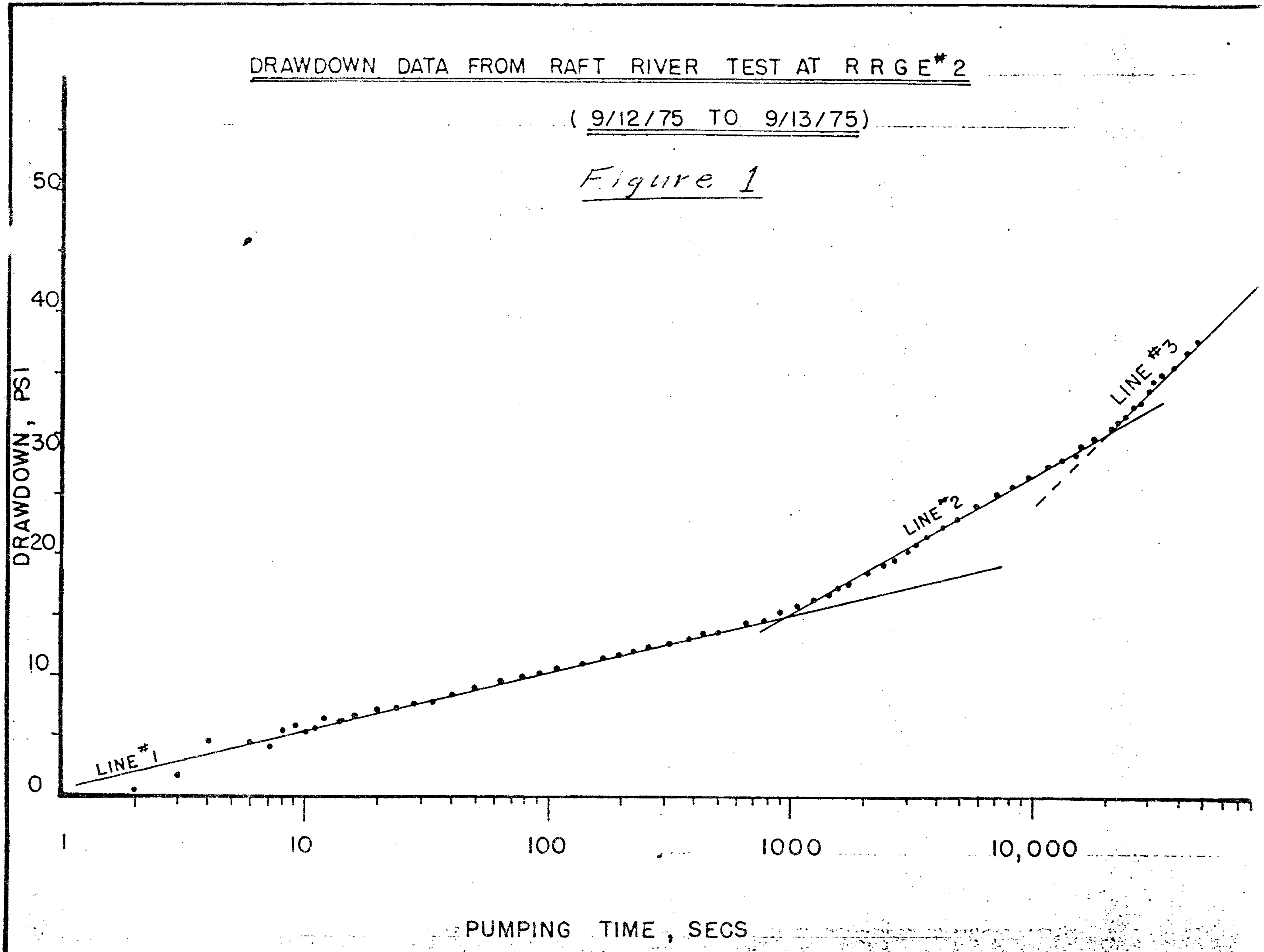
(5) The ratio of pumping rate (Q) to the change in drawdown (ΔS) per log cycle time is not linearly dependent on Q as would be the case for an ideal well exhibiting constant values for kh and T.

Table 1

Selected Parameter Response Obtained From Withdrawal Tests On RRGE-2.

Pump Rate (9pm)	Drawdown at 333 min. (psi)	ΔS/Log Cycle Time (psi)	$Q/\Delta S$/Log Cycle Time (9pm/psi)
200	27.5	12.5	16.0
225	30.0	20.0	11.3
250	43.6	18.2	13.7
300	59.7	22.8	13.2
350	73.4	28.5	12.3
400	92.2	34.0	11.8
740	275.0	74.0	10.0
800	344.0	80.0	10.0

8/16/78



DRAWDOWN DATA FROM RAFT RIVER TEST AT RRGE # 2
(9/12/75 TO 9/13/75)
Figure 1
DRAWDOWN, PSI
50
40
30
20
10
0
LINE # 1
LINE # 2
LINE # 3
1
10
100
1000
10,000
PUMPING TIME, SECS

