GL02976-6

FLUID SAMPLE DATA

Sampler Pressure 0 P.S.I.G. at Surface

Recovery: Cu. Ft. Gas
cc. Oil
cc. Water 2240
cc. Mud
Tot. Liquid cc. 2240

Gravity ° API @ °F.

Gas/Oil Ratio cu. ft./bbl.

	RESISTIVITY	CHLORIDE CONTENT
Recovery Water	3.10 @ 80 °F.	1600 ppm
Recovery Mud	2.10 @ 120 °F.	1600 ppm
Recovery Mud Filtrate	@ °F.	ppm
Mud Pit Sample	2.45 @ 75 °F.	2100 ppm
Mud Pit Sample Filtrate	@ °F.	ppm

Mud Weight 8.9 vis 7 cp

Date 5-14-75 Ticket Number 863708

Kind of Job OPEN HOLE Halliburton District VERNAL

Tester MR. MOUDRY Witness MR. MILLER

Drilling Contractor REYNOLDS ELECTRIC BC S

EQUIPMENT & HOLE DATA

Formation Tested

Elevation Ft.

Net Productive Interval Ft.

All Depths Measured From Kelly Bushing

Total Depth 4247' Ft.

Main Hole/Casing Size 12¼"

Drill Collar Length 262' I.D. 3"

Drill Pipe Length 3844' I.D. 5.965"

Packer Depth(s) 4151' - 4157' Ft.

Depth Tester Valve 4131' Ft.

Cushion TYPE AMOUNT Ft. Depth Back Pres. Valve Surface Choke 1/8" Bottom Choke 3/4"

Recovered 341 Feet of Drilling fluid

Recovered 859 Feet of Water

Recovered Feet of

Recovered Feet of

Recovered Feet of

Meas. From Tester Valve

Remarks See production test data sheet...

Legal Location Sec. - Twp. - Rng.: 23 - 15S - 16E

Lease Name: RAFT RIVER

Well No.: 2

Test No.: 1

Field Area: WILDCAT

Tested Interval: 4157' - 4247'

County: CASSIA

Lease Owner/Company Name: AERO JET NUCLEAR COMPANY

State: IDAHO

TEMPERATURE	Gauge No. 430 Depth: 4136' Ft.		Gauge No. 76 Depth: 4140' Ft.		Gauge No. 205 Depth: 4243' Ft.		TIME	
	24 Hour Clock		24 Hour Clock		24 Hour Clock		Tool Opened 2300 A.M. P.M.	
Est. °F.	Blanked Off No		Blanked Off No		Blanked Off Yes		Opened Bypass 1130 A.M. P.M.	
Actual 245 °F.	Pressures		Pressures		Pressures			
	Field	Office	Field	Office	Field	Office	Reported Minutes	Computed Minutes
Initial Hydrostatic		1874		1874		1926		
First Period Flow Initial		32		35		90	—	—
First Period Flow Final		173		165		210	30	27
First Period Closed in		1730		1727		1769	120	121
Second Period Flow Initial		184		177		223	—	—
Second Period Flow Final		364		357		399	120	118
Second Period Closed in		1694		1693		1737	180	182
Flow Initial		376		370		414	—	—
Flow Final		535		533		571	120	122
Closed in		1682		1683		1730	180	180
Final Hydrostatic		1874		1874		1926	—	—

FORM 161-R1—PRINTED IN U.S.A.

FORMATION TEST DATA

LITTLE'S 96671 10M 6/74

Casing perfs. ______ Bottom choke ______ Surf. temp ______ °F Ticket No. 863708
Gas gravity ______ Oil gravity ______ GOR ______
Spec. gravity ______ Chlorides ______ ppm Res. ______ @ ______ °F
INDICATE TYPE AND SIZE OF GAS MEASURING DEVICE USED ______

Date 5-12-75 Time a.m. p.m.	Choke Size	Surface Pressure psi	Gas Rate MCF	Liquid Rate BPD	Remarks
2000					Called
~~5-13-75~~ 0900					On location
1800					Made up tools
2000					Trip in hole
2300					Set packers, opened tool with a weak
					blow, 3/4" in water
2330					Closed tool
~~5-14-75~~ 0130					Opened tool with a weak blow, 3/4" into
					water, decreasing to ½"
0330					Closed tool
0630					Opened tool with a weak blow, 3/4" into
					water, decreasing to ½"
0830					Closed tool
1130					Pulled packers loose, by-passed
1600					Broke down, loaded out and off location

FORM 182-R1—PRINTED IN U.S.A.

PRODUCTION TEST DATA

LITTLE'S 96672 5M 8/74

Gauge No. 430 | Depth 4136' | Clock No. 9989 | 24 hour | Ticket No. 863708

	First Flow Period		First Closed In Pressure			Second Flow Period		Second Closed In Pressure			Third Flow Period		Third Closed In Pressure		
	Time Defl. .000"	PSIG Temp. Corr.	Time Defl. .000"	$\text{Log}\frac{t+\theta}{\theta}$	PSIG Temp. Corr.	Time Defl. .000"	PSIG Temp. Corr.	Time Defl. .000"	$\text{Log}\frac{t+\theta}{\theta}$	PSIG Temp. Corr.	Time Defl. .000"	PSIG Temp. Corr.	Time Defl. .000"	$\text{Log}\frac{t+\theta}{\theta}$	PSIG Temp. Corr.
0	.0000	32	.0000		173	.0000	184	.0000		364	.0000	376	.0000		535
1	.0106	69*	.0369		1435**	.0596	213***	.0569		1389****	.0721	408*****	.0499		1394
2	.0246	106	.0705		1553	.1259	247	.1071		1496	.1377	437	.0998		1492
3	.0387	136	.1040		1609	.1922	279	.1573		1552	.2033	464	.1497		1546
4	.0528	148	.1376		1644	.2585	309	.2075		1588	.2689	490	.1997		1582
5	.0669	157	.1711		1667	.3247	338	.2577		1614	.3344	512	.2496		1605
6	.0809	165	.2047		1683	.3910	364	.3078		1635	.4000	535	.2995		1625
7	.0950	173	.2382		1697			.3580		1648			.3494		1639
8			.2718		1707			.4082		1662			.3993		1651
9			.3053		1713			.4584		1673			.4492		1662
10			.3389		1720			.5086		1681			.4992		1670
11			.3724		1726			.5588		1688			.5491		1677
12			.4060		1730			.6090		1694			.5990		1682
13															
14															
15															

