

# SOQ-09831

EVALUATION OF PUMPING TEST CARRIED OUT FROM JUNE 15 TO AUGUST 7, 1978 IN GPR NOEL SHELL  
NO 1 PARKE - OCTOBER 1978 - PROJECT 2076 - REPORT #9831

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Report No 9831  
Project No: 2076

RA/cd

October 1978  
Roberto Aguilera,  
Chief of Production  
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The possibilities of the results of the pumping test may be summarized as follows:

Possibilities

1) The boundaries of the reservoir were reached during the flow test. If this is the case, the potential storage volume is 38 BCF. This relatively "small" reservoir volume might be in agreement with Paul Laroche' interpretation that we are in the presence of many small reservoirs not interconnected.

2) Interpretation of small size reservoir is due to a drastic reduction of permeability far from the borehole and that test was not long enough to obtain 45° line characteristic of infinite reservoirs.

The only firm conclusion that can be drawn from the test is that the volume investigated during the test is equivalent to a storage capacity of 38 BCF.



Mario Sanchez

1978-12-12

## INTRODUCTION

This report evaluates a pumping test carried out in GDP Noel Shell No 1 Parke from June 15 to August 7, 1978.

This test represents step 1 of a detailed program (Refer to Appendix II) leading to possible development of an underground gas storage reservoir in Parke.

The drilling of a second well is recommended to obtain and analyze a core sample, to carry out an interference test with Parke No 1, and to better define the structure.

Efforts have been made to present the analysis as clearly as possible so that it can be used on future re-evaluations of the area.

## CONCLUSIONS

The pump test carried out in Parke from June 15 to August 7, 1978 has been analyzed. The following conclusions have been reached:

1. The analysis suggests that the reservoir boundaries were reached during the test.
2. Average reservoir pressure was calculated to be 2892 psi at the middle of the perforations (6837ft). This results in a pressure gradient of 0.423 psi/ft. The average reservoir pressure was the same before and after the 2nd drawdown test.
3. Many methods were used in the analysis in an effort to squeeze as much information as possible from the test. The following is a summary of the most important results:

| TEST         | METHOD                      | VOLUME<br>INVESTIGATED | AREA<br>INVESTIGATED | EQUIVALENT RADIUS<br>OF INVESTIGATION<br>FOR A CIRCULAR<br>RESERVOIR |
|--------------|-----------------------------|------------------------|----------------------|----------------------------------------------------------------------|
|              |                             | MMbb1                  | acres                | ft                                                                   |
| 1st Drawdown | Cox <sup>5</sup>            | 19,0                   | 226                  | 1770                                                                 |
| 1st Buildup  | Muskat <sup>8</sup>         | 38,1                   | 455                  | 2511                                                                 |
| 2nd Drawdown | Earlougher <sup>10</sup>    | 29,3                   | 367                  | 2255                                                                 |
|              | Park Jones <sup>11</sup>    | 34,5                   | 412                  | 2390                                                                 |
|              | Late Transient <sup>9</sup> | 48,0                   | 573                  | 2810                                                                 |
| 2nd Buildup  | Muskat <sup>8</sup>         | 34,1                   | 407                  | 2375                                                                 |
| Average      |                             | 33,8                   | 406                  | 2351                                                                 |

4. Drawdown data suggest that the reservoir may approximate a rectangular shape.
5. Conventional buildup crossplotting suggests the presence of a layered reservoir without crossflow. This is encouraging because it is an indication that the cap rock which is made out of the same inter-layer lithology, might have sufficiently low permeability to form an efficient seal to gas flow.
6. Muskat's method suggests that the permeability may deteriorate away from the wellbore. Permeability around the wellbore is about 82md, and might reach values as low as 9.4 md near the external boundary. Improved permeability around the well-

bore may be the result of the acid job carried out during the original workover.

7. The storage capacity in the pore volume investigated is in the order of 38 BSCF.

8. The economics of gas storage in Parke are attractive for the pore volume investigated below:

Cost of Cushion gas per unit = \$0.24/MSCF

Unit cost without cushion gas = \$0.32/MSCF

Total Cost = \$0.56/MSCF

The basis for the above economics are presented in detail in page 24.

## RECOMMENDATIONS

The following recommendations are presented:

1. Drill three or four additional wells to obtain and analyze core sample, to carry out interference test and to better define the structure.
2. If results from point 1 above are encouraging carry out economic, engineering and surface environmental studies.
3. Drill 4 additional wells and inject gas to establish structure and closure and obtain better reservoir description.
4. If previous efforts are positive, carry out the development program detailed in page 26 of this report.

## DISCUSSION

The data, equations and methods used in this study will be discussed in full detail, so as to provide the basis for possible future evaluations and refinements.

## BASIC DATA

The following reservoir parameters have been used in this evaluation:

- Total Compressibility ( $C_t$ ): It was found to be  $6.6 \times 10^{-6} \text{ psi}^{-1}$  from the relationship

$$C_t = C_w S_w + C_f \dots\dots\dots(1)$$

where  $C_w$  is water compressibility,  $S_w$  is water saturation, and  $C_f$  is formation compressibility. The water saturation is known to be 100%. The water compressibility was estimated to be  $3 \times 10^{-6} \text{ psi}^{-1}$  using Craft and Hawkins<sup>1</sup> (p. 130) correlation as a function of temperature ( $\approx 100^\circ\text{F}$ ) and water salinity (formation water at Parke is fresh).

Formation (rock) compressibility was determined to be  $3.6 \times 10^{-6} \text{ psi}^{-1}$ , using Hall's<sup>2</sup> correlations as a function of average porosity for the 3 zones ( $\approx 22\%$ ).

- Porosity ( $\phi$ ): Sonic, neutron and density logs were evaluated with the following results:

| Zone | Depth(ft) | h(ft)     | $\phi_f$ | $\phi_n$      | $\phi_s$ | $\phi_f h$  |
|------|-----------|-----------|----------|---------------|----------|-------------|
| 1    | 6750-6758 | 8         | ,32      | >,45          | ,56      | 2,56        |
| 2    | 6774-6800 | 26        | ,20      | >,45          | ,34      | 5,20        |
| 3    | 6962-6977 | <u>15</u> | ,20      | $\approx$ ,40 | ,45      | <u>3,00</u> |
|      |           | 49        |          |               |          | 10,76       |

$$\phi_{avg} = 10,76/49 = ,22$$

Porosities from the density log have been assumed to be the most realistic. The original study<sup>3</sup> on Parke ( attached as Appendix I) used sonic porosities to calculate water saturations. The  $S_w$  values for zones 1, 2 and 3 were 0,40, 0,66, and 0,27 respectively. Further perforating of the 3 zones proved that all intervals were water-bearing. Consequently, it is not unreasonable to speculate that the effective porosities are somewhat smaller than the ones originally calculated. For this reason, porosities from the density log are used in this study. Coring of future wells will permit to calibrate the logs and to change the porosity values if necessary.

Average weighted porosity was calculated to be 22% from the relationship  $\phi_{av} = \Sigma \phi h / \Sigma h$ , as shown in the above table.

- Net Pay (h): It was estimated at 49 ft from log analysis.

All 49 ft were perforated.

- Water Viscosity ( $\mu_w$ ): It was estimated at 0.7 cp at 100°F using Craft and Hawkins<sup>1</sup> correlation (p. 264).

- Wellbore Radius ( $r_w$ ): The well is completed with 9-5/8" casing. Wellbore radius for engineering calculations has been assumed at 0.40 ft.

- Stabilized Production Rates: Production did not stabilize during the first flow test (Figure 1-A).  
159 M<sup>3</sup>PD  
The calculations were made using a rate of 1 000 BWPD which is the approximate average for the last hours. The reader is cautioned that the assumption of the rate being stabilized might introduce some error in the calculations of the first drawdown and first buildup tests.

During the second flow test the rate stabilized at about 1810 BWPD, as shown in Figure 1-B.

- Pressure Measurements: Pressures were recorded at pump depth 1241m of 4073 ft. The middle of the perforations is at 2084m 6837 ft. Pressures were corrected to reservoir conditions by adding a constant equal to  $(6837-4073) \times 0.433 + 14.7$  = 1211.5 psi.

## FIRST DRAWDOWN

This test was carried out between June 14 and June 27, 1978. The results are presented in Table 1. Various problems were developed due to scale deposition in the pump. This part of the test is presented in this study for the sake of completeness. The reader is cautioned, however, that stabilized rate conditions required for proper analysis of the test were not attained, and consequently the results can be considered, at most, only directionally correct.

The data of this test represent a "constant pressure-decreasing rate" situation which is opposed to the more general assumption of "constant rate-decreasing pressure" case for which many solutions are available in the literature.

Two methods have been used in an effort to analyze these data: (1) the type curves of Jacob and Lohman<sup>4</sup>, and (2) the method of Cox<sup>5</sup> which assumes that an exponential decline in production rate is analog to pseudo-state flow when production is at constant pressure rather than constant rate.

- Jacob-Lohman Method: Figure 2 shows a cross-plot of flow rate (BWPD) versus time (hours) in log-log coordinates. This cross-plot was placed over Jacob and Lohman<sup>4</sup> type curves trying to find a match as shown in Figure 3. The match can be considered as very poor. This

might be due to scaling conditions in the pump and various close in periods during the test due to mechanical problems.

A match point was selected from Figure 3 as follows:

$$\begin{aligned} q_d &= 0,11; & q &= 1800 \text{ BWPD} \\ t_d &= 3,1 \times 10^7; & t &= 100 \text{ hours} \end{aligned}$$

With the previous data, the formation permeability was calculated to be 165 md with the use of the equation:<sup>4</sup>

$$k = \frac{141.2 B_w \mu_w}{(P_i - P_{wf}) h} \frac{q}{q_d} \dots\dots\dots (2)$$

where  $B_w$  = water formation volume factor  $\approx 1$  bbl/STB

$P_i$  = initial reservoir pressure = 1680 psi at pump depth (4073 ft) = 2892 psi at the middle of the perforations (6837 ft).

$P_{wf}$  = stabilized flowing pressure = 1480 psi at pump depth = 2691 psi at the middle of perforations.

$q$  = flowing rate, BWPD

The permeability (165 md) is compared with other values in Table 2. The other match point ( $t$  and  $t_d$ ) was also used to calculate permeability from the relationship:

$$k = \frac{\phi c_t \mu r_w^2}{0.0002637} \frac{t_d}{t} \dots\dots\dots (3)$$

This resulted in a permeability of 80.2 md. This permeability is believed to be more realistic as it compares reasonably well with the permeability determined from the 2nd drawdown.

The reader is warned that this method is to be used with a good degree of care using all data at hand and judicious judgement because various matches are possible with the same data due to the very small variations of the type curve  $\Delta Q_d$  during successive  $t_d$  cycles.

- Cox Method<sup>5</sup>: Figure 4 shows a cross-plot of log q versus time, and the approximate exponential decline during the test. The pore volume investigated was calculated from the equation:

$$\phi h A = \frac{5.6146 q_i B_w}{D C_t (P_i - P_{wf})} \dots\dots\dots (4)$$

where  $q_i$  = flow rate at zero flow time = 3000 BWPD

D = exponential decline during flow period  $\approx 0.12/\text{day}$

A = area,  $\text{ft}^2$

In general, this method is applicable to reservoirs with long production history, where it might be possible to determine an accurate exponential decline. With only a few days of history in Parke, the method is expected at the most to give an order of magnitude with regard to pore volume.

Inserting known data in equation 4 resulted in a pore volume of  $106.34 \times 10^6 \text{ ft}^3$  (on  $19 \times 10^6$  bbls). Using  $h = 49 \text{ ft}$  and  $\phi = 22\%$ , the reservoir area was calculated at 226 acres ( $r_e = 1770 \text{ ft}$ ).

The equivalent permeability for an assumed circular reservoir with the previous characteristics was calculated to be 9.8 md from the equation:<sup>6</sup>

$$r_e = \sqrt{\frac{Kt}{40 \phi \mu_w C_t}} \dots\dots\dots (5)$$

where  $t$  was taken at about 13 days.

This is only an equivalent permeability for calculations using circular geometry and must not be confused with the effective permeability of the reservoir which is in the order of 80 md. The difference occurs because the geometry of Parke seems to be more nearly a rectangle (Figure 13) than a circle, as will be discussed in page 15 of this study.

# FIRST BUILDUP

This test was carried out between June 27 and July 15, 1978. (Refer to Table 3). The difficulty in analyzing this test arised from the fact that the flow rate did not stabilize previous to shut-in. Consequently the results are considered only as directionally correct.

A conventional Horner<sup>13</sup> cross-plot of  $(t + \Delta t)/\Delta t$  vs pressure shows the typical buildup shape of a layered reservoir without crossflow (Figure 5). This is fortunate as indeed we know that the test was carried out by producing the 3 perforated intervals at the same time (commingled). Since the curve shape indicates a layered reservoir without crossflow, i.e., without vertical communication among the layers, we can tentatively conclude that there is a good possibility that the cap rock which is made out of the same interlayer lithology might be good enough to serve as impermeable barrier of our potential storage reservoir.

Permeability was calculated to be 63 md from the relationship:<sup>15</sup>

$$K = \frac{162.6 q \mu_w B_w}{hm} \dots\dots\dots (6)$$

where m is the slope of the buildup curve, which in this case was found to be 63 md. Figure 5-B also shows a theoretical pressure buildup curve for a two layer reservoir. It is included here for comparison with the actual pressure buildup curve of Parke. Notice the very close resemblance with Parke (Figure 5-A) for the case of no crossflow.

Conventional buildup analysis of a layered reservoir cannot be carried out for determination of average pressure. Lefkovits et al<sup>7</sup> have shown that the modified Muskat's method<sup>8</sup> of pressure analysis is more reliable for analysis of layered reservoirs.

In this method a cross-plot of  $\log (\bar{P} - P_{ws})$  versus shut-in time is prepared by assuming values of  $\bar{P}$  (Table 4) until a straight line is obtained (Figure 6). From this analysis the average reservoir pressure was found to be 1680 psi at pump depth, or 2892 psi at the middle of the perforations (6837 ft). This results in a pressure gradient of .423 psi/ft. The pore volume investigated was calculated from:

$$V_p = \frac{0.1115 q B_w}{B b C_t} \dots\dots\dots (7)$$

where B is the slope of the straight line (1/350 hrs), and b is the intercept at zero time.

It is also possible to obtain an estimate of permeability from the equation:

$$K = \frac{118.6 q \mu_w B_w}{b h} \dots\dots\dots (8)$$

For Parke, it was found that the pore volume was  $38.1 \times 10^6$  bbls and the area of investigation was 455 acres. It must be pointed out that the straight line obtained using this method indicates that boundary effects have been felt, i.e., that Parke is a bounded reservoir probably not too large.

As a check the product  $B\Delta t$  should be approximately 1.0. For our case the product is certainly  $(1/350) \times 350$  equal to 1.

The permeability was calculated to be 11 md from equation 8, which compares well with other permeability values evaluated from late transient data (Table 2).

The equivalent permeability for an assumed circular reservoir would be 17.6 md based on equation 5.

#### SECOND DRAWDOWN

This test was carried out between July 16 and July 30, 1978 (Refer to Table 5). Various methods were used to analyze this second drawdown.

- Earlougher Method<sup>10</sup>: In this method a cross-plot of pressure versus time is prepared in cartesian coordinates. If the external boundary is felt we should obtain a straight line in the late portion of the drawdown. This occurs in Parke (Fig. 7), and indicates that possibly we are in the presence of a bounded reservoir.

Another crossplot of pressure versus logarithm of flowing time is prepared as shown in Figure 8.

With the data of the two crossplots it is possible to calculate the drainage volume from the equation:

$$\phi Ah = \frac{-0.2339 q B_w}{C_t m^*} \dots\dots\dots (9)$$

where  $m^*$  is the slope (-0.39 psi/hr) in Figure 7, and 9 is the stabilized rate prior to shut-in ( $\approx 1810$  BWPD).

From the previous equation it was found that the drainage volume was  $164.48 \times 10^6$  CF or  $29.32 \times 10^6$  bbls. This corresponds to a drainage area of 367 acres.

Earlougher's methods permit to make an estimate of the drainage area shape by solving the equation:

$$C_A = \frac{5.456 m}{m^*} e^{[2.303 (P_{1hr} - P_o)/m]} \dots\dots\dots (10)$$

where  $C_A$  is the shape dependant factor,  $m$  is the slope (50 psi/cycle) in Figure 8,  $P_{1hr}$  is the pressure read at a flowing time of 1 hr in Figure 7, and  $P_o$  is the pressure extrapolated to time zero in Figure 7.