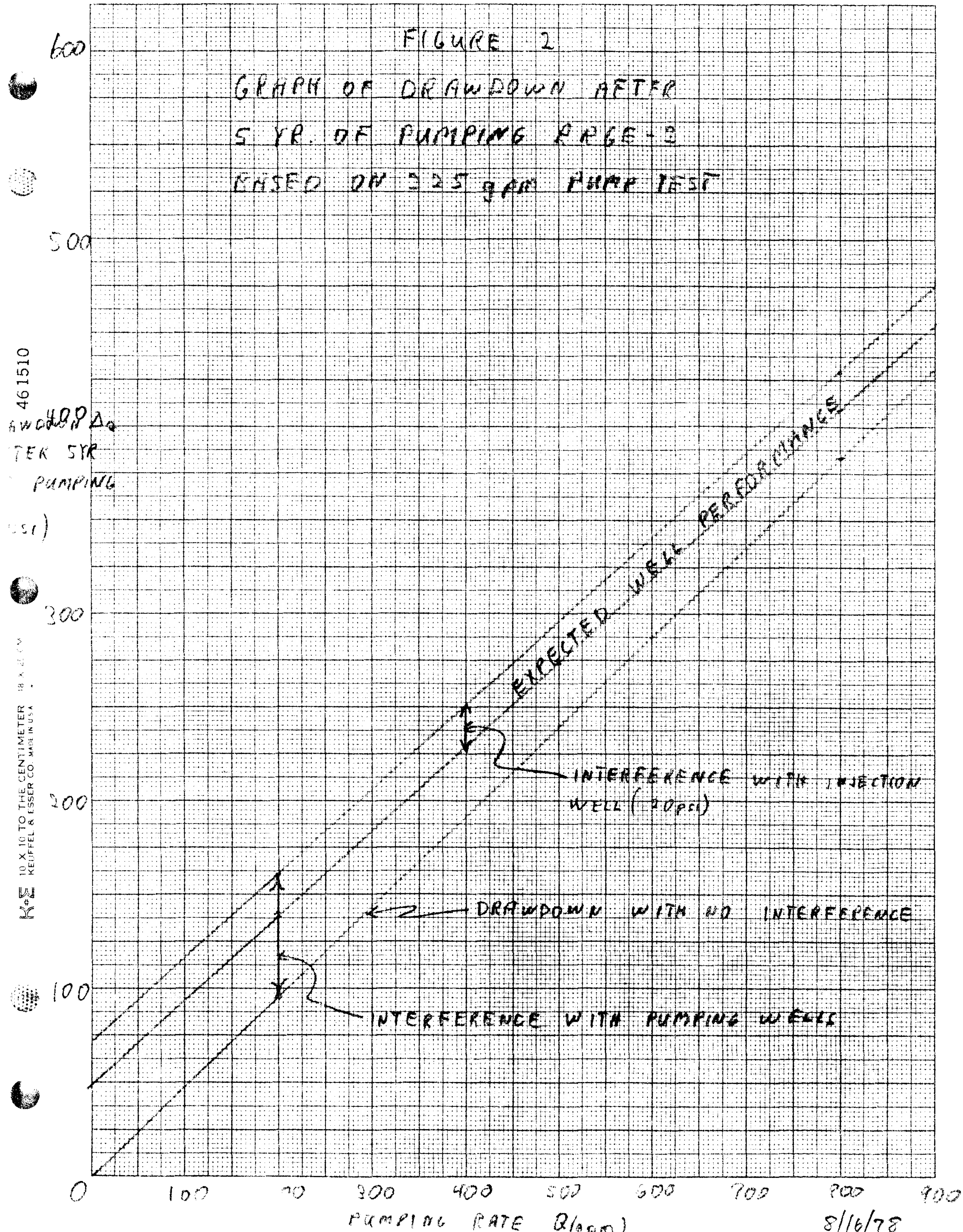
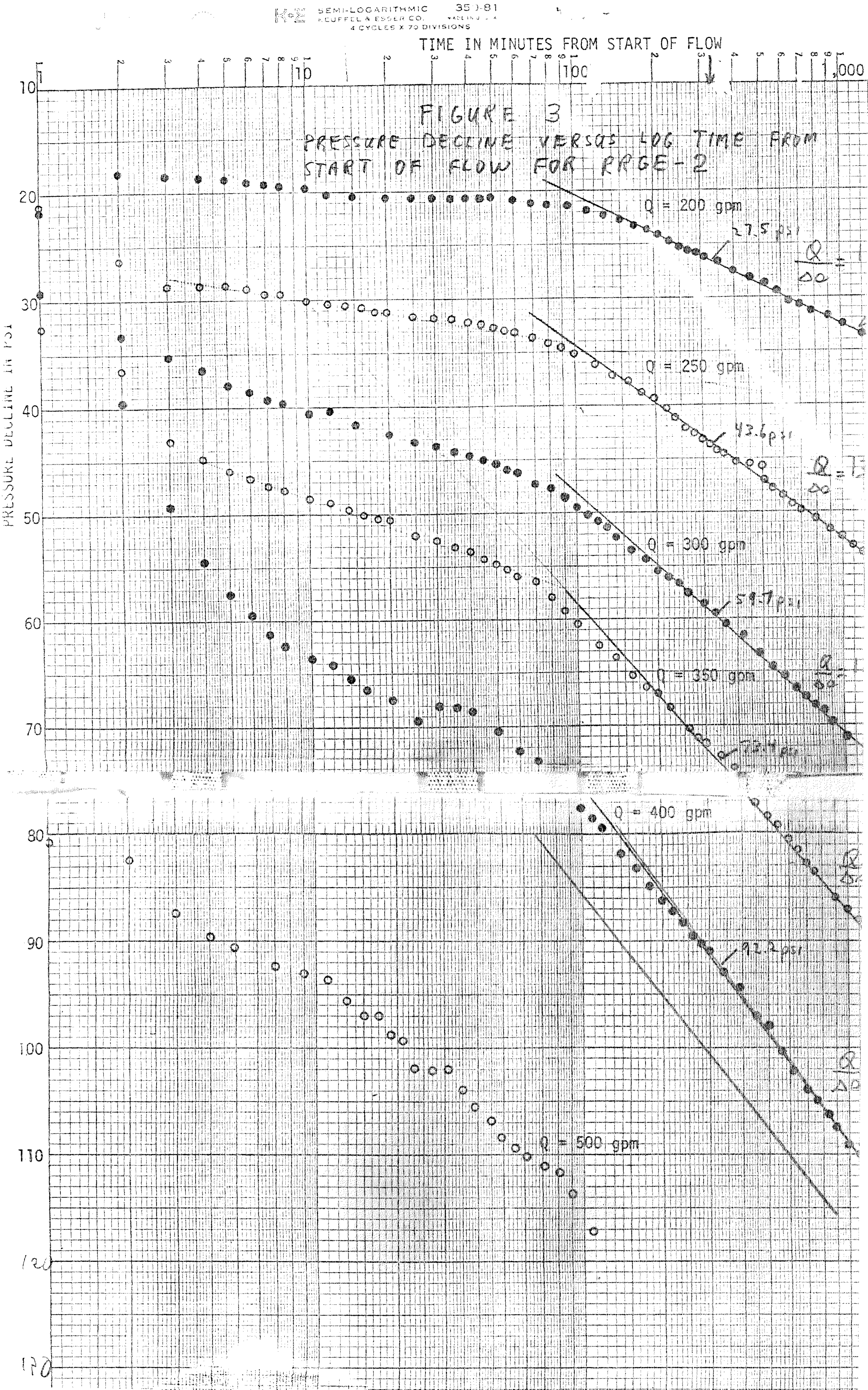