Gauge No. 76 | Depth 4140' | Clock No. 7139 | 24 hour

	First Flow Period		First Closed In Pressure			Second Flow Period		Second Closed In Pressure			Third Flow Period		Third Closed In Pressure		
0	.0000	35	.0000		165	.0000	177	.0000		357	.0000	370	.0000		533
1	.0107	58*	.0366		1435**	.0592	208***	.0567		1392****	.0720	402*****	.0498		1398
2	.0249	98	.0699		1550	.1249	241	.1067		1496	.1374	432	.0995		1495
3	.0391	132	.1032		1609	.1907	273	.1568		1550	.2028	458	.1493		1548
4	.0533	143	.1366		1644	.2565	303	.2068		1587	.2682	485	.1990		1582
5	.0676	151	.1699		1667	.3222	331	.2568		1614	.3336	508	.2488		1606
6	.0818	158	.2032		1683	.3880	357	.3068		1633	.3990	533	.2985		1625
7	.0960	165	.2365		1696			.3569		1649			.3483		1640
8			.2698		1705			.4069		1662			.3980		1652
9			.3031		1712			.4569		1671			.4478		1662
10			.3364		1717			.5069		1681			.4975		1671
11			.3697		1723			.5570		1688			.5473		1677
12			.4030		1727			.6070		1693			.5970		1683
13															
14															
15															
Reading Interval	4		10			20		15			20		15		Minutes

REMARKS: *Interval = 3 minutes **Interval = 11 minutes ***Interval = 18 minutes ****Interval = 17 minutes
*****Interval = 22 minutes

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SPECIAL PRESSURE DATA

LITTLE'S 96673 75C 8/74

Gauge No. 205 | Depth 4243' | Clock No. 2786 | 24 hour | Ticket No. 863708

	First Flow Period		First Closed In Pressure			Second Flow Period		Second Closed In Pressure			Third Flow Period		Third Closed In Pressure		
	Time Defl. .000"	PSIG Temp. Corr.	Time Defl. .000"	$\text{Log}\frac{t+\theta}{\theta}$	PSIG Temp. Corr.	Time Defl. .000"	PSIG Temp. Corr.	Time Defl. .000"	$\text{Log}\frac{t+\theta}{\theta}$	PSIG Temp. Corr.	Time Defl. .000"	PSIG Temp. Corr.	Time Defl. .000"	$\text{Log}\frac{t+\theta}{\theta}$	PSIG Temp. Corr.
0	.0000	90	.0000		210	.0000	223	.0000		399	.0000	414	.0000		571
1	.0101	120*	.0366		1481**	.0601	247***	.0568		1441****	.0732	440*****	.0499		1440
2	.0236	152	.0699		1591	.1269	280	.1069		1537	.1398	470	.0998		1537
3	.0371	178	.1032		1649	.1937	313	.1570		1595	.2063	499	.1497		1594
4	.0506	187	.1366		1682	.2604	343	.2071		1631	.2729	525	.1997		1627
5	.0640	194	.1699		1705	.3272	372	.2572		1657	.3394	548	.2496		1650
6	.0775	202	.2032		1723	.3940	399	.3073		1675	.4060	571	.2995		1669
7	.0910	210	.2365		1736			.3574		1691			.3494		1685
8			.2698		1744			.4076		1704			.3993		1696
9			.3031		1752			.4577		1715			.4492		1707
10			.3364		1758			.5078		1723			.4992		1716
11			.3697		1763			.5579		1730			.5491		1723
12			.4030		1769			.6080		1737			.5990		1730
13															
14															
15															

Gauge No. | Depth | Clock No. | hour

0															
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															
Reading Interval	4		10			20		15			20		15		Minutes

REMARKS: *Interval = 3 minutes **Interval = 11 minutes ***Interval = 18 minutes ****Interval = 17 minutes
*****Interval = 22 minutes

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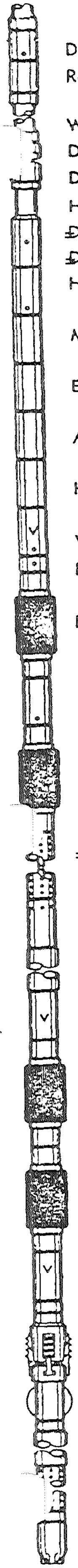
SPECIAL PRESSURE DATA

LITTLE'S 96673 75C 8/74



	O.D.	I.D.	LENGTH	DEPTH
Drill Pipe or Tubing				
Reversing Sub	7 15/16"	2 13/16"	.98'	
Water Cushion Valve				
Drill Pipe	6 5/8"	5.965"	3844'	
Drill Collars	8"	3"	262'	
Handling Sub & Choke Assembly				
~~Dual CIP~~ Valve Triple	5"	.87"	7'	4116'
~~Dual CIP~~ Sampler	5"	2.37"	8'	4123'
Hydro-Spring Tester	5"	.75"	5'	4131'
Multiple CIP Sampler				
Extension Joint				
AP Running Case (2)	5"	2.37"	4'	4136' 4140'
Hydraulic Jar	5"	1.75"	5'	
VR Safety Joint	5"	1.75"	2'	
Pressure Equalizing Crossover				
Packer Assembly	11¼"	2.44"	6'	4151'
Distributor				
Packer Assembly	11¼"	2.44"	4.50'	4157'
Packer tail			1.44'	
Safety Joint	5 3/4"	1 3/4"	4'	
~~Flush Joint Anchor~~ Sub	6 11/16"	2 5/8"	.80'	
Pressure Equalizing Tube				
Perf. anchor	6 1/8"	3½"	4'	
Blanked-Off B.T. Running Case				
Sub	7 13/16"	2 7/8"	.96'	
Drill Collars	8"	3"	58.60"	
Anchor Pipe Safety Joint				
Sub	7 7/8"	2 7/8"	1.03'	
Perf. anchor	6 1/8"	3½"	10'	
Packer Assembly				
Sub	6 3/4"	2 3/4"	.84'	
Distributor				
HT-500	5 7/8"	3"	.94'	
Packer Assembly				
Sub	6 1/8"	2¼"	.76'	
HT-500	5 1/8"	2¼"	1.51'	
Sub	5 7/8"	2 5/8"	.64'	
Anchor Pipe Safety Joint				
Sub	6½"	2 3/4"	.82'	
Side Wall Anchor				
Drill Collars				
Flush Joint Anchor				
Blanked-Off B.T. Running Case	6 1/8"	3½"	4'	4243'
Total Depth				4247'

FORM 107-R1—PRINTED IN U.S.A.