Calculations with equation 10 indicated that the shape dependant factor,  $C_A$ , for Parke is 0.07. This value was compared with

various shape factors as presented in Figure 9, and it was found to correlate mostly with the geometry for a rectangular reservoir as shown in the Figure.

It must be stressed that this can be considered only as qualitative indication of reservoir shape, rather than an absolute configuration. A reservoir of these characteristics would be 2827 ft by 5634 ft, as shown in Figure 10 to account for an area of 367 acres, porosity of 22%, and net pay of 49 feet.

Permeability was calculated from this drawdown to be 82.4 md with the use of equation 6. This is probably the most representative value for Parke.

The possibility of skin damage was calculated with the use of the equation:

$$S = 1.15 \left[ \frac{P_i - P_{1hr}}{m} - \log \frac{h}{\phi_w C_t R_w^2} + 3.23 \right] \quad (11)$$

where  $r_w$  is the wellbore radius in ft. A skin value,  $S = -3.37$ , was found that indicated stimulation rather than damage as anticipated by the fact that the well had been acidized during the original workover.

11

- Park-Jones Method : This technique was used with the idea of trying to determine the configuration of the reservoir. The method consists of crossplotting Y vs time in log-log coordinate as shown in Figure 11.

$$Y = \frac{dP/dt}{q} \dots\dots\dots (12)$$

The derivative,  $dP/dt$ , is taken from Figure 7 and is tabulated in Table 5. In this approach, the crossplot must result in a  $45^\circ$  straight line if the reservoir is homogeneous. If the line shifts of position the presence of barriers or faults can be inferred. When the line becomes horizontal the presence of a bounded reservoir is very likely.

The approach permits to make an estimate of the angle between barriers based on the various slopes of Figure 8. The following table summarizes the slope and the various angles between barriers:

| <u>Slope</u>      | <u>Flow Barrier</u>             | <u>Angle (<math>m/m_i</math>)</u> |
|-------------------|---------------------------------|-----------------------------------|
| 50                | Radial Flow                     | None                              |
| 105               | Effect of 1st barrier           | $\approx 180^\circ$               |
| 200               | Effect of 2nd barrier           | $90^\circ$                        |
| 265               | Effect of 3rd barrier           | $68^\circ$                        |
| Inward<br>curving | Semi-steady state<br>stabilized |                                   |

The distance to each barrier was calculated with the use of equation 5 assuming a permeability of 84.2 md for the whole reservoir.

$$r_1 = 508 \text{ ft}$$

$$r_2 = 1438 \text{ ft}$$

$$r_3 = 2784 \text{ ft}$$

$$r_4 = 4998 \text{ ft}$$

Figure 12 shows the resulting configuration for Parke, which has an area of about 412 acres. This leads to a pore volume of  $34.5 \times 10^6$  bbls.

Figure 13 shows a comparison of shape area as determined by Earlougher and Park -Jones methods. The results can be considered to compare very well.

- Type Curves<sup>12</sup>: Type curves were used to evaluate the 2nd drawdown as shown in Figure 14. It can be noticed that an acceptable match was obtained with the type curve for "natural, unpropped fractures". Actually we do not have fractures in the reservoir. However, it is possible that the match was obtained with the unpropped fractures solution as a result of the acid-job which was carried out during the completion workover.

Permeability for Parke was calculated from the equation:<sup>12</sup>

$$P_D = \frac{kh (\Delta P)}{141.3 q \mu_w B_w} \dots\dots\dots (13)$$

Figure 14 shows the selected match point at  $P_D = 7.2$ ,  
 $\Delta P = 275$  psi and  $t = 75$  hours,  $t_D = 1000$ .

Using equation 13, permeability was found to be 95.13 md,  
 inclusion of the above match point data, a flow rate of  
 1800 BWPD, water viscosity of 0.7, formation volume factor  
 of 1.0, and pay of 49 ft.

Efforts to calculate the reservoir area from the dimensionless  
 time equation resulted in very unrealistic answers. This might  
 be due to the fact that Parke is not actually a fractured  
 reservoir, but rather a reservoir that was acid-washed during  
 the completion workover.

- Late Transient Analysis:<sup>9</sup> The basis of late transient analysis  
 is a crossplot of  $\log (P_{wf} - \hat{P})$  vs  
 flowing time, where  $\hat{P}$  is wellbore pressure at semi-steady state  
 in psi. This pressure  $\hat{P}$  is determined by trial and error as  
 shown in Figure 15, using the data tabulated in Table 5. A  
 straight line is indicative that the correct  $\hat{P}$  has been used  
 and that the flow has reached semi-steady state. This, of cour-  
 se, is an indication of the presence of a bounded reservoir.

From this analysis the pore volume was calculated to be  $48 \times 10^6$  bbl with the use of equation 7. This corresponds to an equivalent area of 573 acres and an equivalent radius of drainage of 2818 ft.

Equation 8 was used to calculate the permeability of the reservoir at 9.44 md.

## SECOND BUILDUP

This test was carried out between July 31 and August 7, 1978. Various methods were used to analyze this buildup.

- Horner's Method: Data used in Horner's method is presented in Table 6. These data was crossplotted in a conventional Horner graphic as shown in Figure 16. Notice again as in the case of the 1st buildup (Figures 5-A and 5-B) that the curve takes the characteristic shape of a layered reservoir. Permeability from the first slope was calculated to be 33.37 md and that from the second slope was found to be 12.74 md.
- Modified Muskat's Method: The data used for this type of analysis is presented in Table 7. Figure 17

shows the Muskat crossplot, and indicates that the average pressure at pump depth was 1680 psi, or 2892 psi at the middle of the perforations (6837 psi).

The pore volume was calculated to be  $34.06 \times 10^6$  bbls with the use of equation 7. This corresponds to an area of 406.9 acres and an equivalent radius of 2375 ft.

Permeability was calculated to be 9.38 md with the use of equation 8.

- McKinleys Method:<sup>16</sup> A type curve developed by McKinley was used to evaluate the 2nd buildup, as shown in Figure 18. Data are presented in Table 7. Notice that a good match is obtained with type curve which corresponds to  $T/F = 25\ 000$ , where T is transmissibility and F is a wellbore storage factor. The analysis using McKinley's type curves is carried out as follows:

1. A match with the type curve is obtained as indicated in Figure 18.
2. The parametric value of T/F is recorded ( $T/F = 25\ 000$ ).
3. A match point is selected. For this case

$$\begin{aligned}\Delta P F / Q &= 0.029 \\ \Delta t &= 400 \text{ min} \\ \Delta P &= 185 \text{ psi} \\ \Delta t &= 384 \text{ min}\end{aligned}$$

where  $\Delta P F / Q$  is a pressure buildup group, and Q is the flow rate.

4. The wellbore storage factor is calculated from

$$F = \frac{Q \times (\Delta P_F/Q)}{\Delta P} = \frac{1810 \times 0.29}{185} = 0.28 \dots\dots\dots (14)$$

5. Wellbore transmissibility is obtained from:

$$T_{wb} = \frac{kh}{\mu} = \frac{T}{F} \times F \dots\dots\dots (15)$$

or  $25\ 000 \times 0.28 = 7000$  md-ft/cp. This analysis indicates that permeability around the wellbore is 100 md.

6. A new match is obtained with the part of the actual curve not matched in point 1 above.

7. The parametric value  $(T/F)_F$  for the new match is  $T/F = 2\ 500$ . This is only an approximation because the match is not very conclusive in this position.

8. Calculate formation transmissibility from

$$T_F = (T/F)_F \times F \dots\dots\dots (16)$$

which for this case is  $2500 \times 0.28 = 700$  md-ft/cp.

This results in a formation permeability of 10 md.

#### GAS STORAGE CAPACITY IN PORE VOLUME INVESTIGATED

Storage capacity in the pore volume investigated has been calculated assuming that we can inject gas up to 4000 psi in the reservoir.

Gas formation volume factor for this condition was calculated to be 0.00349 cf/SCF from the equation:

$$B_{gi} = 0.02771 \times Z \times \frac{T_{res}}{P_{res}} \dots\dots\dots (17)$$

where  $B_{gi}$  = formation volume factor, CF/SCF

$Z$  = gas deviation factor  $\approx 0.9$

$T$  = reservoir temperature  $\approx 560^{\circ}R$

$P$  = reservoir pressure, psi

Gas storage capacity was calculated assuming the zone to be invaded by gas will reduce its water saturation to 30%, from the equation:

$$Vol = \frac{A \times 43560 \times h \times (1 - S_w) \times \Phi}{B_{gi}} \dots\dots\dots (18)$$

where  $A$  = area = 406 acres

$h$  = net pay = 49 ft

$S_w$  = water saturation = 30%

$\Phi$  = porosity = 22%

The previous equation indicated that we can inject  $38 \times 10^9$  SCF in the pore volume investigated in Parke.

#### ECONOMICS

The economics have been run assuming that we will have 20 BSCF of working gas and 18 BSCF of cushion gas. Basic steps indicated in memo of June 29, 1978 giving DETAIL OF INVESTMENT REQUIRED IN PARKE UNDERGROUND STORAGE

PROJECT (attached as Appendix II) would continue being the same, but the economics would change as follows:

| <u>STEP</u> | <u>DESCRIPTION OF JOB</u>                                                                                                                                                 | <u>INVESTMENT (\$)</u> |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| 1           | Pumping test to determine:<br>A) Permeability<br>B) Minimum Size of aquifer<br>C) Intensity of cap rock                                                                   | \$ 200,000             |
| 2           | Drill one well<br>A) To obtain and analyze core sample<br>B) To carry out interference test and to establish<br>reservoir continuity<br>C) To better define the structure | 1,500,000              |
| 3           | Carry out the following studies:<br>A) Technical and economical feasibility<br>B) Seismic<br>C) Surface (flora, fauna and land usage)<br>environmental studies            | 100,000<br><br>100,000 |
| 4           | Drill 4 wells and inject gas to<br>A) Establish structure and closure<br>B) Obtain more detailed reservoir description                                                    | 6,000,000              |
| T O T A L:  |                                                                                                                                                                           | \$ 7,900,000           |

| <u>STEP</u> | <u>DESCRIPTION OF JOB</u>                                                             | <u>INVESTMENT (\$)</u> |
|-------------|---------------------------------------------------------------------------------------|------------------------|
| 5           | Carry out a development program                                                       |                        |
|             | - Probable reservoir area = 406 acres                                                 |                        |
|             | - Total reservoir capacity = 38 BSCF                                                  |                        |
|             | - Working gas = 20 BSCF                                                               |                        |
|             | - Cushion gas = 18 BSCF @ \$3./MSCF                                                   | \$ 54,000,000          |
|             | - Assumed average deliverability per well = 30 MMSCF                                  |                        |
|             | - Required number of wells assuming production cycles of 100 days:                    |                        |
|             | $\frac{20 \text{ BSCF}}{30 \text{ MMSCFD} \times 100 \text{ days}} = 7 \text{ wells}$ | 7,000,000              |
|             | - Well spacing = 406 acres/7 wells = 58 acres/well                                    |                        |
|             | - Drill 3 observation wells                                                           | 3,000,000              |
|             | - Compression system (13,000 BHP)                                                     | 13,000,000             |
|             | - Gathering system                                                                    | 2,500,000              |
|             | - 8 mile long pipeline                                                                | 5,500,000              |
|             | INVESTMENT:                                                                           | <u>\$85,000,000</u>    |

#### ESTIMATE OF TOTAL COST PER UNIT

The investment without cushion gas is estimated at \$31,000,000.

The per unit cost without cushion gas has been calculated as follows:

|                                                                                                                                             |                  |
|---------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| Interest (10% on \$31,000,000)                                                                                                              | \$3,100,000      |
| Depreciation (20 years, straight line)                                                                                                      | 1,550,000        |
| Operating cost (\$2000/well/month + \$0.075/MSCF)                                                                                           |                  |
| $= \frac{\$2000 \times 7 \text{ wells} \times 12 \text{ months}}{\text{well-month}} + \frac{\$0.075 \times 20 \text{ BSCF}}{\text{MSCF}} =$ | <u>1,668,000</u> |

SUBTOTAL \$6,318,000

Unit cost without cushion gas =  $\frac{\$6,318,000}{20 \text{ BSCF}} = \frac{\$0.32}{\text{MSCF}}$

The unitary cost of cushion gas was calculated as follows:

|                                 |                    |
|---------------------------------|--------------------|
| Interest (10% on \$54,000,000)  | \$5,400,000        |
| Escalation (5% on \$54,000,000) | (2,700,000)        |
| Depreciation                    | <u>1,550,000</u>   |
|                                 | <u>\$4,250,000</u> |

$$\text{Unit cost of cushion gas} = \frac{\$4,250,000}{18 \text{ BSCF}} = \frac{\$0.24}{\text{MSCF}}$$

$$\underline{\text{TOTAL COST PER UNIT}} = \$0.32 + \$0.24 = \underline{\underline{\$0.56}}$$

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TABLE 1  
IST DRAWDOWN

GPR NOEL SHELL NO 1 PARKE

| <u>DATE ET HEURE</u> | <u>TEMPS (HR)</u> | <u>V<sub>1</sub></u> | <u>V<sub>2</sub></u> | <u>P PUIT</u> | <u>P SURFACE</u> | <u>REMARQUES</u>            | <u>B/D</u> |
|----------------------|-------------------|----------------------|----------------------|---------------|------------------|-----------------------------|------------|
| <u>14 juin</u>       |                   |                      |                      |               |                  |                             |            |
| 18h00                | 0                 | 0                    | 0                    | ---           | ---              | Ajustement des génératrices | 1175       |
| 18h35                | 0.58              | 1,000                | 1,007                | ---           | ---              |                             |            |
| <u>15 juin</u>       |                   |                      |                      |               |                  |                             |            |
| 09h35                | 15.58             | 1,000                | 1,007                | ---           | ---              | Q ≈ 80 gpm PH ≈ 14.0        | 3291       |
| 11h00                | 17                | 6,420                | 6,450                | ---           | ---              | Q ≈ 57 gpm PH ≈ 11.0        | 2345       |
| 12h00                | 18                | ≈ 9,500              | ≈ 9,500              | ---           | 525              | PH ≈ 7.5                    |            |
| 15h30                | 21.5              | ---                  | ---                  | 832           | 510              | Q ≈ 58 gpm                  | 2386       |
| <u>16 juin</u>       |                   |                      |                      |               |                  |                             |            |
| 08h00                | 36                | 75,600               | 76,500               | ---           | 450              | Q = 55.3 gpm PH ≈ 7.5       | 2275.2     |
| 16h30                |                   | ---                  | ---                  | ---           | 370              | Q = 46 gpm Choke: 20        | 1892       |
| 16h53                |                   | ---                  | ---                  | ---           | 240              | Q = 49 gpm Choke: 23        | 2016       |
| 20h00                | 50                | 110,000              | 111,400              | 1115.2        | 215              |                             |            |
| <u>17 juin</u>       |                   |                      |                      |               |                  |                             |            |
| 08h00                | 62                | 132,900              | 134,500              | 1209.5        | 0                | Arrêt de la pompe à 05h00   |            |
| 08h08                |                   | 133,000              | 134,600              | 1211.3        | 0                | puis arrêt 06h30-08h05      |            |
| 09h47                |                   | 133,100              | 134,700              | 1210          | 190              | Intermittents: 09h45        |            |
| 11h42                |                   | 133,600              | 135,200              | ---           | 540              | Mise en marche manuelle     |            |
| ≈ 13h00              | 67                | 136,200              | 137,800              | 1207          | 310              |                             |            |
| 14h30                |                   | 136,800              | 138,500              | 1202.6        | 315              |                             |            |
| 18h10                |                   | 137,200              | 138,900              | 1208.5        | 315              |                             |            |