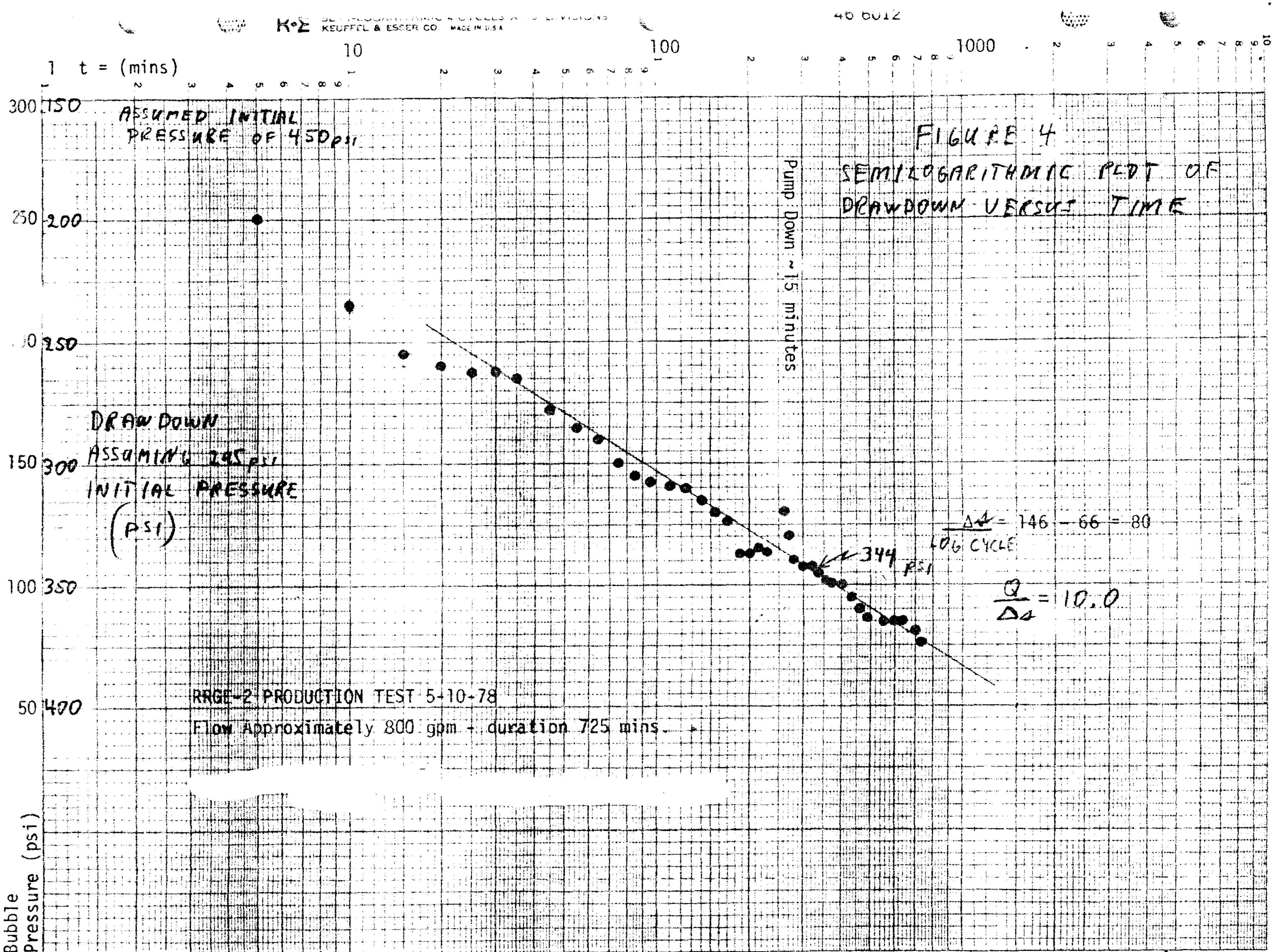