EQUIPMENT DATA

LITTLE'S 96676 78C 8/74

SUMMARY OF PUMP TEST RESULTS ON RRGE-2

AS OF AUGUST 16, 1978

David W. Allman

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 th wellbore as the temperature of the water in the wellbore increases as a resul 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 $Q/\Delta S$/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 $Q/\Delta S$/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 $Q/\Delta S$ log cycle time is not a constant since there is a non zero interrupt. Figure 8 is a graph of $Q/\Delta S$/log cycle time versus Q. The non-linearity of this relationship is readily apparent. An ideal well would have a $Q/\Delta S$/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 $Q/\Delta S$/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 $Q/\Delta S$/log cycle time is not dependent on Q, or (c) the relationship between $Q/\Delta S$/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.

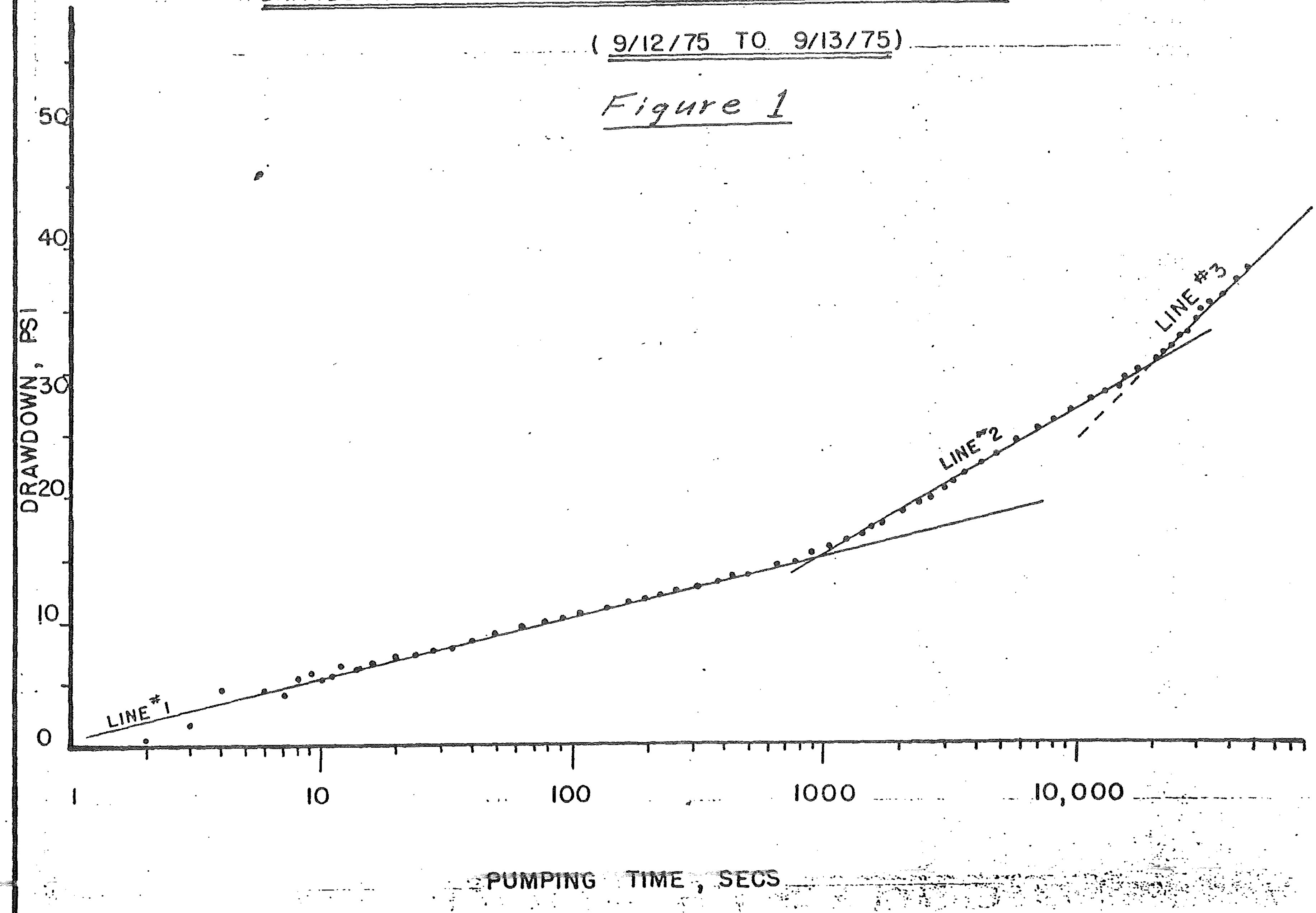
Pump Rate (9pm)	Drawdown at 333 min. (psi)	ΔS/Log Cycle Time (psi)	Q/ΔS/Log Cycle Time (9pm/psi)
200	27.5	12.5	16.0
225	30.0	20.0	11.3
250	43.6	18.2	13.7
300	59.7	22.8	13.2
350	73.4	28.5	12.3
400	92.2	34.0	11.8
740	275.0	74.0	10.0
800	344.0	80.0	10.0

8/16/78

DRAWDOWN DATA FROM RAFT RIVER TEST AT RRGE#2

(9/12/75 TO 9/13/75)