TABLE I (CONT)

| <u>DATE ET HEURE</u> | <u>TEMPS (HR)</u> | <u>V<sub>1</sub></u> | <u>V<sub>2</sub></u> | <u>P PUITES</u> | <u>P SURFACE</u> | <u>REMARQUES</u>                      | <u>B/D</u> |
|----------------------|-------------------|----------------------|----------------------|-----------------|------------------|---------------------------------------|------------|
| <u>18 juin</u>       |                   |                      |                      |                 |                  |                                       |            |
| 07h00                |                   | 141,100              | 142,800              | 1205.3          | ---              | Arrêt après quelques minutes          |            |
| 13h00                |                   | 141,300              | 143,000              | 1124.3          | 400              | Q = 41 gpm Choke: 18.5                | 1686       |
| 13h11                |                   | 141,700              | 143,411              | 1125.9          | ---              |                                       |            |
| 13h54                |                   | 141,700              | 143,411              | 1130.6          | 0                | Choke ouvert                          |            |
| 13h57                |                   | 141,854              | 143,572              | 1130.2          | 0                |                                       |            |
| 15h00                | 93                | 141,854              | 143,572              | 1133.9          | 0                | V primaire: 480 volts                 |            |
| 15h03                |                   | 142,037              | 143,756              | 1133.7          | 0                | V sec: 1010<br>I: 31 amp              |            |
| <u>19 juin</u>       |                   |                      |                      |                 |                  |                                       |            |
| 08h00                |                   | 142,037              | 143,756              | 1510.1          | 0                | Prélevé un échantillon                |            |
| 08h04                |                   | 142,243              | 143,965              | 1507.6          | 0                | d'eau                                 |            |
| <u>20 juin</u>       |                   |                      |                      |                 |                  |                                       |            |
|                      |                   |                      |                      |                 |                  | Ajusté l'appareil de pression Sperry. |            |
| <u>21 juin</u>       |                   |                      |                      |                 |                  |                                       |            |
| 08h30                | 158.5             | 142,243              | 143,965              | 1647.5          | 5                | Q = 51 gpm                            | 2098       |
| 08h40                |                   | ---                  | ---                  | 1628.3          | 5                | Q = 51 gpm                            | 2098       |
| 08h50                |                   | ---                  | ---                  | 1595.5          | 5                | Q = 51 gpm                            | 2098       |
| 09h00                | 159.0             | ---                  | ---                  | 1570.5          | 5                | Q = 51 gpm                            | 2098       |
| 09h15                |                   | ---                  | ---                  | 1550.2          | 5                | Q = 51 gpm                            | 2098       |
| 09h30                |                   | ---                  | ---                  | 1540.7          | 5                | Q = 51 gpm                            | 2098       |
| 09h45                |                   | ---                  | ---                  | 1538.8          | 5                | Q = 51 gpm                            | 2098       |
| 10h00                | 160               | 146,700              | 148,478              | 1537.8          | 5                | Q = 48.8 90 min                       | 2049       |
| 10h30                |                   | 148,203              | 149,981              | 1536.7          | 5                | Q = 50.1 30 min                       | 2061       |
| 11h00                | 161               | 149,689              | 151,482              | 1536.5          | 5                | Q = 49.8 30 min                       | 2049       |
| 11h30                |                   | 151,178              | 152,983              | 1535.0          | 5                | Q = 49.8 30 min                       | 2049       |
| 12h00                | 162               | 152,667              | 154,486              | 1533.5          | 5                | Q = 49.9 30 min                       | 2053       |

TABLE I (CONT)

| DATE ET HEURE         | TEMPS (HR) | V <sub>1</sub> | V <sub>2</sub> | P PUIT | P SURFACE | REMARQUES        | B/D  |
|-----------------------|------------|----------------|----------------|--------|-----------|------------------|------|
| <u>21 juin (cont)</u> |            |                |                |        |           |                  |      |
| 13h00                 |            | 155,600        | 157,500        | 1531.9 | 5         | Q = 49.6 1 hr    | 2041 |
| 14h00                 |            | 158,591        | 160,468        | 1530.8 | 5         | Q = 49.7 1 hr    | 2041 |
| 15h00                 |            | 161,524        | 163,429        | 1526.9 | 5         | Q = 49.1 1 hr    | 2020 |
| 16h00                 |            | 164,442        | 166,380        | 1523.7 | 5         | Q = 48.9 1 hr    | 2012 |
| 17h00                 |            | 167,345        | 169,312        | 1520.6 | 5         | Q = 48.6 1 hr    | 1999 |
| 18h00                 | 168        | 170,290        | 172,285        | 1518.2 | 5         | Q = 49.3 { 48.3  | 1987 |
| 19h00                 |            | 173,080        | 175,106        | 1513.8 | 5         | Q = 46.76 {      |      |
| 20h00                 | 170        | 175,855        | 177,940        | 1509.9 | 5         | Q = 46.74 {      |      |
| 21h00                 |            | 178,710        | 180,895        | 1507.0 | 5         | Q = 48.42 {      |      |
| 22h00                 | 172        | 181,500        | 183,605        | 1504.0 | 5         | Q = 45.8 { 46.9  | 1930 |
| 23h00                 |            | 184,270        | 186,415        | 1501.3 | 5         | Q = 46.5 {       |      |
| 24h00                 | 174        | 187,070        | 189,246        | 1499.0 | 5         | Q = 46.9 {       |      |
| <u>22 juin</u>        |            |                |                |        |           |                  |      |
| 01h00                 |            | 189,800        | 192,005        | 1497.1 | 0         | Q = 45.7         | 1880 |
| 02h00                 | 176        | 192,500        | 194,738        | 1495.4 | 0         | Q = 45.3         | 1864 |
| 03h00                 |            | 195,177        | 197,441        | 1493.9 | 0         | Q = 44.8         | 1843 |
| 04h00                 | 178        | 197,825        | 200,120        | 1492.4 | 0         | Q = 44.4         | 1826 |
| 05h00                 |            | 200,447        | 202,770        | 1492.6 | 0         | Q = 43.9         | 1806 |
| 06h00                 | 180        | 203,038        | 205,390        | 1492.6 | 0         | Q = 43.4         | 1786 |
| 07h00                 |            | 205,600        | 207,980        | 1493.3 | 0         | Q = 42.9         | 1765 |
| 08h00                 | 182        | 208,133        | 210,545        | 1494.0 | 0         | Q = 42.5         | 1749 |
| 09h00                 |            | 210,625        | 213,025        | 1493.4 | 0         | Q = 41.4         | 1703 |
| 10h00                 | 184        | 213,119        | 215,591        | 1492.5 | 0         | Q = 42.1         | 1732 |
| 11h00                 |            | 215,563        | 218,070        | 1492.3 | 0         | Q = 41.1         | 1691 |
| 12h00                 | 186        | 217,985        | 220,526        | 1491.4 | 0         | Q = 40.6         | 1670 |
| 14h00                 |            | 222,750        | 225,455        | 1490.1 | 0         | Q = 40.4 gpm 2 h | 1662 |
| 16h00                 | 190        | 227,305        | 230,070        | 1489.1 | 0         | Q = 38.2 2 h     | 1572 |
| 20h00                 | 194        | 236,470        | 239,265        | 1487.6 | 0         | Q = 38.3 2 h     | 1576 |

TABLE I (CONT)

| <u>DATE ET HEURE</u> | <u>TEMPS (HR)</u> | <u>V<sub>1</sub></u> | <u>V<sub>2</sub></u> | <u>P PUIITS</u> | <u>P SURFACE</u> | <u>REMARQUES</u>                 | <u>B/D</u> |
|----------------------|-------------------|----------------------|----------------------|-----------------|------------------|----------------------------------|------------|
| <u>23 juin</u>       |                   |                      |                      |                 |                  |                                  |            |
| 08h00                | 206               | 261,690              | 264,765              | 1485.4          | 0                | Q = 35.2 gpm 12 h                | 1448       |
| 20h00                | 218               | 284,490              | 288,810              | 1484.6          | 0                | Q = 32.5 gpm 17 h                | 1337       |
| <u>24 juin</u>       |                   |                      |                      |                 |                  |                                  |            |
| 08h00                | 230               | 305,370              | 309,230              | 1482.8          | 0                | Q = 28.7 gpm 12 h<br>I = 28-29-A | 1181       |
| 20h00                | 242               | 324,726              | 328,911              | 1484.0          | 0                | Q = 27.1 gpm 12 h                | 1115       |
| <u>25 juin</u>       |                   |                      |                      |                 |                  |                                  |            |
| 08h00                | 254               | 342,612              | 347,070              | 1485.2          | 0                | Q = 25.0 gpm 12 h                | 1029       |
| 20h00                | 266               | 359,425              | 364,155              | 1486.3          | 0                | Q = 23.5 gpm 12 h                | 967        |
| <u>26 juin</u>       |                   |                      |                      |                 |                  |                                  |            |
| 08h00                | 278               | 375,290              | 380,255              | 1488.6          | 0                | Q = 22.2 gpm 18 h                | 913        |
| 20h00                | 290               | 390,551              | 395,570              | 1490.0          | 0                | Q = 21.2 gpm 12 h                | 873        |
| <u>27 juin</u>       |                   |                      |                      |                 |                  |                                  |            |
| 08h00                | 302               | 404,785              | 410,225              | 1488.8          | 0                | Q = 20.0 gpm 12 h                | 823        |
| 12h00                | 306               | 409,414              | 414,951              | 1490.0          | 0                | Q = 19.5 gpm 4 h                 | 802        |
| 16h00                | 310               | 404,019              | 419,635              | 1490.3          | 0                | Q = 19.4 gpm 4 h                 | 798        |
| 20h00                | 314               | 418,584              | 424,258              | 1489.6          | 0                | Q = 19.1 gpm 4 h                 | 786        |
| 21h00                | 315               | 419,651              | 425,364              | 1489.0          | 0                | Q = 18.7 gpm 53 min              | 769        |

21h00: FERME LE PUIITS POUR UNE REMONTEE DE PRESSION JUSQU'AU 12 JUILLET

TABLE 2

GPR NOEL SHELL NO 1 PARKE  
SUMMARY OF PUMPING TEST RESULT

| TEST         | METHOD                        | VOLUME<br>INVESTIGATED<br>MMres bbl | AREA<br>INVESTIGATED<br>acres | EQUIVALENT<br>Ri FOR A<br>CIRCULAR<br>RESERVOIR<br>ft | PERMEABILITY (md) BASED ON |                |                |                |                                        |            |
|--------------|-------------------------------|-------------------------------------|-------------------------------|-------------------------------------------------------|----------------------------|----------------|----------------|----------------|----------------------------------------|------------|
|              |                               |                                     |                               |                                                       | LATE<br>TRANSIENT          | P <sub>D</sub> | t <sub>D</sub> | q <sub>D</sub> | KNOWN PORE<br>VOLUME AND<br>EQUATION 5 | EQUATION 6 |
| 1st drawdown | Cox<br>Jacob & Lohman         | 19.0                                | 226                           | 1770                                                  | ---                        | ---            | ---            | ---            | 9.8                                    | ---        |
|              |                               | ---                                 | ---                           | ---                                                   | ---                        | ---            | 80.2           | 165            | ---                                    | ---        |
| 1st buildup  | Muskat<br>Hurst-vanEverdingen | 38.1                                | 455                           | 2511                                                  | 11.0                       | ---            | ---            | ---            | 17.6                                   | ---        |
|              |                               | ---                                 | ---                           | ---                                                   | 13.5                       | ---            | ---            | ---            | ---                                    | 63         |
| 2nd drawdown | Type curves                   | ---                                 | ---                           | ---                                                   | ---                        | 95.1           | ---            | ---            | ---                                    | ---        |
|              | Earlougher                    | 29.3                                | 367                           | 2255                                                  | ---                        | ---            | ---            | ---            | 13.8                                   | 82.4       |
|              | Park Jones                    | 34.5                                | 412                           | 2390                                                  | ---                        | ---            | ---            | ---            | 15.5                                   | 82.4       |
|              | Late Transient                | 48.0                                | 573                           | 2810                                                  | 9.4                        | ---            | ---            | ---            | 21.4                                   | ---        |
| 2nd buildup  | Muskat                        | 34.1                                | 407                           | 2375                                                  | 9.4                        | ---            | ---            | ---            | 32.9                                   | ---        |
|              | Hurst vanEverdingen           | ---                                 | ---                           | ---                                                   | 12.7                       | ---            | ---            | ---            | ---                                    | ---        |
|              | McKinley type curve           | ---                                 | ---                           | ---                                                   | 10.0                       | ---            | ---            | ---            | ---                                    | ---        |

TABLE 3

## 1ER BUILDUP

## GPR NOEL SHELL NO 1 PARKE

|                      |               |                      |           |                        | Type Curve                |
|----------------------|---------------|----------------------|-----------|------------------------|---------------------------|
|                      |               | P <sub>mesurée</sub> | t + Δt    | P <sub>formation</sub> | $\hat{P} - 1180$          |
| <u>DATE ET HEURE</u> | <u>Δt (h)</u> | <u>(psig)</u>        | <u>Δt</u> | <u>(psia)</u>          | <u>P<sub>ws</sub> - P</u> |
| <u>27 juin</u>       |               |                      |           |                        |                           |
| 21h02                | 0.020         | 1489.0               | 20.064    | 2701                   | 308                       |
| 21h025               | 0.025         | 1489.0               | 16.051    | 2701                   | 308                       |
| 21h030               | 0.030         | 1489.0               | 13.376    | 2701                   | 308                       |
| 21h040               | 0.040         | 1489.4               | 10.032    | 2701                   | 309.4                     |
| 21h03                | 0.050         | 1489.8               | 8.026     | 2701                   | 309.8                     |
| 21h04                | 0.060         | 1490.2               | 6.689     | 2702                   | 310.20                    |
| 21h05                | 0.080         | 1491.6               | 5.017     | 2703                   | 311.6                     |
| 21h06                | 0.100         | 1493.1               | 4.014     | 2705                   | 313.10                    |
| 21h08                | 0.130         | 1495.6               | 3.088     | 2707                   | 315.6                     |
| 21h09                | 0.150         | 1497.1               | 2.676     | 2709                   | 317.10                    |
| 21h11                | 0.190         | 1501.0               | 2.113     | 2713                   | 321.00                    |
| 21h14                | 0.240         | 1505.1               | 1.673     | 2717                   | 325.10                    |
| 21h19                | 0.310         | 1510.4               | 1.295     | 2722                   | 330.4                     |
| 21h23                | 0.390         | 1515.2               | 1.030     | 2727                   | 335.20                    |
| 21h29                | 0.480         | 1519.1               | 837       | 2731                   | 339.1                     |
| 21h36                | 0.600         | 1522.3               | 670       | 2734                   | 342.3                     |
| 21h45                | 0.720         | 1524.6               | 536       | 2736                   | 344.6                     |
| 21h57                | 0.950         | 1525.6               | 423       | 2737                   | 345.6                     |
| 22h12                | 1.200         | 1526.6               | 335       | 2738                   | 346.60                    |
| 22h30                | 1.500         | 1527.2               | 269       | 2739                   | 347.20                    |
| 22h48                | 1.800         | 1527.7               | 224       | 2739                   | 347.70                    |
| 23h24                | 2.400         | 1528.5               | 168       | 2740                   | 348.50                    |
| 24h00                | 3.000         | 1529.0               | 135       | 2741                   | 349.0                     |

TABLE 3 (CONT)