FIGURE 2
GRAPH OF DRAWDOWN AFTER
5 YR. OF PUMPING RRGE-3
BASED ON 325 gpm PUMP TEST
600
500
400
300
200
100
0
100
200
300
400
500
600
700
800
900
AWDOWN Δs
TER 5YR
PUMPING
SI)
EXPECTED WELL PERFORMANCE
INTERFERENCE WITH INJECTION WELL (20 psi)
DRAWDOWN WITH NO INTERFERENCE
INTERFERENCE WITH PUMPING WELLS
PUMPING RATE Q (gpm)
8/16/78


K&E SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO.
4 CYCLES X 70 DIVISIONS
TIME IN MINUTES FROM START OF FLOW
PRESSURE DECLINE IN PSI
FIGURE 3
PRESSURE DECLINE VERSUS LOG TIME FROM START OF FLOW FOR RRGE-2
Q = 200 gpm
27.5 psi
Q = 250 gpm
43.6 psi
Q = 300 gpm
59.7 psi
Q = 350 gpm
Q = 400 gpm
92.2 psi
Q = 500 gpm
10
100
1,000



KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6012
1 t = (mins)
10
100
1000
ASSUMED INITIAL PRESSURE OF 450psi
FIGURE 4
SEMILOGARITHMIC PLOT OF DRAWDOWN VERSUS TIME
Pump Down ~15 minutes
300 150
250 200
200 250
150 300
100 350
50 400
DRAW DOWN ASSUMING 295 psi INITIAL PRESSURE (PSI)
Δs / LOG CYCLE = 146 − 66 = 80
344 psi
Q / Δs = 10.0
RRGE-2 PRODUCTION TEST 5-10-78
Flow Approximately 800 gpm - duration 725 mins.
Bubble Pressure (psi)