Figure 1



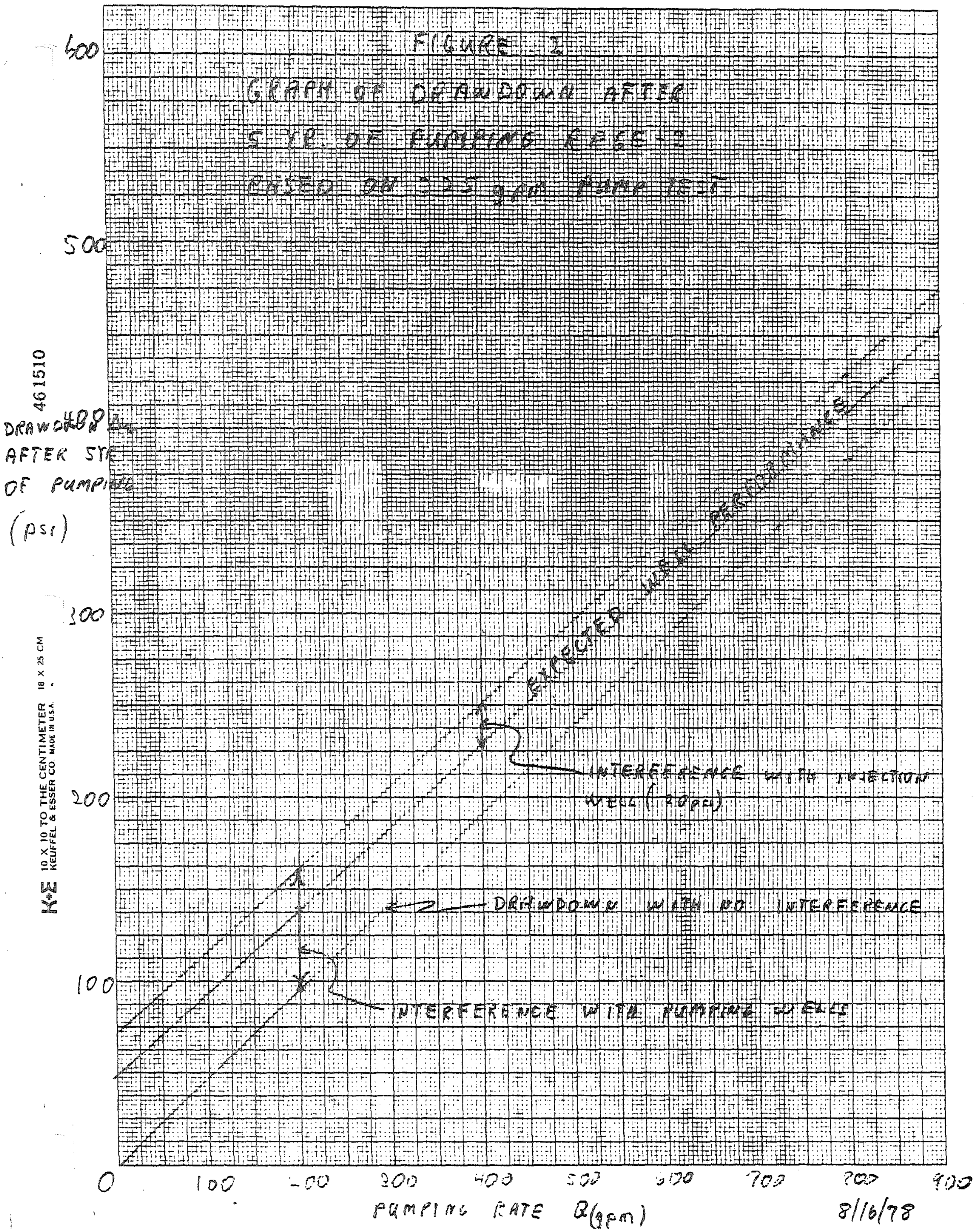
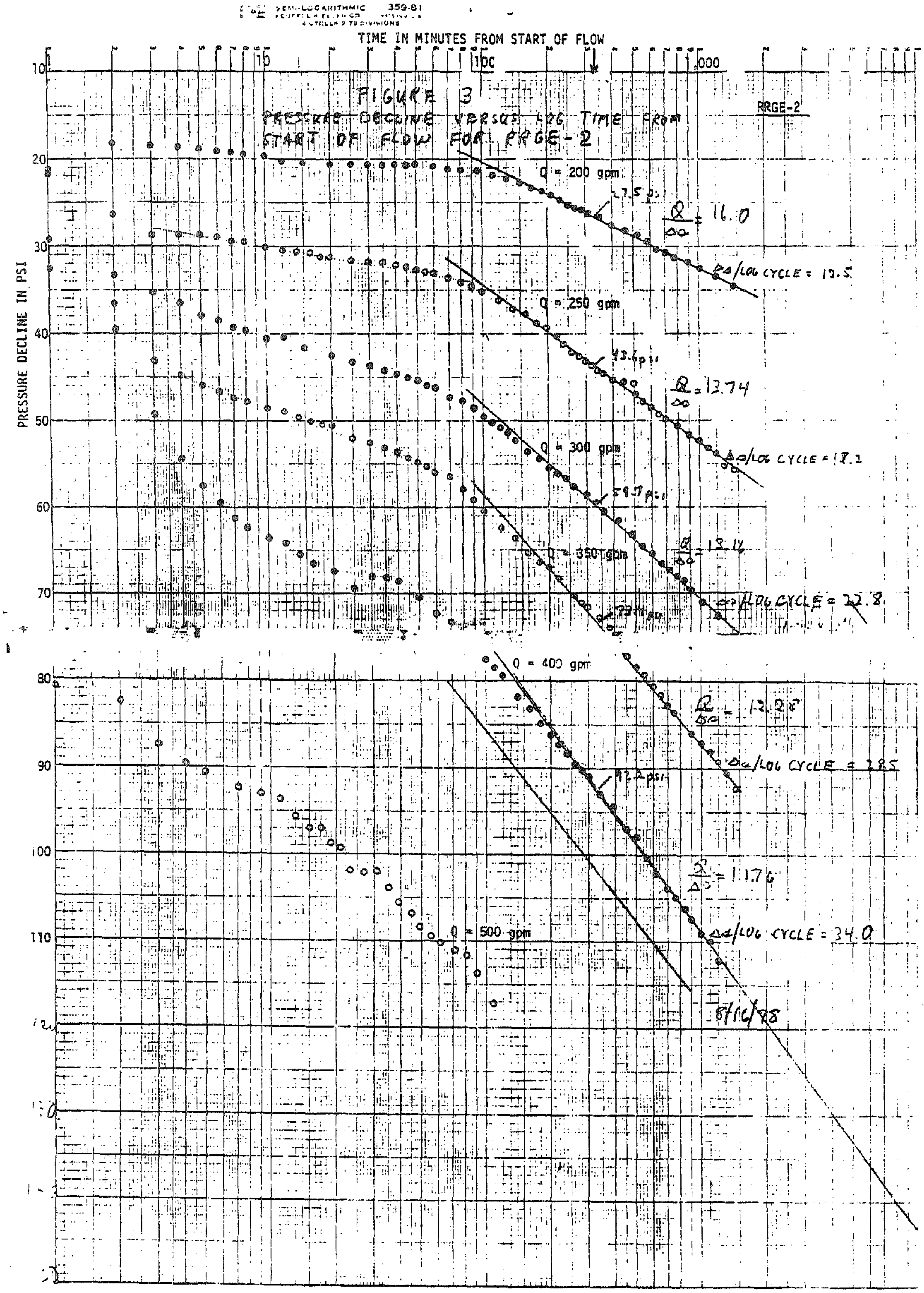
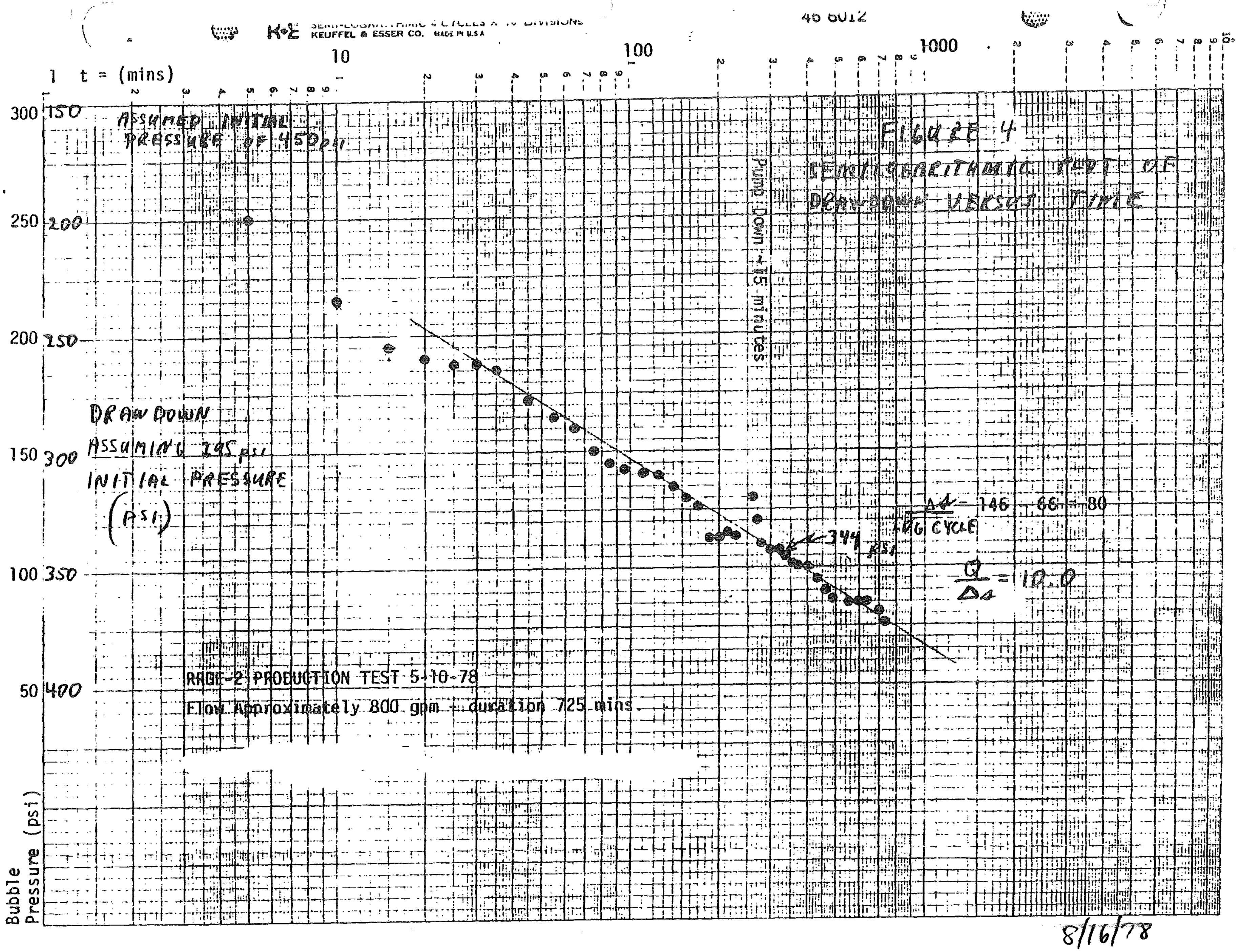