1ST BUILDUPGPR SHELL NO 1 PARKE

|                      |                                  |                                                   |                                                   |                                                     | Type Curve                           |
|----------------------|----------------------------------|---------------------------------------------------|---------------------------------------------------|-----------------------------------------------------|--------------------------------------|
|                      |                                  |                                                   |                                                   |                                                     | $\hat{P} - 1180$                     |
| <u>DATE ET HEURE</u> | <u><math>\Delta t</math> (h)</u> | <u><math>P_{\text{mesurée}}</math><br/>(psig)</u> | <u><math>\frac{t + \Delta t}{\Delta t}</math></u> | <u><math>P_{\text{formation}}</math><br/>(psia)</u> | <u><math>P_{ws} - \hat{P}</math></u> |
| <u>28 juin</u>       |                                  |                                                   |                                                   |                                                     |                                      |
| 00h48                | 3.800                            | 1529.4                                            | 107                                               | 2741                                                | 349.0                                |
| 01h42                | 4.700                            | 1530.4                                            | 86                                                | 2742                                                | 350.40                               |
| 03h00                | 6.000                            | 1532.3                                            | 68                                                | 2744                                                | 352.30                               |
| 04h24                | 7.400                            | 1534.0                                            | 55.2                                              | 2746                                                | 354.00                               |
| 06h18                | 9.300                            | 1536.2                                            | 44.1                                              | 2748                                                | 356.20                               |
| 09h00                | 12.000                           | 1539.6                                            | 34.4                                              | 2751                                                | 359.60                               |
| 12h00                | 15.000                           | 1542.7                                            | 27.8                                              | 2754                                                | 362.70                               |
| 16h00                | 19.000                           | 1546.4                                            | 22.1                                              | 2758                                                | 366.40                               |
| 20h30                | 23.500                           | 1549.3                                            | 18.1                                              | 2761                                                | 369.30                               |
| <u>29 juin</u>       |                                  |                                                   |                                                   |                                                     |                                      |
| 01h30                | 28.500                           | 1551.0                                            | 15.1                                              | 2763                                                | 371.00                               |
| 06h30                | 33.500                           | 1555.9                                            | 13.0                                              | 2767                                                | 375.90                               |
| 09h30                | 36.500                           | 1561.3                                            | 12.0                                              | 2773                                                | 381.30                               |
| 14h00                | 41.000                           | 1566.9                                            | 10.8                                              | 2778                                                | 386.90                               |
| 18h00                | 46.000                           | 1567.2                                            | 9.72                                              | 2779                                                | 387.90                               |
| <u>30 juin</u>       |                                  |                                                   |                                                   |                                                     |                                      |
| 00h30                | 51.500                           | 1573.1                                            | 8.8                                               | 2785                                                | 393.10                               |
| 16h00                | 67.000                           | 1582.2                                            | 7.0                                               | 2794                                                | 402.20                               |
| 01h30                | 76.500                           | 1588.7                                            | 6.25                                              | 2800                                                | 408.20                               |

TABLE 3 (CONT)

1ST BUILDUPGPR SHELL NO 1 PARKE

| DATE ET HEURE      | $\Delta t$ (h) | $P_{\text{mesurée}}$<br>(psig) | $\frac{t + \Delta t}{\Delta t^2}$ | $P_{\text{formation}}$<br>(psia) | Type Curve<br>$\hat{P} - 1180$<br>$P_{ws} - \hat{P}$ |
|--------------------|----------------|--------------------------------|-----------------------------------|----------------------------------|------------------------------------------------------|
| <u>1er juillet</u> |                |                                |                                   |                                  |                                                      |
| 14h00              | 89.000         | 1599.3                         | 5.51                              | 2811                             | 419.30                                               |
| 05h30              | 104.500        | 1605.0                         | 4.84                              | 2817                             | 425.00                                               |
| <u>2 juillet</u>   |                |                                |                                   |                                  |                                                      |
| 19h00              | 118.000        | 1612.5                         | 4.40                              | 2824                             | 432.50                                               |
| <u>3 juillet</u>   |                |                                |                                   |                                  |                                                      |
| 15h30              | 138.500        | 1622.4                         | 3.90                              | 2834                             | 442.4                                                |
| <u>4 juillet</u>   |                |                                |                                   |                                  |                                                      |
| 13h30              | 160.500        | 1627.5                         | 3.50                              | 2839                             | 447.50                                               |
| <u>6 juillet</u>   |                |                                |                                   |                                  |                                                      |
| 05h30              | 200.500        | 1634.6                         | 3.00                              | 2846                             | 454.6                                                |
| <u>7 juillet</u>   |                |                                |                                   |                                  |                                                      |
| 17h00              | 236.000        | 1645.8                         | 2.70                              | 2857                             | 465.8                                                |
| <u>8 juillet</u>   |                |                                |                                   |                                  |                                                      |
| 24h00              | 267.000        | 1652.9                         | 2.50                              | 2864.4                           | 472.9                                                |
| <u>9 juillet</u>   |                |                                |                                   |                                  |                                                      |
| 16h00              | 283.000        | 1661.1                         | 2.42                              | 2873                             | 481.10                                               |
| <u>10 juillet</u>  |                |                                |                                   |                                  |                                                      |
| 09h00              | 300.00         | 1660.0                         | 2.34                              | 2877                             | 480.01                                               |
| <u>12 juillet</u>  |                |                                |                                   |                                  |                                                      |
| 09h00              | 348.00         | 1665.4                         | 2.15                              | 2877                             | 485.4                                                |

TABLE 4

1ST BUILDUP

AVERAGE PRESSURE USING MUSKAT'S METHOD

| TIME (HR) | PWS<br>PRESSURE<br>(at pump depth, 4071,6') | $\bar{P} = 1665.0^*$<br>$\bar{P} - P_{ws}$ | $\bar{P} = 1680^{**}$<br>$\bar{P} - P_{ws}$ (at pump depth) |
|-----------|---------------------------------------------|--------------------------------------------|-------------------------------------------------------------|
| 0.02      | 1489.0                                      | 176.0                                      | 191.0                                                       |
| 0.13      | 1495.6                                      | 169.4                                      | 184.4                                                       |
| 0.20      | 1501.6                                      | 163.4                                      | 178.4                                                       |
| 0.30      | 1509.8                                      | 155.2                                      | 170.2                                                       |
| 0.40      | 1515.8                                      | 149.2                                      | 164.2                                                       |
| 0.80      | 1525.0                                      | 140.0                                      | 155.0                                                       |
| 1.60      | 1527.5                                      | 137.5                                      | 152.5                                                       |
| 4.00      | 1529.6                                      | 135.4                                      | 150.4                                                       |
| 9.10      | 1535.9                                      | 129.1                                      | 144.1                                                       |
| 21.5      | 1547.9                                      | 117.1                                      | 132.1                                                       |
| 44.5      | 1567.4                                      | 97.6                                       | 112.6                                                       |
| 100.5     | 1603.5                                      | 61.5                                       | 76.5                                                        |
| 348.2     | 1665                                        | 0                                          | 15.0                                                        |

\* Generates a curve

\*\* Works correctly as it gives a straight line in a crossplot of time vs log ( $\bar{P} - P_{ws}$ )

$\bar{P} = 2892$  psi at the middle of perforations

TABLE 5  
2ND DRAWDOWN  
GPR NOEL SHELL NO 1 PARKE

| DATE ET<br>HEURE | TEMPS<br>(hr) | V <sub>1</sub> | V <sub>2</sub> | P PUIITS | P SURFACE | REMARQUES                                                         | dP/dt<br>psi/hr | q <sub>1</sub> | q <sub>2</sub> | q <sub>av</sub><br>bbl/hr | Y = $\frac{dP/dt}{qB}$<br>psi/res bbl | "Ramey"<br>Pi - P | 1er essai<br>P̄ = 1230<br>Pwf - P̄ | 2e essai<br>P̄ = 1200<br>Pwf - P̄ | 3e essai<br>P̄ = 1180<br>Pwf - P̄ |
|------------------|---------------|----------------|----------------|----------|-----------|-------------------------------------------------------------------|-----------------|----------------|----------------|---------------------------|---------------------------------------|-------------------|------------------------------------|-----------------------------------|-----------------------------------|
| <u>15 juil.</u>  |               |                |                |          |           |                                                                   |                 |                |                |                           |                                       |                   |                                    |                                   |                                   |
| 09h00            |               | 419,651        | 425,364        |          |           | Essai de la pompe                                                 |                 |                |                |                           |                                       |                   |                                    |                                   |                                   |
| <u>16 juil.</u>  |               |                |                |          |           |                                                                   |                 |                |                |                           |                                       |                   |                                    |                                   |                                   |
| 09h00            | 0             | 420,455        | 426,071        | 1716.8   | 450       | Q <sub>i</sub> = 70 gpm<br>Choke: .23<br>pH ≈ 12.5<br>Eau blanche |                 |                |                |                           |                                       | 36.8              | 486.8                              | 516.8                             | 536.8                             |
| 09h15            | 0.25          | 421,323        | 427,051        | 1632.8   | 535       | Q <sub>i</sub> = 60 gpm<br>Q = 61.6<br>pH ≈ 12.8                  |                 | 99.2           | 112.0          | 105.6                     |                                       | 47.2              | 402.8                              | 432.8                             | 452.8                             |
| 09h30            | 0.50          | 422,212        | 427,950        | 1595.8   | 565       | Q <sub>i</sub> = 60 gpm<br>Q = 59.6<br>pH = 12.3                  | 109.2           | 101.6          | 102.7          | 102.2                     | 1.07                                  | 84.2              | 365.8                              | 395.8                             | 415.8                             |
| 09h45            | 0.75          | 423,081        | 428,831        | 1578.7   | 550       | Q <sub>i</sub> = 60<br>Q = 58.3<br>pH = 12.1                      | 54.5            | 99.3           | 100.7          | 100.0                     | 0.55                                  | 101.3             | 348.7                              | 378.7                             | 398.7                             |
| 10h00            | 1             | 423,949        | 429,709        | 1568.7   | 560       | Q = 58.2<br>pH = 11.0                                             | 27.9            | 99.2           | 100.3          | 99.8                      | 0.28                                  | 111.3             | 338.7                              | 368.7                             | 388.7                             |
| 10h20            | 1.33          | 425,148        | 430,923        | 1564.4   | 560       | Q = 60.3<br>pH ≈ 10.1                                             | 8.9             | 102.8          | 104.1          | 103.4                     | 0.09                                  | 115.6             | 334.4                              | 364.4                             | 384.4                             |
| 10h40            | 1.66          | 426,232        | 432,019        | 1562.0   | 570       | Q = 54.5<br>pH = 8.5                                              | 5.7             | 92.9           |                | 93.4                      | 0.061                                 | 118.0             | 332.0                              | 362.0                             | 382.0                             |
| 11h00            | 2             | 427,366        | 433,168        | 1560.9   | 560       | Q = 57.1<br>pH = 8.0                                              | 4.0             | 97.2           |                | 97.9                      | 0.041                                 | 119.1             | 330.9                              | 360.9                             | 380.9                             |

TABLE 5 (CONT)

## 2ND DRAWDOWN

GPR NOEL SHELL NO 1 PARKE

| DATE ET<br>HEURE | TEMPS<br>(hr) | V <sub>1</sub> | V <sub>2</sub> | P PUIITS | P SURFACE | REMARQUES            | dP/dt<br>psi/hr | q <sub>1</sub> | q <sub>2</sub> | q <sub>av</sub><br>bbl/hr | Y = $\frac{dP/dt}{q_B}$<br>psi/res bbl | "Ramey"<br>P <sub>i</sub> - P | 1er essai<br>P̄ = 1230<br>P <sub>wf</sub> - P̄ | 2e essai<br>P̄ = 1200<br>P <sub>wf</sub> - P̄ | 3e essai<br>P̄ = 1180<br>P <sub>wf</sub> - P̄ |
|------------------|---------------|----------------|----------------|----------|-----------|----------------------|-----------------|----------------|----------------|---------------------------|----------------------------------------|-------------------------------|------------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| <u>16 juil.</u>  |               |                |                |          |           |                      |                 |                |                |                           |                                        |                               |                                                |                                               |                                               |
| 11h20            | 2.33          | 428,496        | 434,312        | 1560.3   | 570       | Q = 56.9             | 3.9             | 96.9           |                | 97.5                      | 0.040                                  | 119.7                         | 330.3                                          | 360.3                                         | 380.3                                         |
| 11h40            | 2.66          | 429,624        | 435,454        | 1559.2   | 580       | Q = 56.8             | 3.8             | 96.7           |                | 97.4                      | 0.039                                  | 120.8                         | 329.2                                          | 359.2                                         | 379.2                                         |
| 12h00            | 3             | 430,732        | 436,577        | 1560.4   | 600       | Q = 55.8<br>pH = 8.0 | 3.7             | 95.0           |                | 95.7                      | 0.039                                  | 119.6                         | 330.4                                          | 360.4                                         | 380.4                                         |
| 12h30            | 3.5           | 432,488        | 438,360        | 1554.5   | 545       | Q = 59.0             | 3.6             | 100.3          |                | 101.1                     | 0.036                                  | 125.5                         | 324.50                                         | 354.5                                         | 374.5                                         |
| 13h00            | 4             | 434,180        | 440,070        | 1551.7   | 540       | Q = 56.7             | 3.5             | 96.7           |                | 97.2                      | 0.036                                  | 128.3                         | 321.7                                          | 351.7                                         | 371.7                                         |
| 13h30            | 4.5           | 435,935        | 441,862        | 1549.9   | 550       | Q = 59.1             | 3.4             | 100.3          |                | 101.3                     | 0.034                                  | 130.1                         | 319.9                                          | 349.9                                         | 369.9                                         |
| 14h00            | 5             | 437,629        | 443,553        | 1548.4   | 550       | Q = 56.4             | 3.3             | 96.8           |                | 96.7                      | 0.034                                  | 131.6                         | 318.4                                          | 348.4                                         | 368.4                                         |
| 15h00            | 6             | 441,070        | 447,033        | 1545.5   | 550       | Q = 57.7             | 3.2             | 98.3           |                | 98.9                      | 0.032                                  | 134.5                         | 315.50                                         | 345.50                                        | 365.50                                        |
| 16h00            | 7             | 444,507        | 450,515        | 1542.0   | 550       | Q = 57.7             | 3.20            | 98.2           |                | 98.9                      | 0.032                                  | 138.0                         | 312.00                                         | 341.00                                        | 362.00                                        |
| 17h00            | 8             | 447,947        | 453,991        | 1538.0   | 550       | Q = 57.6             | 3.19            | 98.3           |                | 98.7                      | 0.032                                  | 142.0                         | 308.0                                          | 338.0                                         | 358.0                                         |
| 18h00            | 9             | 451,387        | 457,468        | 1533.7   | 555       | Q = 57.6             | 3.19            | 98.3           |                | 98.7                      | 0.032                                  | 146.3                         | 303.7                                          | 333.7                                         | 353.7                                         |
| 20h00            | 11            | 458,266        | 464,415        | 1524.9   | 550       | Q = 57.6             | 3.09            | 98.3           |                | 98.7                      | 0.031                                  | 155.1                         | 294.9                                          | 324.9                                         | 344.9                                         |
| 24h00            | 15            | 471,917        | 478,198        | 1512.5   | 550       | Q = 57.2             | 2.98            | 97.5           |                | 98.1                      | 0.030                                  | 167.5                         | 282.50                                         | 312.50                                        | 332.5                                         |
| <u>17 juil.</u>  |               |                |                |          |           |                      |                 |                |                |                           |                                        |                               |                                                |                                               |                                               |
| 08h00            | 23            | 498,898        | 505,414        | 1492.2   | 530       | Q = 56.5             | 2.36            |                |                | 96.9                      | 0.024                                  | 187.8                         | 262.20                                         | 292.20                                        | 312.20                                        |
| 20h00            | 35            | 538,520        | 545,370        | 1463.4   | 525       | Q = 55.3             | 2.30            |                |                | 94.8                      | 0.024                                  | 216.6                         | 233.40                                         | 263.40                                        | 283.4                                         |
| <u>18 juil.</u>  |               |                |                |          |           |                      |                 |                |                |                           |                                        |                               |                                                |                                               |                                               |
| 08h00            | 47            | 577,672        | 584,858        | 1439.4   | 510       | Q = 54.6             | 1.87            |                |                | 93.6                      | 0.020                                  | 240.6                         | 209.40                                         | 239.40                                        | 259.40                                        |
| 20h00            | 59            | 615,455        | 623,975        | 1420.8   | 525       | Q = 53.4             | 1.47            |                |                | 91.5                      | 0.016                                  | 259.2                         | 190.00                                         | 220.00                                        | 240.00                                        |
| <u>19 juil.</u>  |               |                |                |          |           |                      |                 |                |                |                           |                                        |                               |                                                |                                               |                                               |
| 08h00            | 71            | 652,458        | 660,425        | 1402.1   | 522       | Q = 51.0             | 1.05            |                |                | 87.4                      | 0.012                                  | 277.9                         | 172.10                                         | 202.10                                        | 222.1                                         |
| 20h00            | 83            | 689,020        | 697,235        | 1388.6   | 525       | Q = 51.0             | 0.91            |                |                | 87.4                      | 0.010                                  | 291.4                         | 158.60                                         | 188.60                                        | 208.6                                         |

TABLE 5 (CONT)