8/16/78

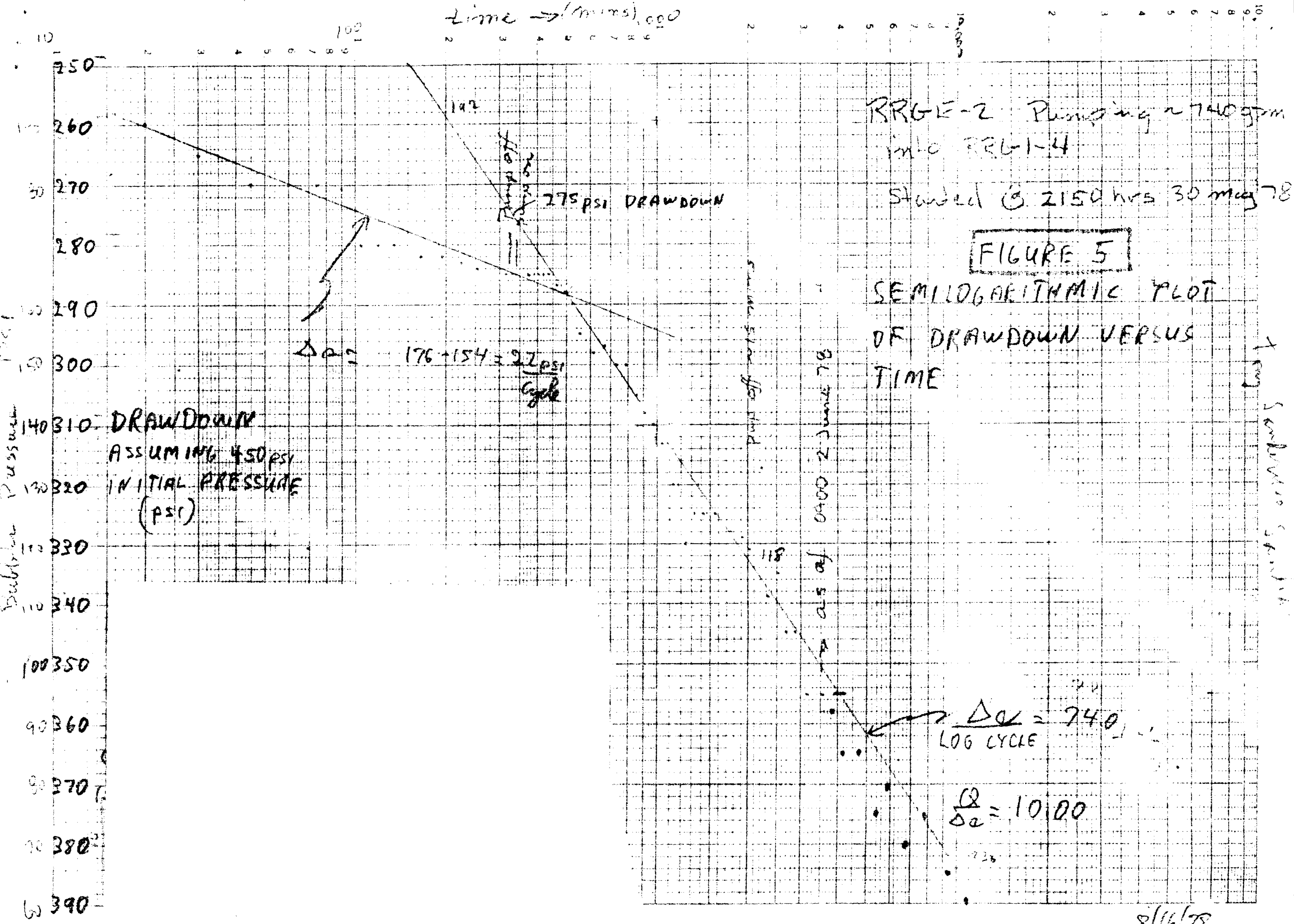


FIGURE 5

SEMILOGARITHMIC PLOT OF DRAWDOWN VERSUS TIME

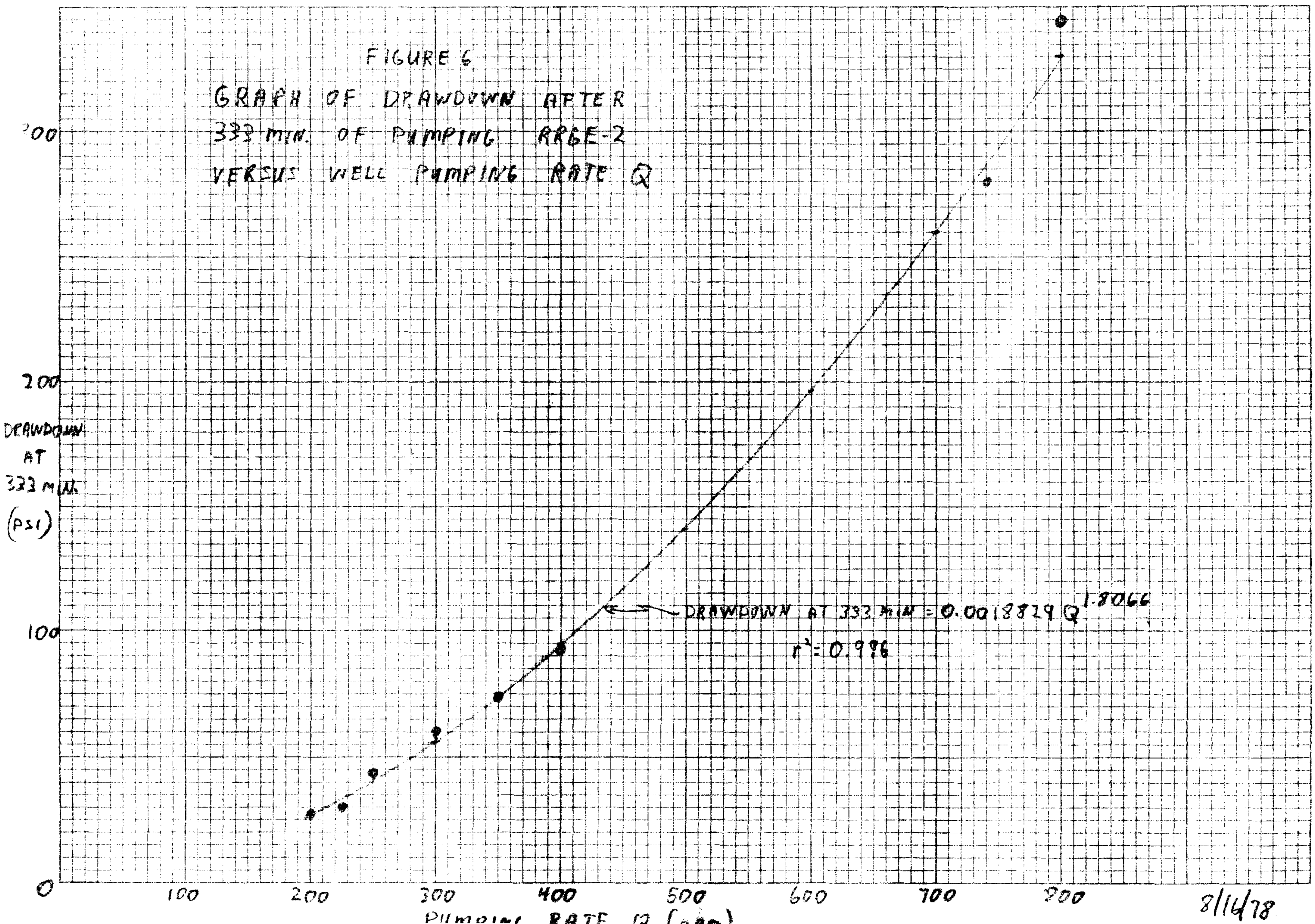


FIGURE 6
GRAPH OF DRAWDOWN AFTER
333 MIN. OF PUMPING RRGE-2
VERSUS WELL PUMPING RATE Q
300
200
100
0
DRAWDOWN AT 333 MIN. (PSI)
100
200
300
400
500
600
700
800
DRAWDOWN AT 333 MIN = 0.0018829 Q^1.8066
r² = 0.996
8/16/78