FIGURE 2
GRAPH OF DRAWDOWN AFTER
5 YR. OF PUMPING
BASED ON 225 gpm PUMP TEST
DRAWDOWN AFTER 5 YR OF PUMPING (psi)
600
500
400
300
200
100
0
100
200
300
400
500
600
700
800
900
PUMPING RATE Q(gpm)
EXPECTED WELL PERFORMANCE
INTERFERENCE WITH INJECTION WELL (20 psi)
DRAWDOWN WITH NO INTERFERENCE
INTERFERENCE WITH PUMPING WELLS
8/16/78


SEMI-LOGARITHMIC 359-81
TIME IN MINUTES FROM START OF FLOW
10
100
1,000
FIGURE 3
PRESSURE DECLINE VERSUS LOG TIME FROM START OF FLOW FOR RRGE-2
RRGE-2
PRESSURE DECLINE IN PSI
10
20
30
40
50
60
70
80
90
100
110
Q = 200 gpm
27.5 psi
Q/Δα = 16.0
Δα/LOG CYCLE = 12.5
Q = 250 gpm
43.6 psi
Q/Δα = 13.74
Δα/LOG CYCLE = 18.2
Q = 300 gpm
59.7 psi
Q/Δα = 13.14
Δα/LOG CYCLE = 22.8
Q = 350 gpm
Q = 400 gpm
92.2 psi
Q/Δα = 12.28
Δα/LOG CYCLE = 28.5
Q/Δα = 11.76
Δα/LOG CYCLE = 34.0
Q = 500 gpm
8/16/78


KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6012
t = (mins)
10
100
1000
ASSUMED INITIAL PRESSURE OF 450 psi
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