## 2ND DRAWDOWN

## GPR NOEL SHELL NO 1 PARKE

| DATE ET<br>HEURE | TEMPS<br>(hr) | $V_1$     | $V_2$     | P PUIITS | P SURFACE | REMARQUES | dP/dt<br>psi/hr | $q_1$ | $q_2$ | $q_{av}$<br>bbl/hr | $Y = \frac{dP/dt}{qB}$<br>psi/res bbl | "Ramey"<br>$P_i - P$ | 1er essai<br>$\bar{P} = 1230$<br>$P_{wf} - \bar{P}$ | 2e essai<br>$P = 1200$<br>$P_{wf} - \bar{P}$ | 3e essai<br>$\hat{P} = 1180$<br>$P_{wf} - \hat{P}$ |
|------------------|---------------|-----------|-----------|----------|-----------|-----------|-----------------|-------|-------|--------------------|---------------------------------------|----------------------|-----------------------------------------------------|----------------------------------------------|----------------------------------------------------|
| <u>20 juil.</u>  |               |           |           |          |           |           |                 |       |       |                    |                                       |                      |                                                     |                                              |                                                    |
| 08h00            | 95            | 724,385   | 732,960   | 1376.6   | 525       | Q = 49.4  | 0.90            |       |       | 84.7               | 0.011                                 | 303.4                | 146.60                                              | 176.60                                       | 196.6                                              |
| 20h00            | 107           | 758,320   | 767,215   | 1367.9   | 525       | Q = 47.4  | 0.88            |       |       | 81.3               | 0.011                                 | 312.1                | 137.9                                               | 167.9                                        | 187.9                                              |
| <u>21 juil.</u>  |               |           |           |          |           |           |                 |       |       |                    |                                       |                      |                                                     |                                              |                                                    |
| 08h00            | 119           | 792,335   | 801,540   | 1356.0   | 525       | Q = 47.5  | 0.86            |       |       | 81.4               | 0.011                                 | 324.0                | 126.0                                               | 176.0                                        | 176.0                                              |
| 20h00            | 131           | 826,105   | 835,610   | 1343.4   | 525       | Q = 47.1  | 0.81            |       |       | 80.7               | 0.010                                 | 336.6                | 113.40                                              | 143.40                                       | 163.40                                             |
| <u>22 juil.</u>  |               |           |           |          |           |           |                 |       |       |                    |                                       |                      |                                                     |                                              |                                                    |
| 08h00            | 143           | 859,542   | 869,334   | 1334.3   | 525       | Q = 46.6  | 0.77            |       |       | 79.9               | 0.010                                 | 345.7                | 104.30                                              | 134.3                                        | 154.3                                              |
| 20h00            | 155           | 892,558   | 902,652   | 1325.2   | 525       | Q = 46.1  | 0.76            |       |       | 79.0               | 0.0096                                | 354.8                | 95.20                                               | 125.20                                       | 145.20                                             |
| <u>23 juil.</u>  |               |           |           |          |           |           |                 |       |       |                    |                                       |                      |                                                     |                                              |                                                    |
| 08h00            | 167           | 923,370   | 933,755   | 1326.7   | 525       | Q = 43.0  | 0.66            |       |       | 73.7               | 0.0090                                | 353.3                | 96.70                                               | 126.70                                       | 146.70                                             |
| 20h00            | 179           | 956,365   | 967,030   | 1307.8   | 525       | Q = 46.0  | 0.58            |       |       | 78.9               | 0.0074                                | 372.2                | 77.80                                               | 107.80                                       | 127.80                                             |
| <u>24 juil.</u>  |               |           |           |          |           |           |                 |       |       |                    |                                       |                      |                                                     |                                              |                                                    |
| 08h00            | 191           | 989,041   | 1,000,010 | 1303.6   | 525       | Q = 45.6  | 0.39            |       |       | 78.2               | 0.0050                                | 376.4                | 73.60                                               | 103.60                                       | 123.60                                             |
| 20h00            | 203           | 1,021,412 | 1,032,700 | 1297.5   | 515       | Q = 45.2  | 0.39            |       |       | 77.5               | 0.0050                                | 382.5                | 67.50                                               | 97.50                                        | 117.50                                             |
| <u>25 juil.</u>  |               |           |           |          |           |           |                 |       |       |                    |                                       |                      |                                                     |                                              |                                                    |
| 08h00            | 215           | 1,053,600 | 1,065,205 | 1292.4   | 520       | Q = 44.9  | 0.39            |       |       | 77.0               | 0.0051                                | 387.6                | 62.40                                               | 92.40                                        | 112.40                                             |
| 20h00            | 227           | 1,085,370 | 1,097,285 | 1288.1   | 525       | Q = 44.3  | 0.39            |       |       | 75.9               | 0.0051                                | 391.9                | 58.10                                               | 88.10                                        | 108.10                                             |

TABLE 5 (CONT)

## 2ND DRAWDOWN

GPR NOEL SHELL NO 1 PARKE

| DATE ET<br>HEURE | TEMPS<br>(hr) | $V_1$     | $V_2$     | P PUIITS | P SURFACE | REMARQUES | dP/dt<br>psi/hr | $q_1$ | $q_2$ | $q_{av}$<br>bbl/hr | $Y = \frac{dP/dt}{qB}$<br>psi/res bbl | "Ramey"<br>$P_i - P$ | 1er essai<br>$\bar{P} = 1230$<br>$P_{wf} - \bar{P}$ | 2e essai<br>$\bar{P} = 1200$<br>$P_{wf} - \bar{P}$ | 3e essai<br>$\bar{P} = 1180$<br>$P_{wf} - \bar{P}$ |
|------------------|---------------|-----------|-----------|----------|-----------|-----------|-----------------|-------|-------|--------------------|---------------------------------------|----------------------|-----------------------------------------------------|----------------------------------------------------|----------------------------------------------------|
| <u>26 juil.</u>  |               |           |           |          |           |           |                 |       |       |                    |                                       |                      |                                                     |                                                    |                                                    |
| 08h00            | 239           | 1,117,263 | 1,129,508 | 1284.2   | 525       | Q = 44.5  | 0.39            |       |       | 76.3               | 0.0051                                | 395.8                | 54.20                                               | 84.20                                              | 104.20                                             |
| 20h00            | 251           | 1,148,905 | 1,161,485 | 1279.6   | 510       | Q = 44.2  | 0.39            |       |       | 75.8               | 0.0051                                | 400.4                | 49.60                                               | 79.60                                              | 99.60                                              |
| <u>27 juil.</u>  |               |           |           |          |           |           |                 |       |       |                    |                                       |                      |                                                     |                                                    |                                                    |
| 08h00            | 263           | 1,180,460 | 1,193,450 | 1274.3   | 520       | Q = 44.2  | 0.39            |       |       | 75.8               | 0.0051                                | 405.7                | 44.30                                               | 74.30                                              | 94.30                                              |
| 20h00            | 275           | 1,211,826 | 1,225,036 | 1271.5   | 520       | Q = 43.7  | 0.39            |       |       | 74.9               | 0.0052                                | 408.5                | 41.50                                               | 71.50                                              | 91.50                                              |
| <u>28 juil.</u>  |               |           |           |          |           |           |                 |       |       |                    |                                       |                      |                                                     |                                                    |                                                    |
| 08h00            | 287           | 1,243,185 | 1,256,705 | 1266.7   | 500       | Q = 43.8  | 0.39            |       |       | 75.1               | 0.0052                                | 413.3                | 36.70                                               | 66.70                                              | 86.70                                              |
| 20h00            | 299           | 1,274,040 | 1,287,880 | 1260.4   | 490       | Q = 43.1  | 0.39            |       |       | 73.9               | 0.0053                                | 419.6                | 30.00                                               | 60.00                                              | 80.00                                              |
| <u>29 juil.</u>  |               |           |           |          |           |           |                 |       |       |                    |                                       |                      |                                                     |                                                    |                                                    |
| 08h00            | 311           | 1,306,005 | 1,320,170 | 1255.7   | 490       | Q = 44.6  | 0.39            |       |       | 76.5               | 0.0051                                | 424.3                | 25.70                                               | 55.70                                              | 75.70                                              |
| 20h00            | 323           | 1,337,772 | 1,352,245 | 1251.4   | 485       | Q = 44.3  | 0.39            |       |       | 75.9               | 0.0051                                | 428.6                | 21.40                                               | 51.40                                              | 71.40                                              |
| <u>30 juil.</u>  |               |           |           |          |           |           |                 |       |       |                    |                                       |                      |                                                     |                                                    |                                                    |
| 08h00            | 335           | 1,369,590 | 1,384,380 | 1246.0   | 485       | Q = 44.4  | 0.39            |       |       | 76.1               | 0.0051                                | 434.0                | 16.00                                               | 46.00                                              | 66.00                                              |
| 20h00            | 347           | 1,401,246 | 1,416,419 | 1242.1   | 475       | Q = 44.2  | 0.39            |       |       | 75.8               | 0.0051                                | 437.9                | 12.10                                               | 42.10                                              | 62.10                                              |
| <u>31 juil.</u>  |               |           |           |          |           |           |                 |       |       |                    |                                       |                      |                                                     |                                                    |                                                    |
| 08h00            | 359           | 1,432,802 | 1,448,287 | 1238.6   | 475       | Q = 44.0  | 0.39            |       |       | 75.4               | 0.0052                                | 441.4                | 8.60                                                | 38.60                                              | 58.60                                              |
|                  |               | 1,435,753 | 1,451,261 |          |           |           |                 |       |       |                    |                                       |                      |                                                     |                                                    |                                                    |

TABLE 6

## 2ND BUILDUP

## GPR SHELL NO 1 PARKE

| <u>DATE ET HEURE</u> | <u><math>\Delta t</math> (h)</u> | <u>P<sub>mesurée</sub><br/>(psig)</u> | <u>t + <math>\Delta t</math><br/><math>\Delta t</math></u> | <u>P<sub>formation</sub><br/>(psia)</u> |
|----------------------|----------------------------------|---------------------------------------|------------------------------------------------------------|-----------------------------------------|
| <u>31 juillet</u>    |                                  |                                       |                                                            |                                         |
| 09h096               | 0.096                            | 1255.1                                | 5834                                                       | 2467.3                                  |
| 09h111               | 0.111                            | 1261.8                                | 5046                                                       | 2474                                    |
| 09h126               | 0.126                            | 1268.4                                | 4445                                                       | 2478.6                                  |
| 09h146               | 0.146                            | 1272.6                                | 3837                                                       | 2484.8                                  |
| 09h171               | 0.171                            | 1280.3                                | 3276                                                       | 2492.5                                  |
| 09h196               | 0.196                            | 1288.3                                | 2858                                                       | 2500.5                                  |
| 09h14                | 0.236                            | 1299.5                                | 2374                                                       | 2511.7                                  |
| 09h18                | 0.296                            | 1312.3                                | 1893                                                       | 2524.5                                  |
| 09h23                | 0.376                            | 1324.7                                | 1490                                                       | 2536.9                                  |
| 09h28                | 0.466                            | 1334.2                                | 1203                                                       | 2546.4                                  |
| 09h34                | 0.566                            | 1341.1                                | 990                                                        | 2553.3                                  |
| 09h42                | 0.696                            | 1345.6                                | 806                                                        | 2557.8                                  |
| 09h52                | 0.866                            | 1348.8                                | 648                                                        | 2561.0                                  |
| 10h05                | 1.076                            | 1350.8                                | 521                                                        | 2563.0                                  |
| 10h21                | 1.346                            | 1352.2                                | 417                                                        | 2564.4                                  |
| 10h41                | 1.686                            | 1353.8                                | 333                                                        | 2566.0                                  |
| 11h09                | 2.146                            | 1355.2                                | 262                                                        | 2567.4                                  |
| 11h24                | 2.396                            | 1356.2                                | 235                                                        | 2568.4                                  |
| 12h31                | 3.520                            | 1359.5                                | 160                                                        | 2571.7                                  |
| 13h20                | 4.339                            | 1361.8                                | 130                                                        | 2574                                    |
| 14h24                | 5.400                            | 1364.0                                | 105                                                        | 2576.2                                  |
| 16h00                | 7.000                            | 1367.9                                | 81                                                         | 2580.1                                  |
| 17h30                | 8.500                            | 1372.0                                | 66.8                                                       | 2584.2                                  |
| 19h00                | 10.000                           | 1374.1                                | 57.0                                                       | 2586.3                                  |
| 21h30                | 12.500                           | 1378.1                                | 45.8                                                       | 2590.3                                  |

TABLE 6 (CONT)

2ND BUILDUPGPR SHELL NO 1 PARKE

| <u>DATE ET HEURE</u> | <u>Δt (h)</u> | <u>P<sub>mesurée</sub><br/>(psig)</u> | <u><math>\frac{t - \Delta t}{\Delta t}</math></u> | <u>P<sub>formation</sub><br/>(psia)</u> |
|----------------------|---------------|---------------------------------------|---------------------------------------------------|-----------------------------------------|
| <u>1er août</u>      |               |                                       |                                                   |                                         |
| 00h30                | 15.500        | 1384.4                                | 37.1                                              | 2596.6                                  |
| 04h00                | 19.00         | 1391.6                                | 30.5                                              | 2603.8                                  |
| 08h00                | 23.00         | 1400.4                                | 25.4                                              | 2612.6                                  |
| 13h00                | 28.00         | 1412.2                                | 21.0                                              | 2624.4                                  |
| 18h00                | 33.00         | 1421.0                                | 18.0                                              | 2633.2                                  |
| 24h00                | 39.00         | 1430.4                                | 15.4                                              | 2642.6                                  |
| <u>2 août</u>        |               |                                       |                                                   |                                         |
| 08h00                | 47.00         | 1443.7                                | 12.9                                              | 2655.9                                  |
| 17h00                | 56.00         | 1458.3                                | 11                                                | 2670.5                                  |
| <u>3 août</u>        |               |                                       |                                                   |                                         |
| 01h00                | 64.00         | 1467.5                                | 9.75                                              | 2679.7                                  |
| 12h30                | 75.5          | 1484.4                                | 8.42                                              | 2696.6                                  |
| 22h00                | 85.0          | 1494.6                                | 7.59                                              | 2706.8                                  |
| <u>4 août</u>        |               |                                       |                                                   |                                         |
| 09h30                | 96.5          | 1507.4                                | 6.80                                              | 2719.6                                  |
| 20h30                | 107.5         | 1517.2                                | 6.21                                              | 2729.4                                  |
| <u>5 août</u>        |               |                                       |                                                   |                                         |
| 11h00                | 122.0         | 1533.9                                | 5.59                                              | 2746.1                                  |
| <u>6 août</u>        |               |                                       |                                                   |                                         |
| 01h30                | 136.5         | 1543.8                                | 5.10                                              | 2756.0                                  |
| 14h30                | 149.5         | 1555.7                                | 4.75                                              | 2767.9                                  |
| <u>7 août</u>        |               |                                       |                                                   |                                         |
| 08h26                | 167.426       | 1568.0                                | 4.34                                              | 2780.2                                  |