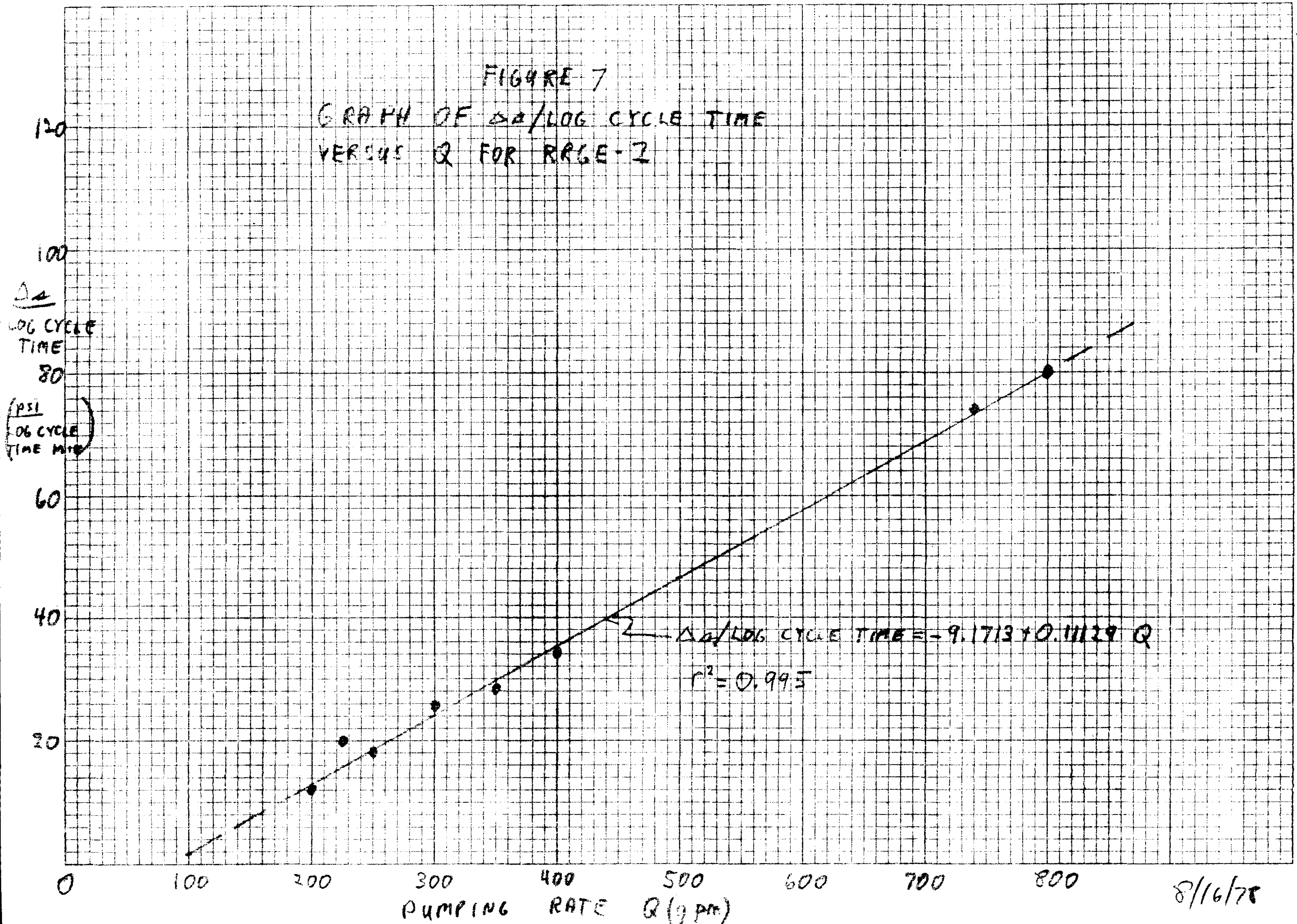
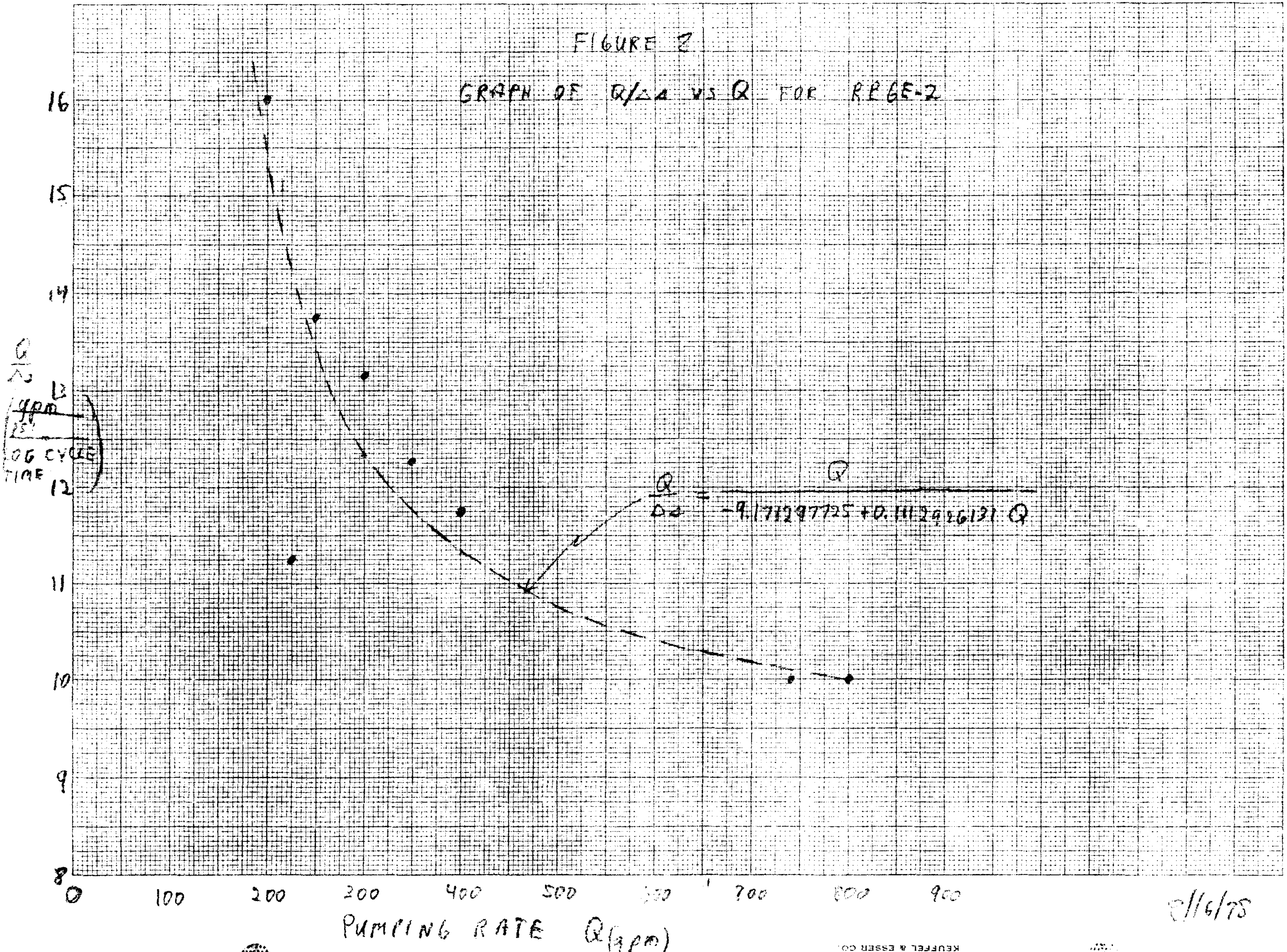