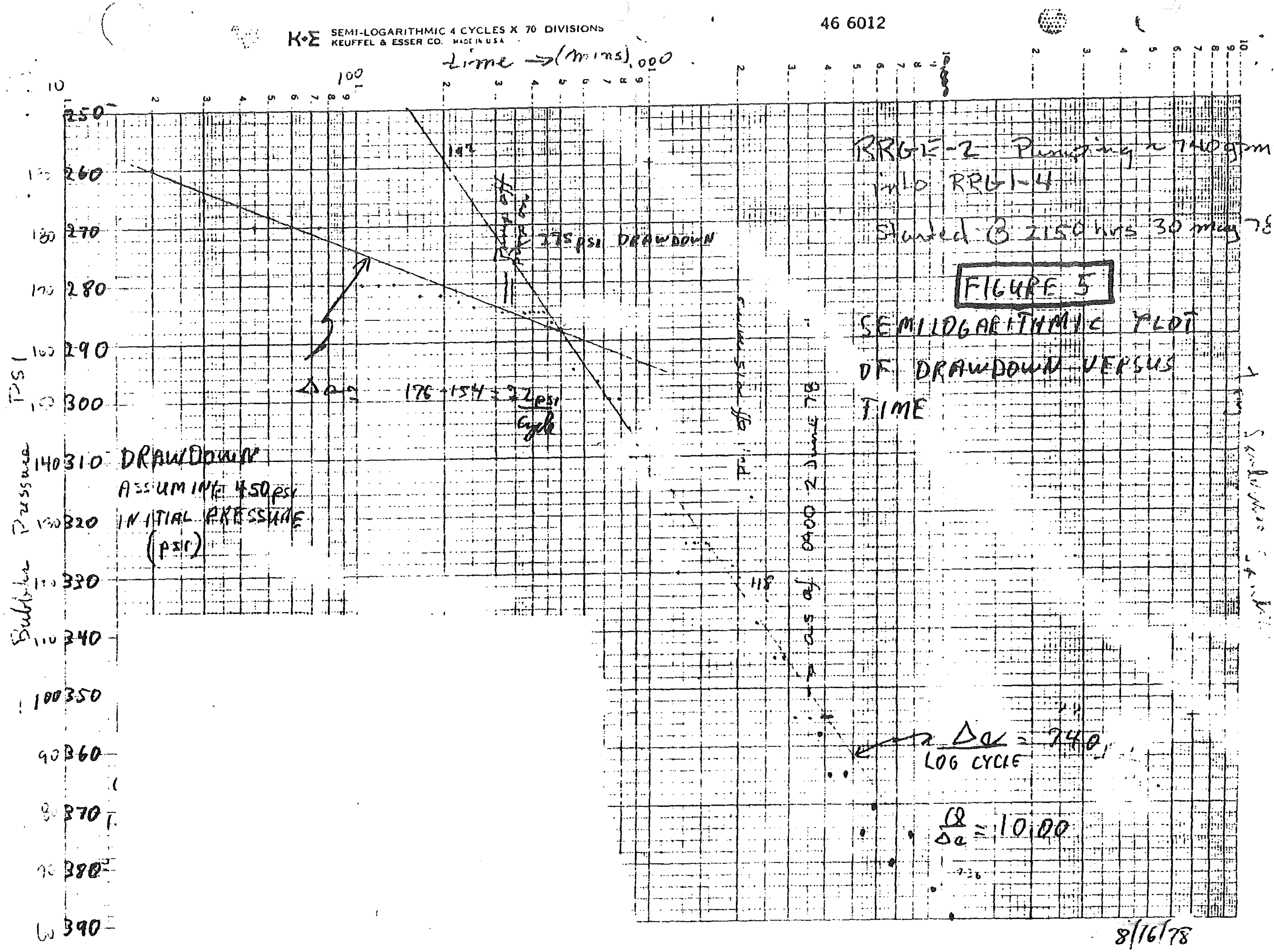


FIGURE 5

SEMILOGARITHMIC PLOT OF DRAWDOWN VERSUS TIME

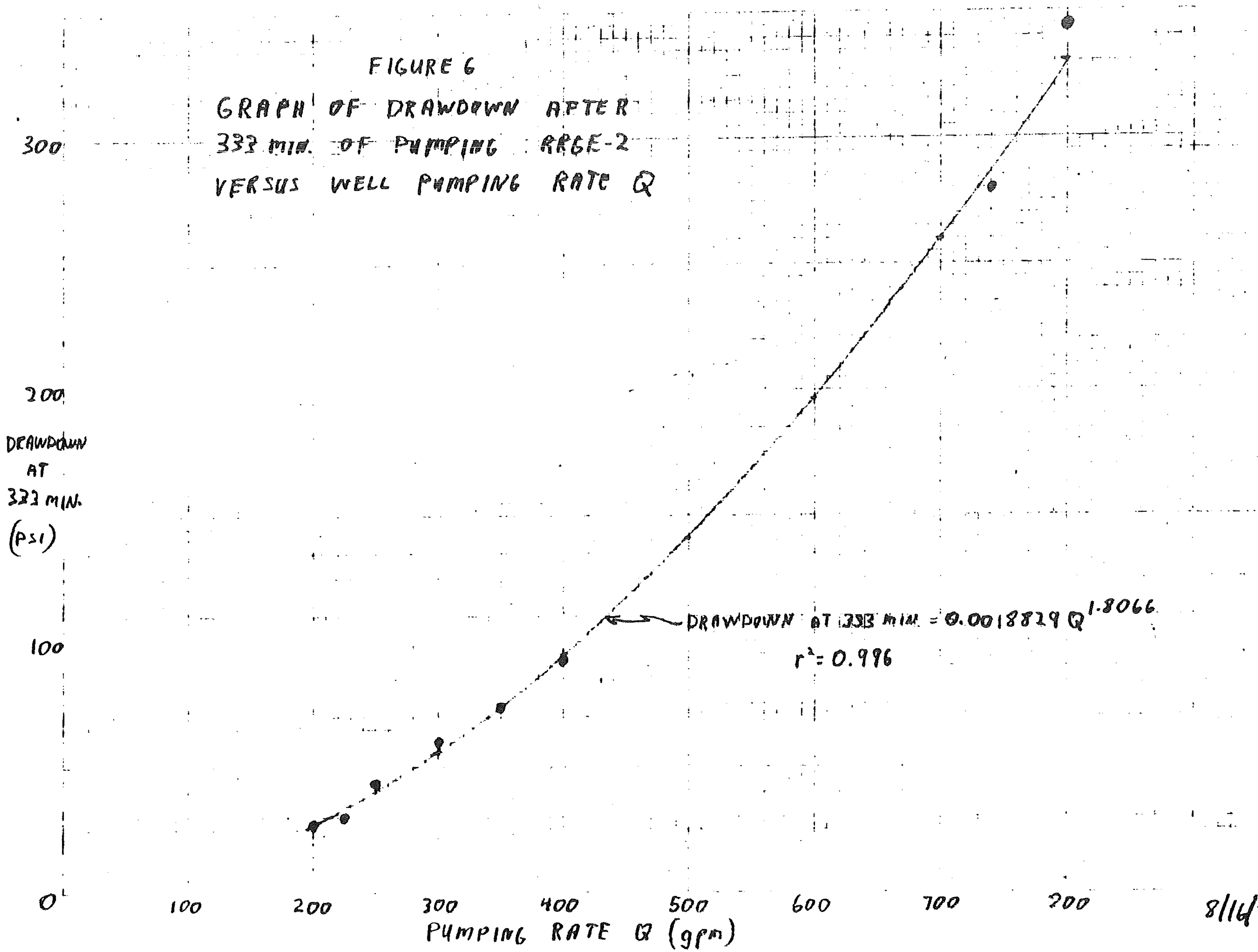


FIGURE 6

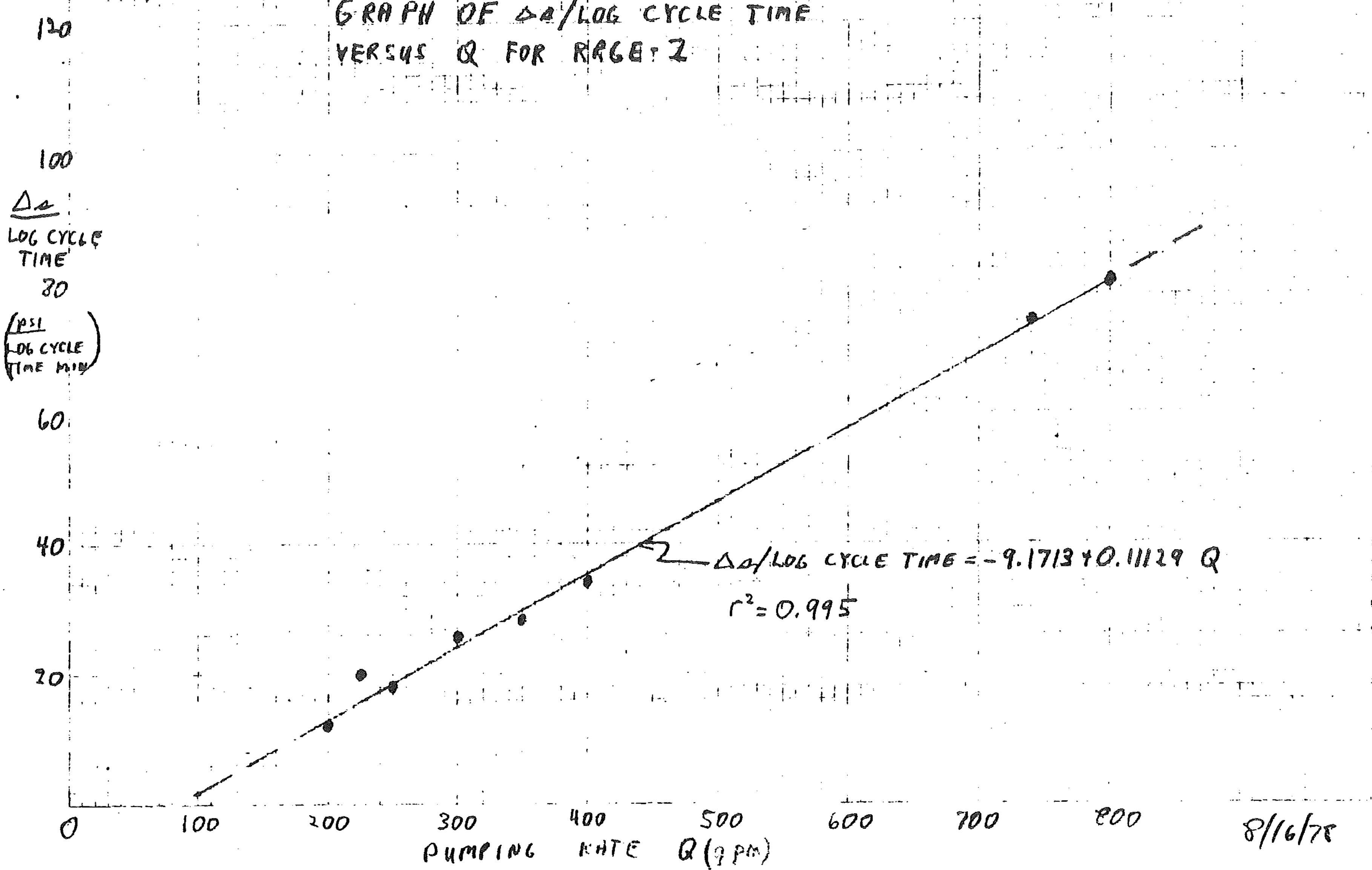
GRAPH OF DRAWDOWN AFTER 333 MIN. OF PUMPING RRGE-2 VERSUS WELL PUMPING RATE Q

$\text{DRAWDOWN AT 333 MIN} = 0.0018829\,Q^{1.8066}$