TABLE 7

2ND BUILDUP

AVERAGE PRESSURE USING MUSKAT'S METHOD

| TIME (HR) | PWS<br>PRESSURE<br>(at pump depth) | $\bar{P} = 1680$<br>$\bar{P} - P_{ws}$ | McKinley<br>$P = 1180$<br>$\bar{P}_{ws} - P$ |
|-----------|------------------------------------|----------------------------------------|----------------------------------------------|
| .096      | 1255.1                             | 429.9                                  | 75.10                                        |
| 0.111     | 1261.8                             | 418.2                                  | 81.8                                         |
| 0.126     | 1268.4                             | 411.6                                  | 88.4                                         |
| 0.146     | 1272.6                             | 407.6                                  | 92.60                                        |
| 0.171     | 1280.3                             | 399.7                                  | 100.3                                        |
| 0.196     | 1288.3                             | 391.7                                  | 108.30                                       |
| 0.236     | 1299.5                             | 380.5                                  | 119.50                                       |
| 0.296     | 1312.3                             | 367.7                                  | 132.30                                       |
| 0.376     | 1324.7                             | 355.3                                  | 144.70                                       |
| 0.466     | 1334.2                             | 345.8                                  | 154.20                                       |
| 0.566     | 1341.1                             | 338.9                                  | 161.10                                       |
| 0.696     | 1345.6                             | 334.4                                  | 165.60                                       |
| 0.866     | 1348.8                             | 331.2                                  | 168.80                                       |
| 1.076     | 1350.8                             | 329.2                                  | 170.80                                       |
| 1.346     | 1352.2                             | 327.8                                  | 172.20                                       |
| 1.686     | 1353.8                             | 326.2                                  | 173.80                                       |
| 2.146     | 1355.2                             | 324.8                                  | 175.20                                       |
| 2.396     | 1356.2                             | 323.8                                  | 176.20                                       |
| 3.520     | 1359.5                             | 320.5                                  | 179.50                                       |
| 4.339     | 1361.8                             | 318.2                                  | 181.80                                       |
| 5.400     | 1364.0                             | 316.00                                 | 184.00                                       |
| 7.000     | 1367.9                             | 312.1                                  | 187.90                                       |
| 8.500     | 1372.0                             | 308.0                                  | 192.00                                       |
| 10.000    | 1374.1                             | 305.9                                  | 194.10                                       |
| 12.500    | 1378.1                             | 301.9                                  | 198.10                                       |
| 15.500    | 1384.4                             | 295.6                                  | 204.40                                       |
| 19.00     | 1391.6                             | 288.4                                  | 211.60                                       |
| 23.00     | 1400.4                             | 279.6                                  | 220.40                                       |
| 28.00     | 1412.2                             | 267.8                                  | 232.20                                       |
| 33.00     | 1421.0                             | 259.0                                  | 241.00                                       |
| 39.00     | 1430.4                             | 249.6                                  | 250.40                                       |
| 47.00     | 1443.7                             | 236.3                                  | 263.70                                       |
| 56.00     | 1458.3                             | 221.7                                  | 278.30                                       |
| 64.00     | 1467.5                             | 212.5                                  | 287.50                                       |
| 75.5      | 1484.4                             | 195.6                                  | 304.40                                       |
| 85.0      | 1494.6                             | 185.4                                  | 314.60                                       |
| 96.5      | 1507.4                             | 172.6                                  | 327.40                                       |
| 107.5     | 1517.2                             | 162.8                                  | 337.20                                       |
| 122.0     | 1533.9                             | 146.10                                 | 353.90                                       |
| 136.5     | 1543.8                             | 136.2                                  | 363.80                                       |
| 149.5     | 1555.7                             | 124.3                                  | 375.70                                       |
| 167.426   | 1568.0                             | 112.0                                  | 388.00                                       |

M E M O

TO : Mario Sanchez  
FROM : Roberto Aguilera  
DATE : 1977-07-12  
RE : Well GPD NOEL SHELL #1 PARKE

---

The possibility of opening some zones in the reference well has been evaluated. Based on this evaluation, it is recommended to perforate intervals 6750-58,6774-6800,6962-77 feet for a twofold purpose: (1) to determine if any production is feasible and (2) to evaluate the possibility of gas underground storage. SOQUIP's investment would be in the order of \$20,000, if the federal government pays for the rig expenses related to the abandonment of the well.

Discussion

The following data have been used in this analysis:

1. Sonic, neutron, density, resistivity and stratigraphic log
2. Drilling report
3. Geologic descriptions of drill cuttings
4. "Etude Pétrographique Du Puits Shell Noel Great Plains Parke" prepared by INRS-Institut National de la Recherche Scientifique-Université du Québec

.../

Log Analysis (Tables I,II,and III)

Porosity (Table II)

Log analysis indicates that intervals 6750-58 and 6774-6800 are highly porous. Porosity in the upper interval is in the order of 32% and in the lower interval in the order of 20%. Sonic and neutron porosities are higher, which in this case indicate the presence of shale, fact that is corroborated by the geologic lithological summary. The lithologic analysis between 6710 and 6760 ft indicates that the interval is made of sandstone with up to 50% shale. The same lithological description applies to interval 6774-6800 with the inclusion of up to 30% metamorphosed rock..

The high porosity is corroborated by the Drilling Report, which indicates that penetration rate between 6785 and 6800 feet averaged less than one minute per foot. In addition, 80 barrels of mud were lost between 6785 and 6838 in May 11, 1972. Previously 500 barrels of mud had been lost in interval 6665 to 6785 ft on May 10.

All this information is factual and leads to the conclusion that there is an excellent development of porosity in the recommended intervals. The INRS report indicates that there is no porosity in this well, but the report did not consider the zones considered of interest in this note.

.../

Water Saturation (Table III)

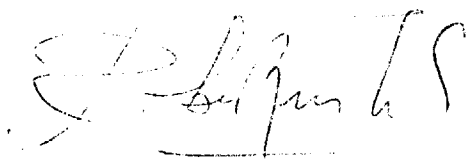
Water saturations were estimated assuming that the intervals of interest have 50% volume of shale as indicated in the lithological description. The following values of Sw were found

| <u>Interval</u> | <u>Sw (%)</u> | <u>ft</u> |
|-----------------|---------------|-----------|
| 6750-6758 ft    | 40            | 8         |
| 6774-6800 ft    | 66            | 26        |
| 6962-6977 ft    | 27            | <u>15</u> |
|                 |               | 49        |

The previous values might be high because the water resistivity as determined from the SP log is high, due to SP attenuation in the presence of shale.

Remaining Saturation

The fluid that corresponds to the remaining saturation is unknown. Since a rig will have to be moved to abandon the well, it appears worthwhile to test the intervals to determine (1) production possibilities and (2) feasibility of underground storage.



Roberto Aguilera

RA/cd

TABLE I

Well: GPD NOEL SHELL #1 PARKE

Estimate of  $R_w$

|                             |                                                                                                                       |
|-----------------------------|-----------------------------------------------------------------------------------------------------------------------|
| SP:                         | -32mv                                                                                                                 |
| e:                          | 8 ft                                                                                                                  |
| Ri:                         | 40                                                                                                                    |
| Rm:                         | 3.75 @ 72°F                                                                                                           |
| Temp. at depth of interest: | 100°F @ 6700 ft                                                                                                       |
| Rm:                         | 2.8 @ 100°F                                                                                                           |
| Ri:                         | ≈40                                                                                                                   |
| Ri/Rm:                      | 40/28 = 14.3                                                                                                          |
| Correction factor:          | ≈ 1.2                                                                                                                 |
| SSP:                        | ≈ -38.4                                                                                                               |
| Mud Nature:                 | Gel Chem.                                                                                                             |
| Density:                    | 9.1                                                                                                                   |
| $R_{mf_e}/R_{w_e}$ :        | 3.4                                                                                                                   |
| Rmf :                       | 4.07 @ 69°F                                                                                                           |
| Rmf :                       | 2.8 @ 100°F                                                                                                           |
| $R_{mf_e}$ :                | $0.85 R_{mf} = 0.85 \times 2.8 = 2.38 @ 100°F$                                                                        |
| Rwe :                       | 0.70                                                                                                                  |
| Rw :                        | 1.0 @ 100°F (Fresh water)                                                                                             |
|                             | (Resistivity of water<br>is probably too high,<br>due to attenuation of<br>SP curve due to a shale<br>volume of ≈50%) |

TABLE II

Estimates of Porosity

$$\text{Matrix Values} \quad \left\{ \begin{array}{l} \Delta t_m = 55 \\ \rho_m = 2.65 \end{array} \right.$$

Interval 6750-58 (8')

$$\begin{array}{lll} \Delta t = 130 & \rho_b = 2.12 & \\ \phi_s = 56\% & \phi_D = 32\% & \phi_n > 45\% \end{array}$$

NOTE: The lithological summary (DRILLING AND ABANDONMENT REPORT OF GRAIN PLAINS NOEL SHELL NO 1 PARKE, by J.M. Scott - Novembre 20, 1972) between 6710-6760' indicates sandstone with up to 50% shale, which is corroborated by the difference between the sonic and density porosities.

Interval 6774-6800 (26')

$$\begin{array}{lll} \Delta t = \approx 100 & \rho_b = 2.32 & \\ \phi_s = 34\% & \phi_D = 20\% & \phi_n > 45\% \end{array}$$

NOTE: Same lithological description as above, with up to 30% metamorphosed rock. Drilling penetration between 6785 and 6800 averaged less than one minute per foot, which is indicative of excellent value of porosity. Also 80 bbls of mud were lost between 6785 and 6838 in May 11, 1972.

Interval 6962-6977 (15')

$$\begin{array}{lll} \Delta t = 115 & \rho_b = 2.32-2.42 & \\ \phi_s = 45\% & \phi_D = 20\% - 14\% & \phi_n = \approx 30-45\% \end{array}$$

NOTE: 20 bbls of mud were lost on May 12/77

TABLE III

Estimates of Water Saturation

Assuming that the intervals of interest have a 50% volume of shale as indicated in the lithological description, the values of  $S_w$  can be calculated directly from Archie's equation provided the porosity is given by a sonic log  $S_w = [(FR_w/R_t)^{\frac{1}{2}}]$

Interval 6750-58

$$S_w = \sqrt{\frac{1.0}{0.56^2 \times 20}} = 40\%$$

Interval 6774-6800

$$S_w = \sqrt{\frac{1.0}{0.34^2 \times 20}} = 66\%$$

The above values are believed to be too high because the water resistivity as determined from the SP log is believed to be too high. In fact, since the intervals have about 50% shale, the SP deflection is somewhat attenuated.