FIGURE 7
GRAPH OF Δs/LOG CYCLE TIME
VERSUS Q FOR RRGE-2
Δs / LOG CYCLE TIME (psi / LOG CYCLE TIME MIN)
120
100
80
60
40
20
0
100
200
300
400
500
600
700
800
PUMPING RATE Q (gpm)
Δs/LOG CYCLE TIME = -9.1713 + 0.11129 Q
r² = 0.995

8/16/78

FIGURE 2



8/16/75

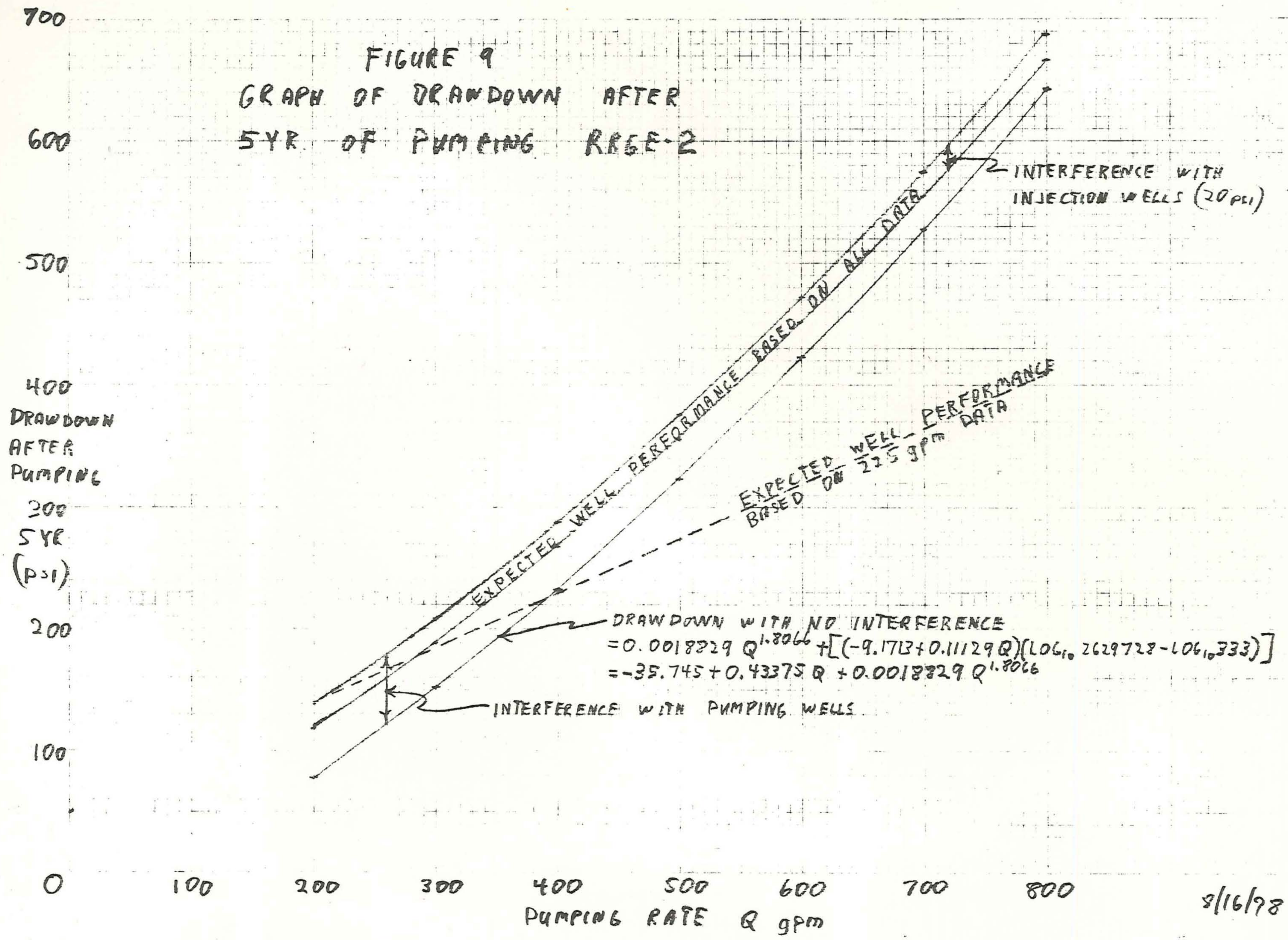


FIGURE 9
GRAPH OF DRAWDOWN AFTER 5 YR OF PUMPING RRGE-2

8/16/78

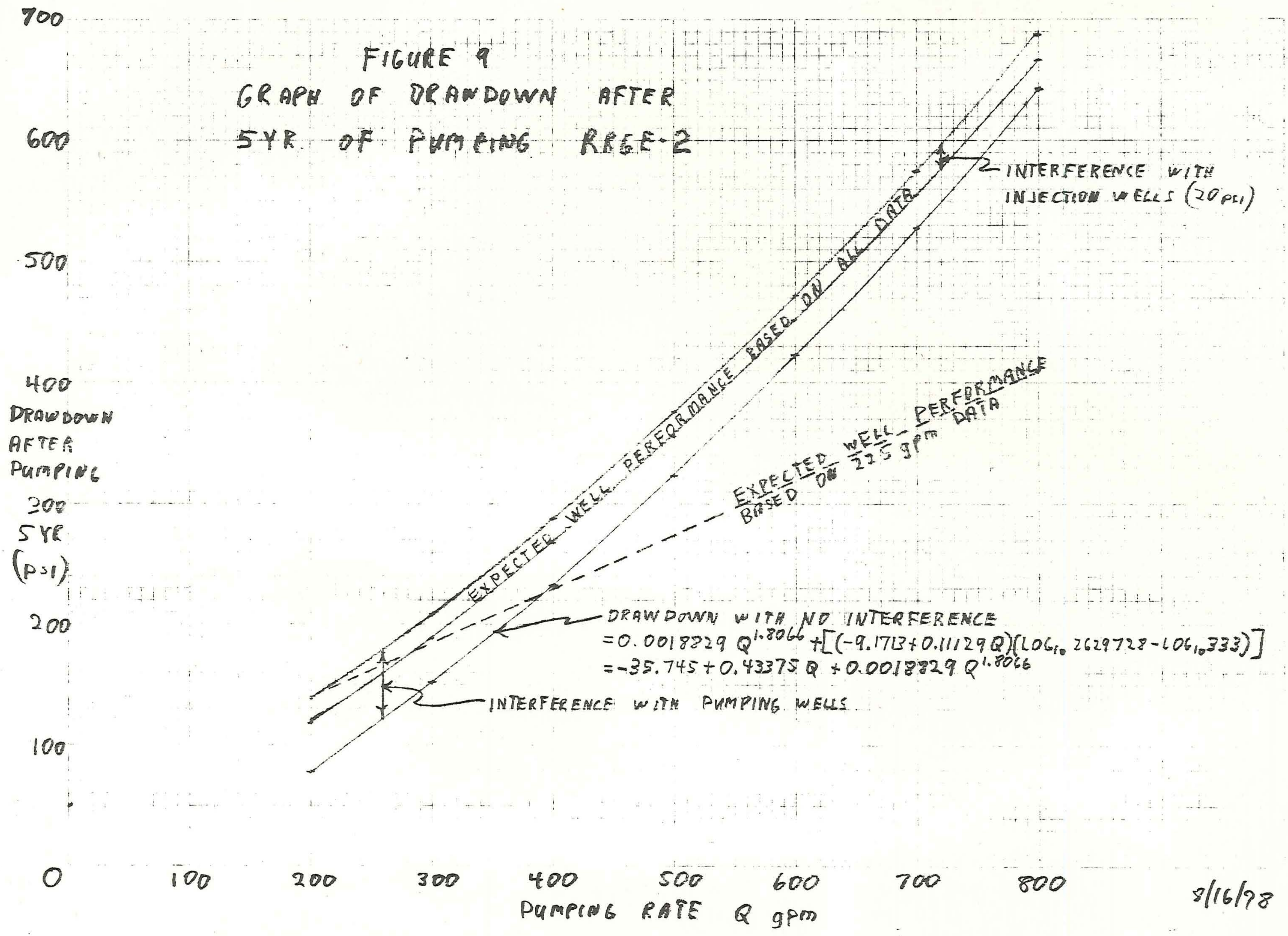


FIGURE 9
GRAPH OF DRAWDOWN AFTER
5 YR OF PUMPING RRGE-2
700
600
500
400
300
200
100
0
DRAWDOWN AFTER PUMPING 5 YR (psi)
100
200
300
400
500
600
700
800
PUMPING RATE Q gpm
EXPECTED WELL PERFORMANCE BASED ON ALL DATA
INTERFERENCE WITH INJECTION WELLS (20 psi)
EXPECTED WELL PERFORMANCE BASED ON 225 gpm DATA
DRAWDOWN WITH NO INTERFERENCE
=0.0018829 Q^1.8066 +[(-9.1713+0.11129 Q)(LOG10 2629728-LOG10 333)]
=-35.745+0.43375 Q +0.0018829 Q^1.8066
INTERFERENCE WITH PUMPING WELLS

8/16/78