$r^2 = 0.996$

8/16/78

FIGURE 7
GRAPH OF Δs/LOG CYCLE TIME VERSUS Q FOR RAGE: 2



RRGE 2

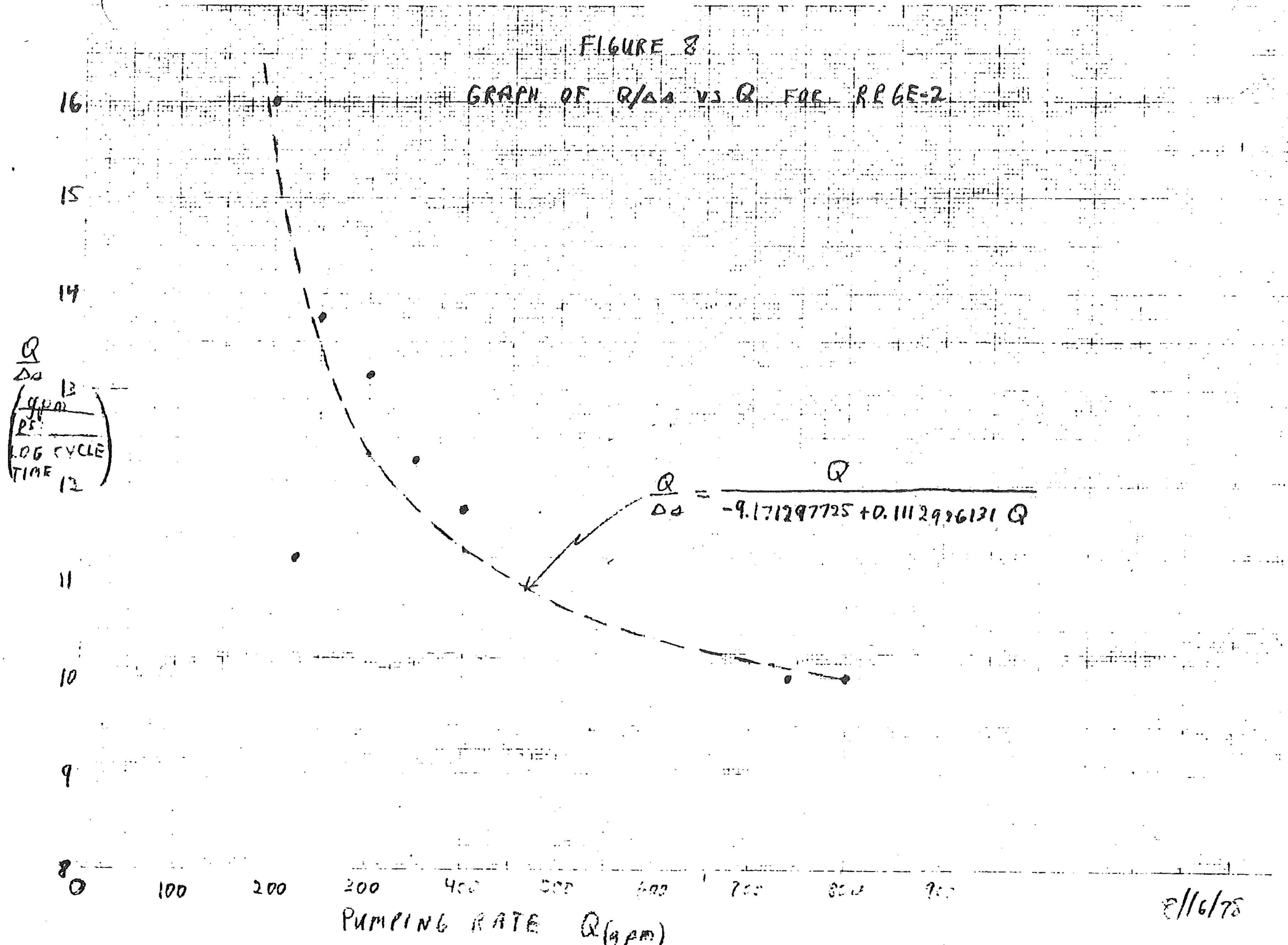


FIGURE 8
GRAPH OF Q/Δs vs Q FOR RRGE-2
16
15
14
13
12
11
10
9
8
Q/Δs (gpm / PSI / LOG CYCLE TIME)
Q/Δs = Q / (-9.171297725 + 0.1112996131 Q)
0
100
200
300
400
PUMPING RATE Q (gpm)