Interval 6962-6977

$$S_w = \sqrt{\frac{1.0}{.45^2 \times 70}} = 27\%$$

-52-

6800

6700

Zero Shift

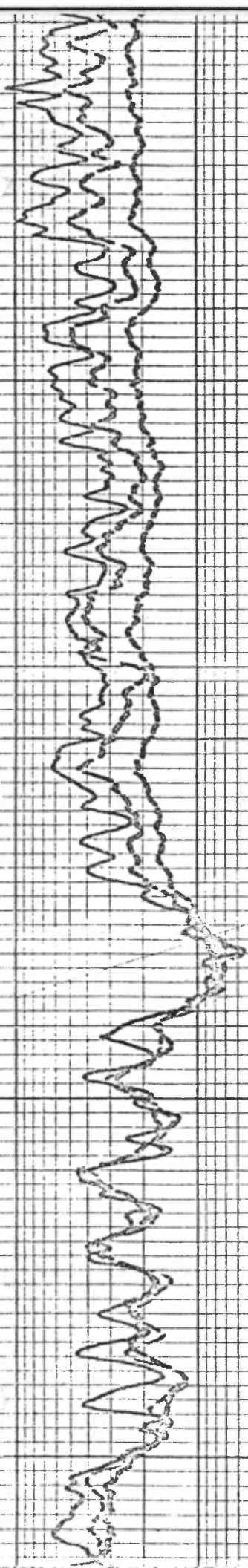
-52-

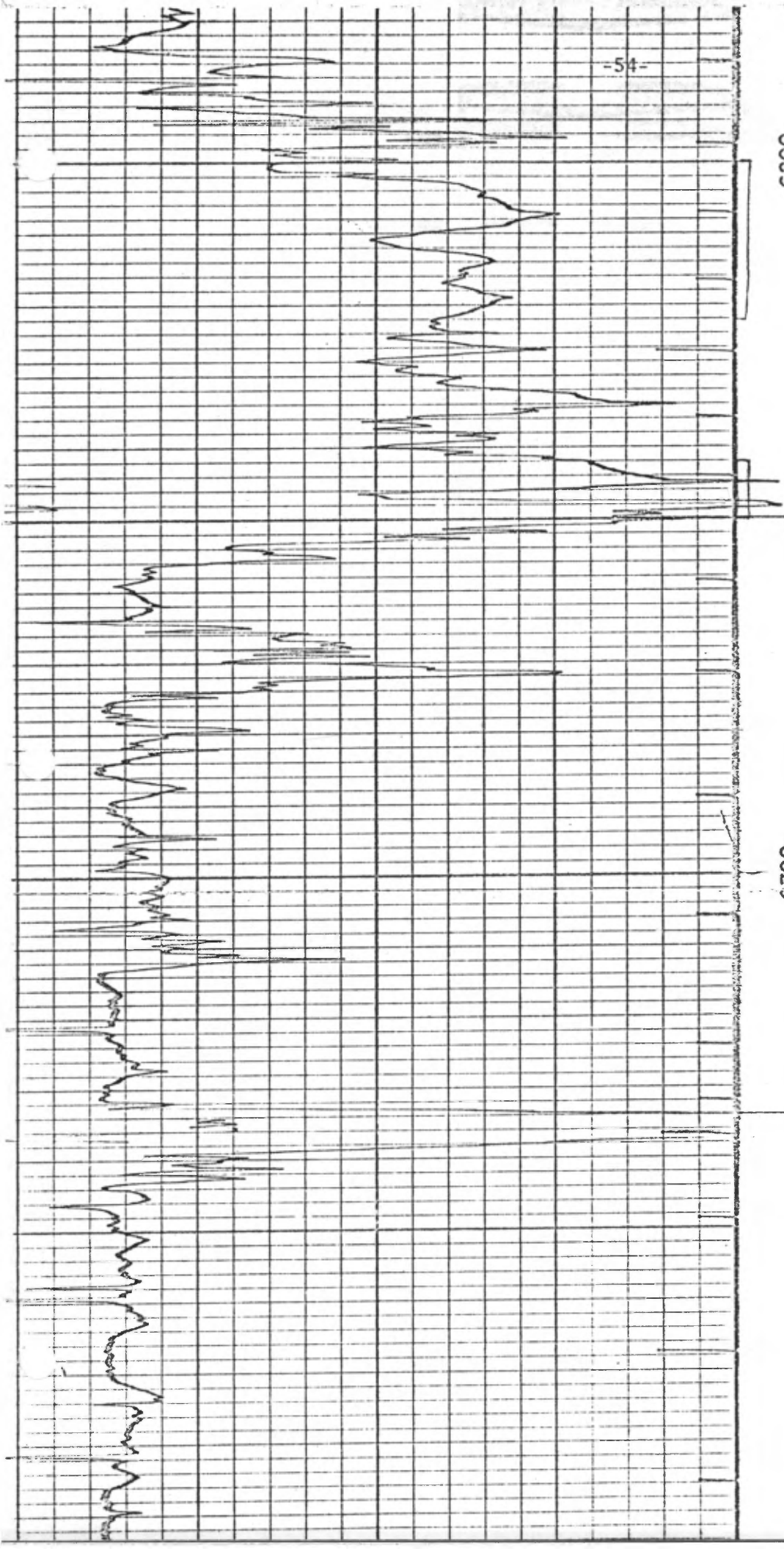
6900

7000

7100

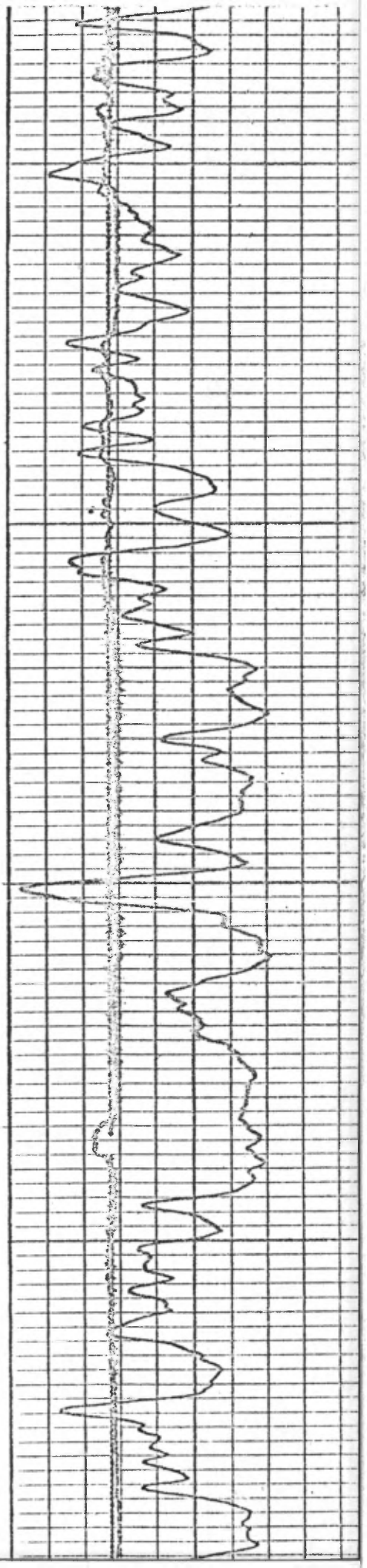
Scale Change  
- 10 +  
- 20 +

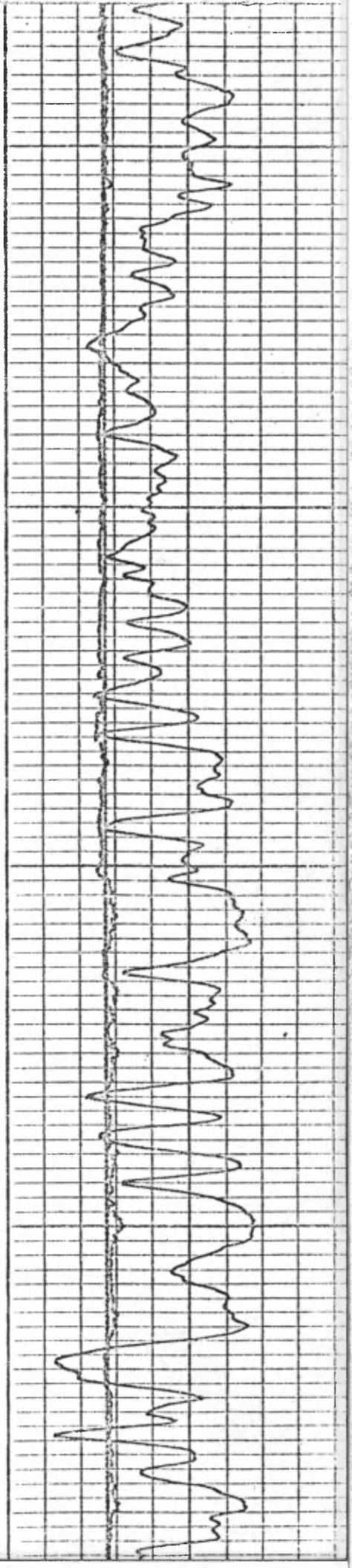




6800

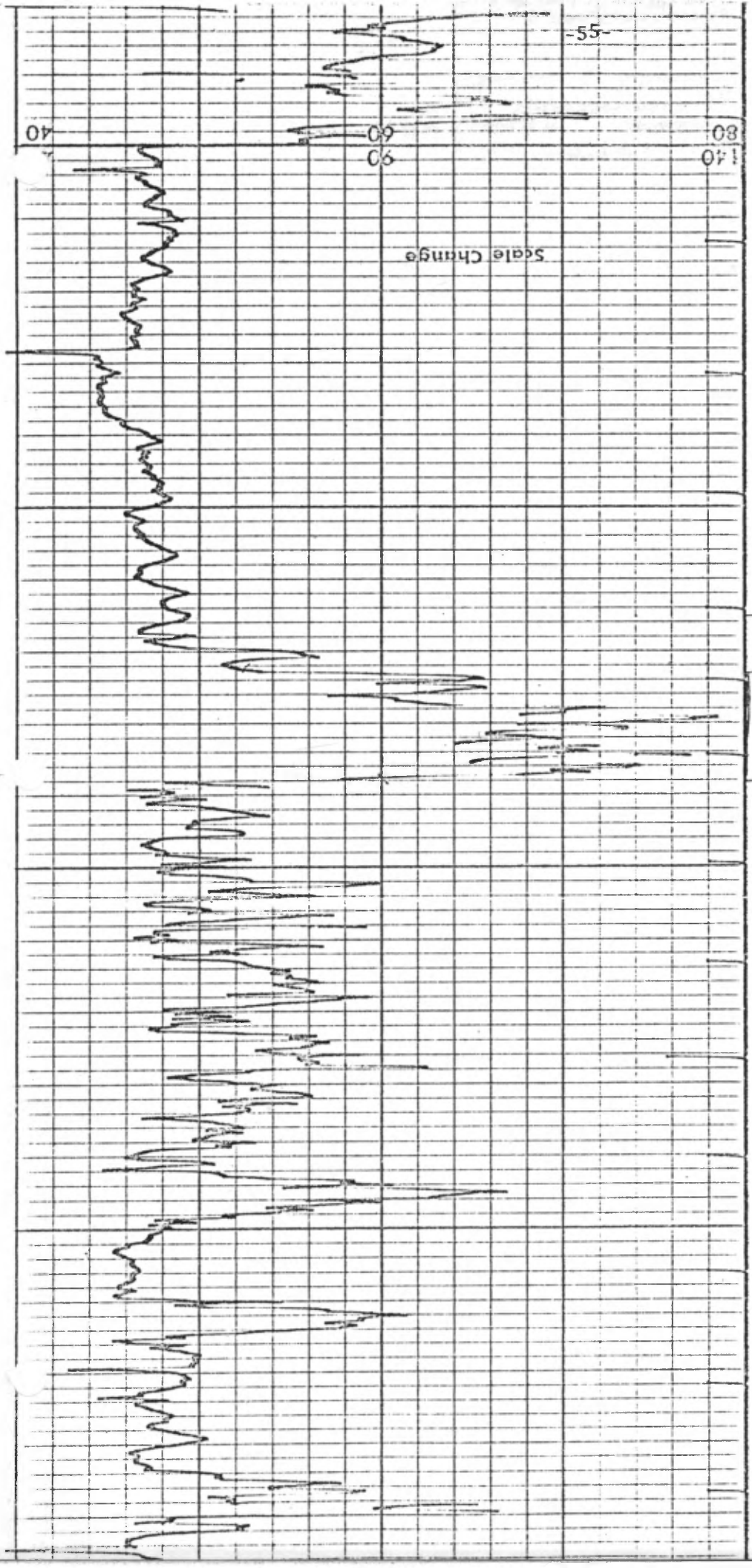
6700





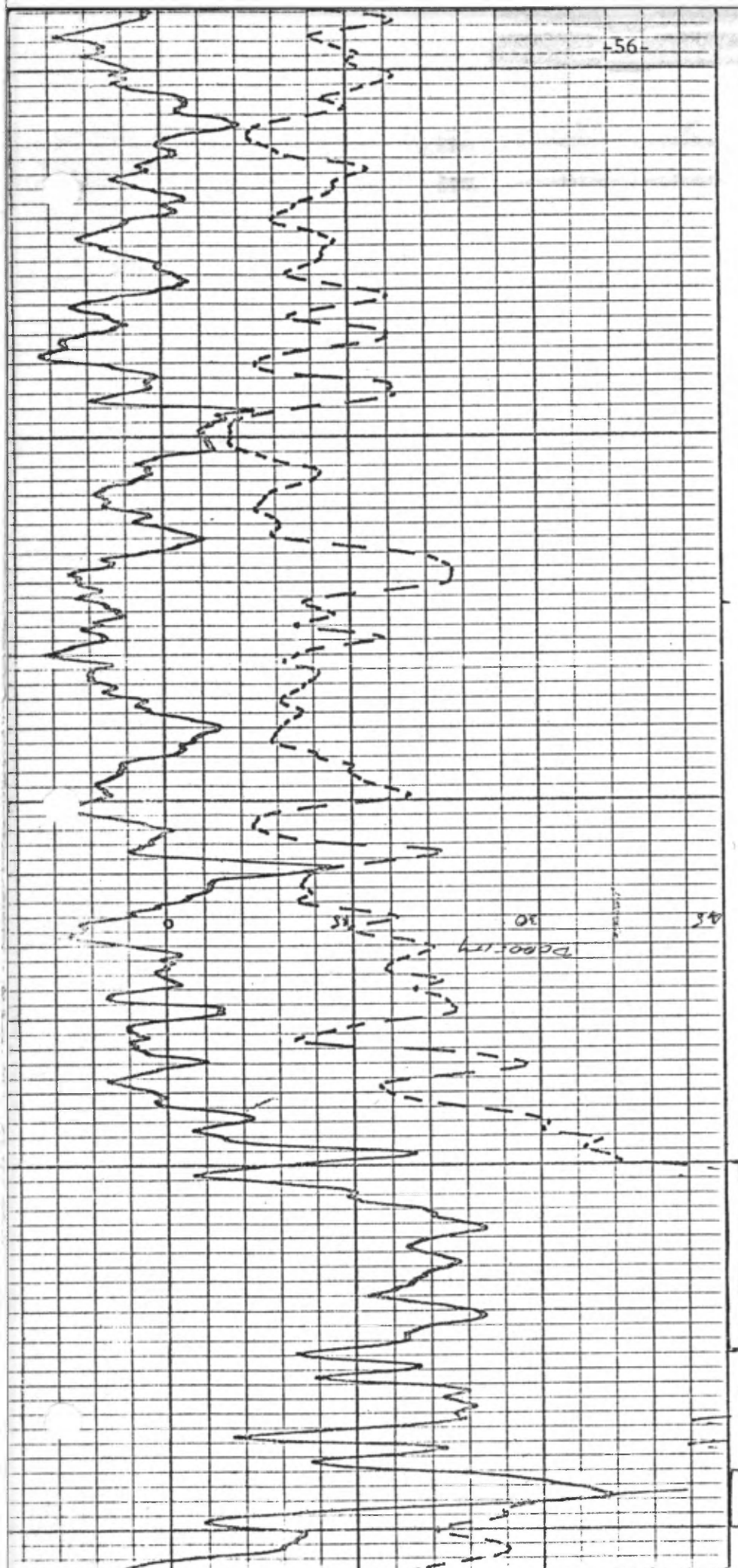
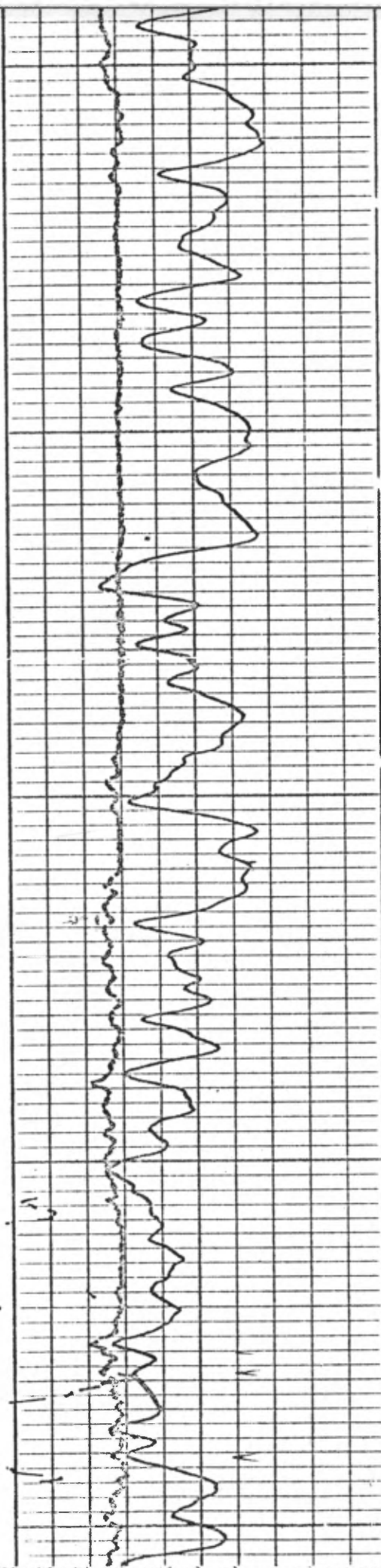
7000

0069



0069

0089



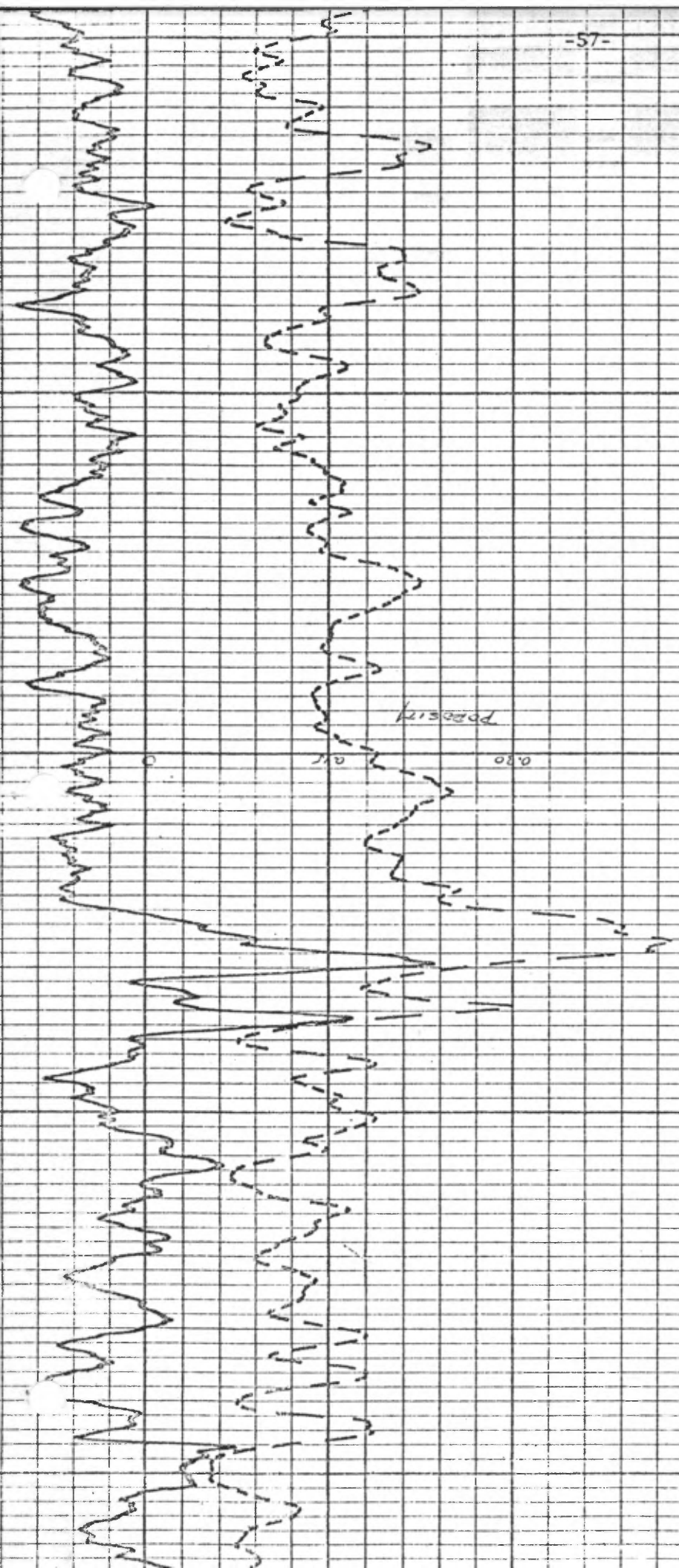
6900

7000

7100

02c

-57-



APPENDIX II

NOSSION PARKE #1  
2076  
EXPL.

TO : Mr. Mario Sanchez  
FROM : Roberto Aguilera  
DATE : June 29, 1978  
SUBJECT : DETAIL OF INVESTMENT REQUIRED IN PARKE UNDERGROUND STORAGE PROJECT.

This note presents some details in regards with the required investment in the Parke Underground Storage Project. .

Most of these estimates were generated in discussions with Mr. Raj Agrawal of Intercomp about four months ago.

The following steps and investment are anticipated for full development of the project:

| Step | Description of job                                                                                                                                                       | Estimated Date | Investment (\$)                 |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|---------------------------------|
| 1    | Pumping test to determine:<br>A-in situ reservoir permeability<br>B- minimum size of aquifer<br>C- integrity of cap rock                                                 | Autumn 1979    | 200,000.00 ✓                    |
| 2    | Drill one well:<br>A- to obtain and analyze core sample<br>B- to better define the structure<br>C- to carry out interference test to establish reservoir continuity      | Spring 1979.   | 1,500,000. ✓                    |
| 3    | Carry out the following studies:<br>A- technical and economic feasibility of the project<br>B- surface (flora, fauna and land usage) environmental studies<br>C- Seismic | Summer 1979    | 100,000 ✓                       |
| 4    | Drill 4 wells and inject gas to:<br>A- establish structure and closure<br>B- obtain more detailed reservoir description<br>C- incidentals                                | during 1979-80 | 6,000,000<br><br><u>200,000</u> |

SOQUIP'S INVESTMENT

8,000,000 ✓

5 Carry out a development program 1980-87  
in association with  
partners:

- assumed area = 10-12 square miles
  - total reservoir capacity = 600 BSCF
  - working gas = 300 BSCF (this is 3  
times the present Ontario capacity  
of 96 BSCF and 2 times the present  
storage capacity of Canada which is  
138 BSCF)
  - cushion gas, 300 BSCF @ \$3/MSCF 900,000,000
  - assumed initial deliverability per  
well = 50 MMSCFD
  - assumed average deliverability per  
well = 30 MMSCFD
  - required number of wells:
- $$\frac{300 \text{ BSCF}}{30 \text{ MMSCF} \times 100 \text{ days}} = 100 \text{ wells} \quad 100,000,000$$
- $$\frac{\text{day/well}}{\text{day/well}}$$
- previous calculation assumes 100 days  
production cycles
  - well spacing =
- $$\frac{12 \text{ sq. miles} \times 640 \text{ acres/sq. mile}}{100 \text{ wells}} = \frac{77 \text{ acres}}{\text{well}}$$
- ≈ 80 acres/well
- drill 10 observation wells 10,000,000
  - compression system (100,000 BHP) 100,000,000
  - gathering system 20,000,000
  - 8 mile long pipeline 25,000,000
- INVESTMENT FROM OTHER SOURCES \$ 1,155,000,000

A second case has been considered where the reservoir is only one tenth in size, i.e., a case where we assume 30 BSCF of working gas and 30 BSCF of cushion gas. The investment (without cushion gas) is estimated at \$33,000,000 for this case.