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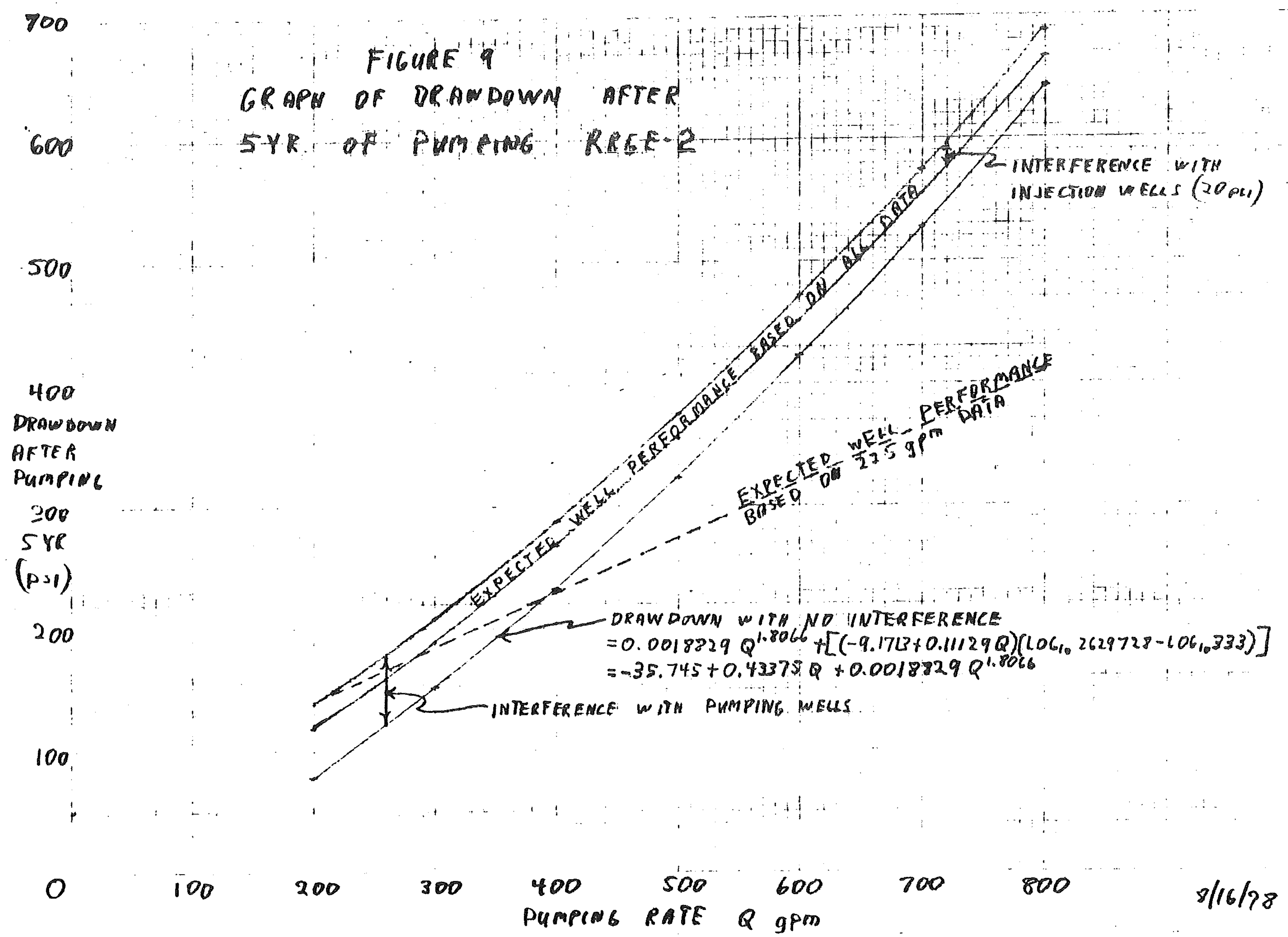
FIGURE 9
GRAPH OF DRAWDOWN AFTER 5 YR OF PUMPING RRGE-2



$= 0.0018829\, Q^{1.8066} + [(-9.1713 + 0.11129Q)(\log_{10} 2629728 - \log_{10} 333)]$

$= -35.745 + 0.43375\, Q + 0.0018829\, Q^{1.8066}$

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