Cost of the cushion gas is estimated at \$90,000,000. The economics of the projects are attractive as indicated in the following per unit cost analysis:

|                                                                                                                               |                     |
|-------------------------------------------------------------------------------------------------------------------------------|---------------------|
| Interest (10% on \$33,000,000)                                                                                                | 3,300,000           |
| Depreciation (20 years, straight line)                                                                                        | 1,650,000           |
| Operating costs (\$2000/well/month + \$0.075/MSCF)                                                                            |                     |
| = $\frac{(\$2000 \times 10 \text{ wells} \times 12 \text{ months} + \$0.075 \times 30 \text{ BSCF})}{\text{well-month MSCF}}$ | 2,500,000           |
|                                                                                                                               | <u>\$ 7,450,000</u> |

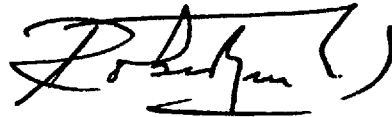
$$\text{UNIT COST} = \frac{\$7,450,000}{30,000,000 \text{ MSCF}} = \frac{\$0.25}{\text{MSCF}}$$

Cushion gas

|                                 |                     |
|---------------------------------|---------------------|
| Interest (10% on \$90,000,000)  | \$ 9,000,000        |
| Escalation (5% on \$90,000,000) | ( 4,500,000)        |
| Depreciation                    | <u>1,650,000</u>    |
|                                 | <u>\$ 6,150,000</u> |

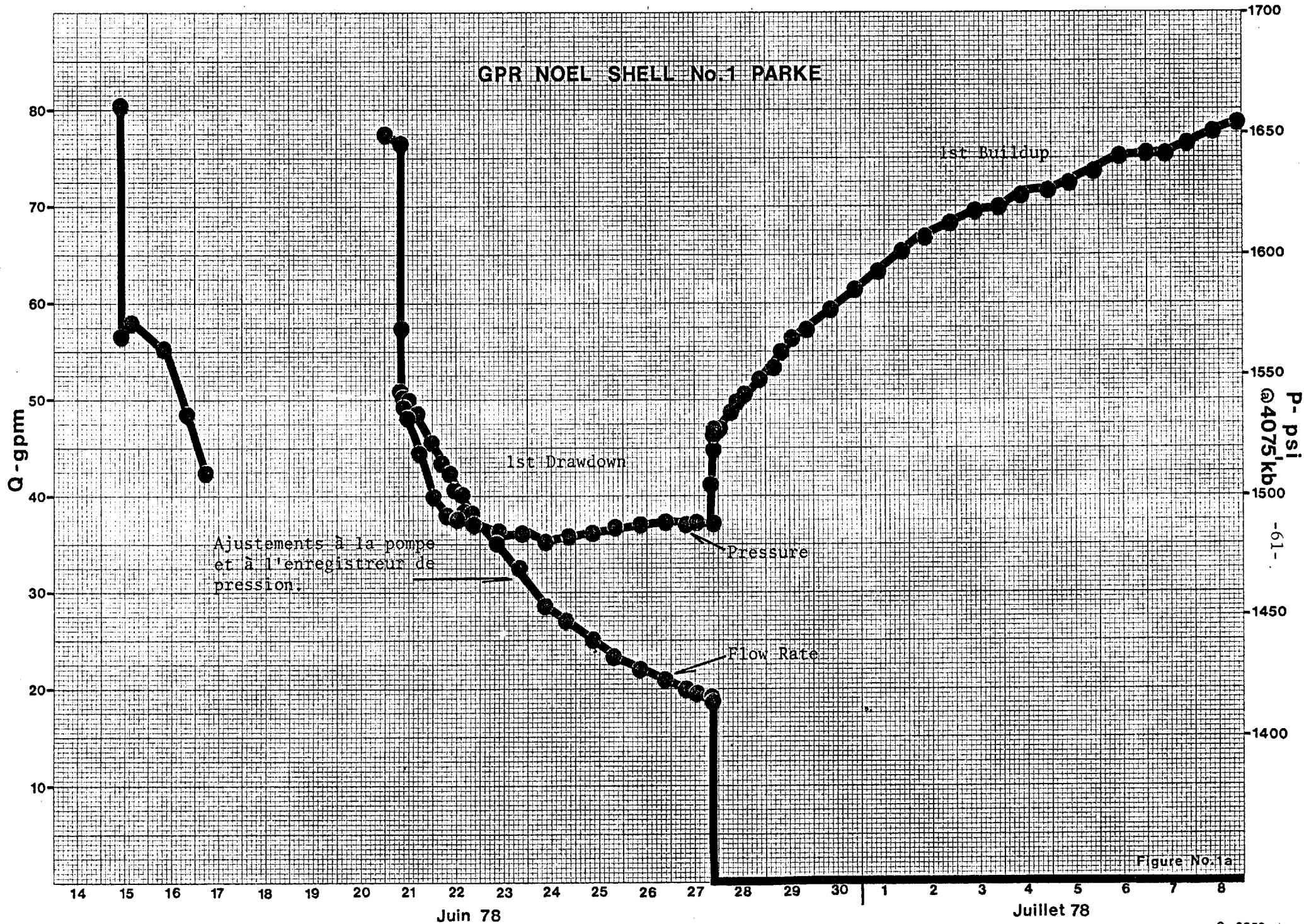
$$\text{UNIT COST} = \frac{\$6,150,000}{30,000,000 \text{ MSCF}} = \frac{\$0.21}{\text{MSCF}}$$

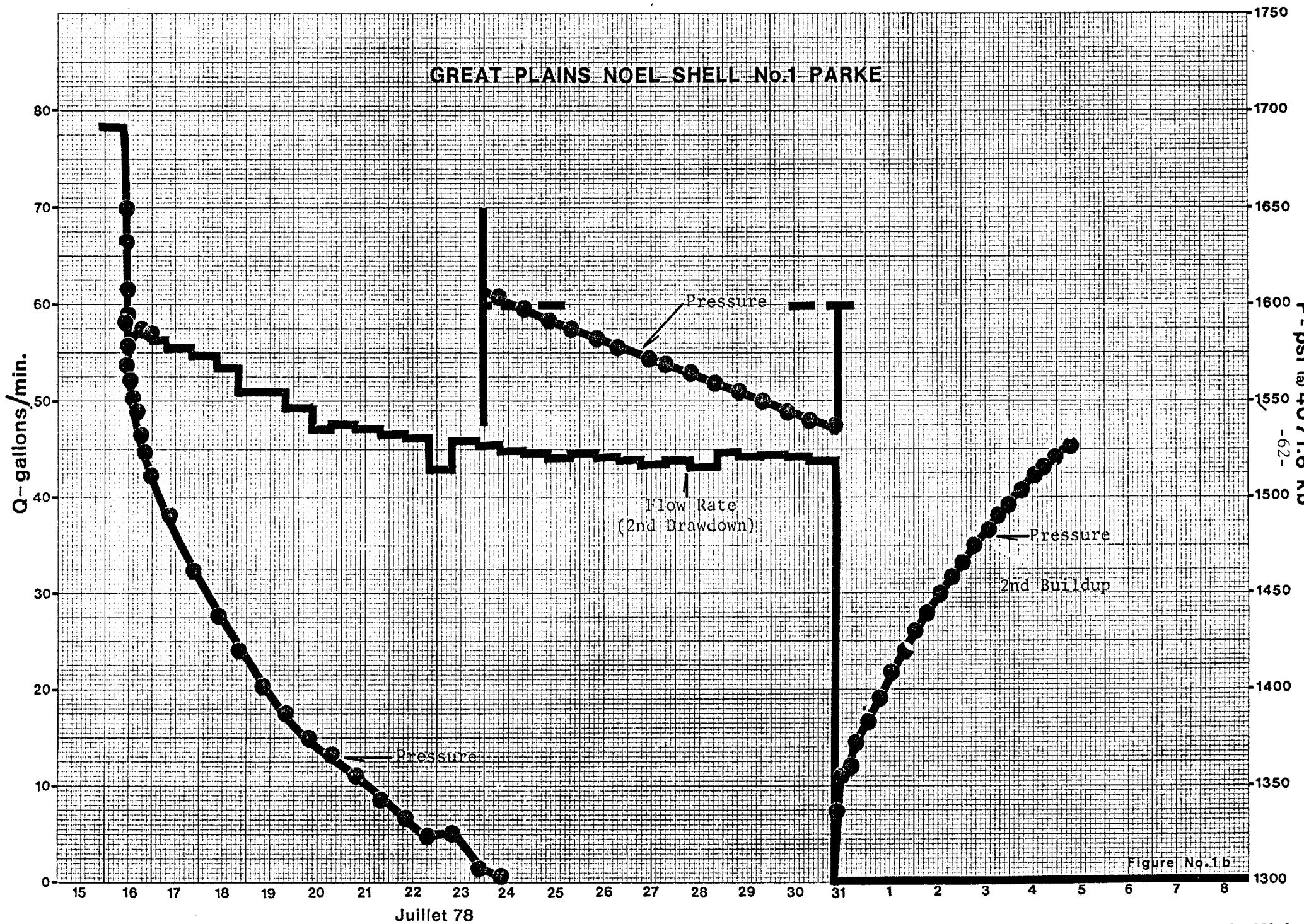
$$\text{TOTAL COST PER UNIT} = \$0.25 + \$0.21 = \$0.46/\text{MSCF}$$



Roberto Aguilera

RA/hbh





FIRST DRAWDOWN DATA ON LOG - LOG  
COORDINATES, GREAT NOEL SHELL No.1 PARKE

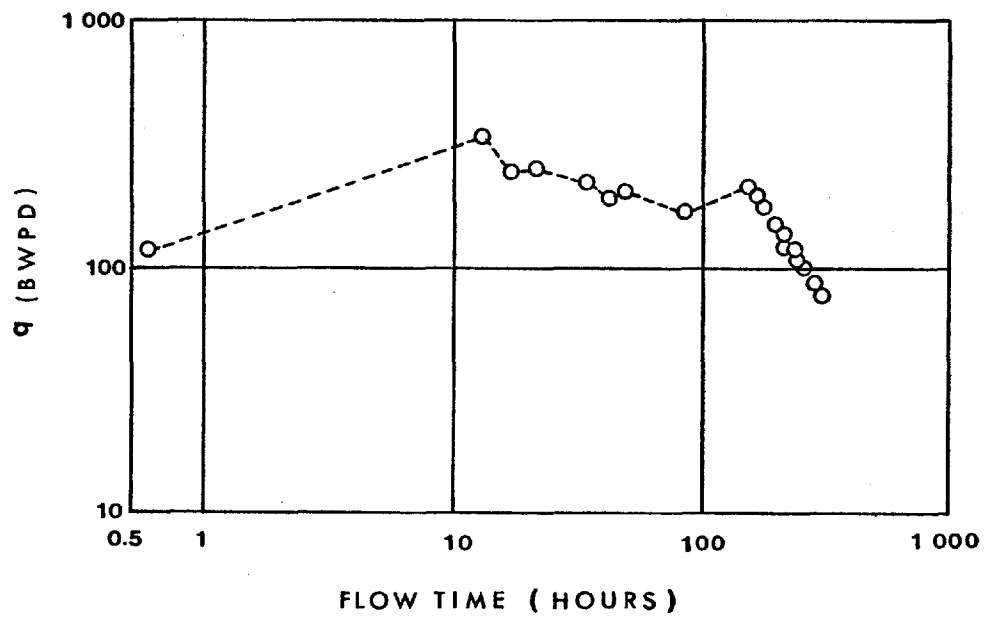


FIGURE 2

# JACOB AND LOHMAN TYPE CURVE

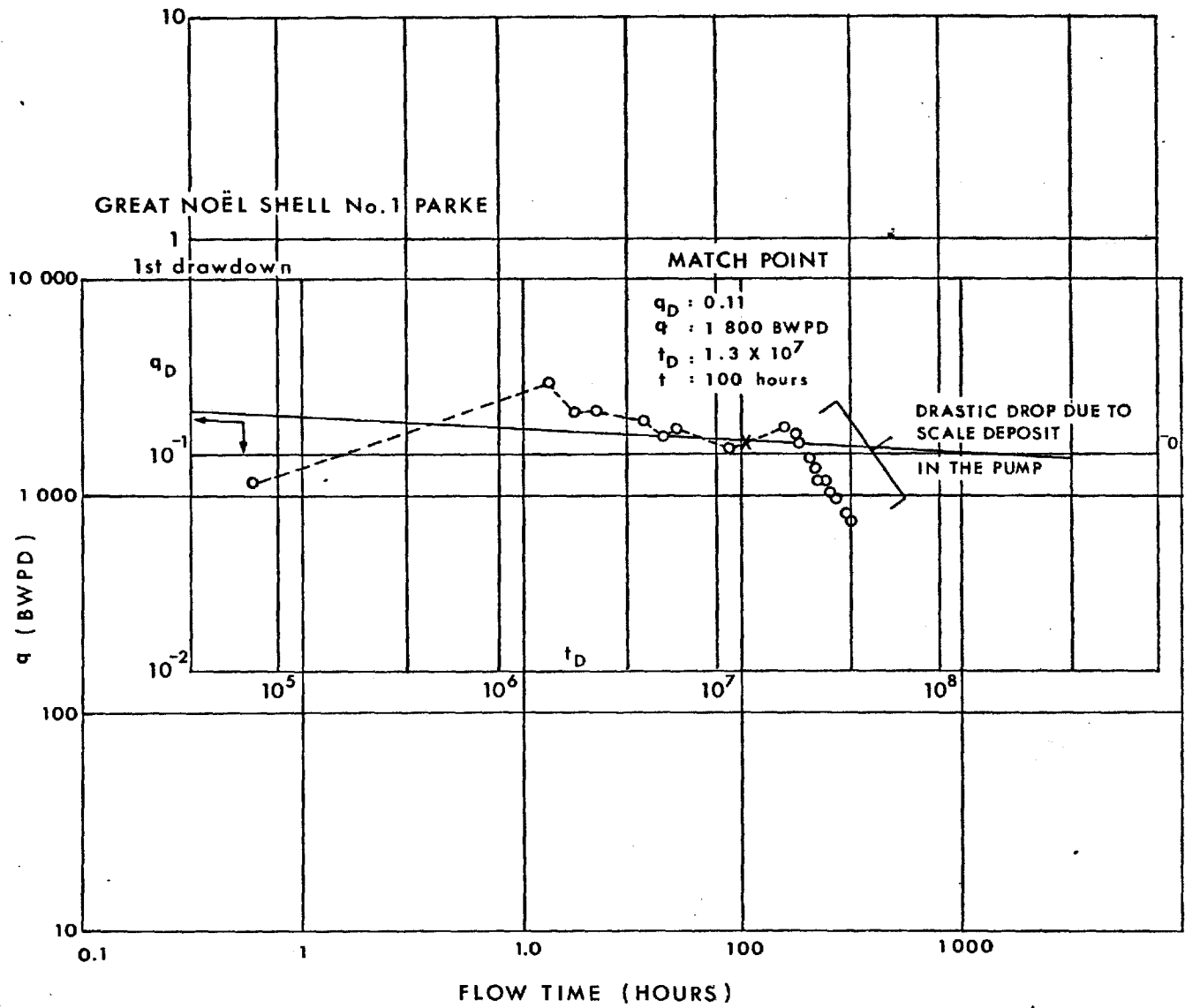
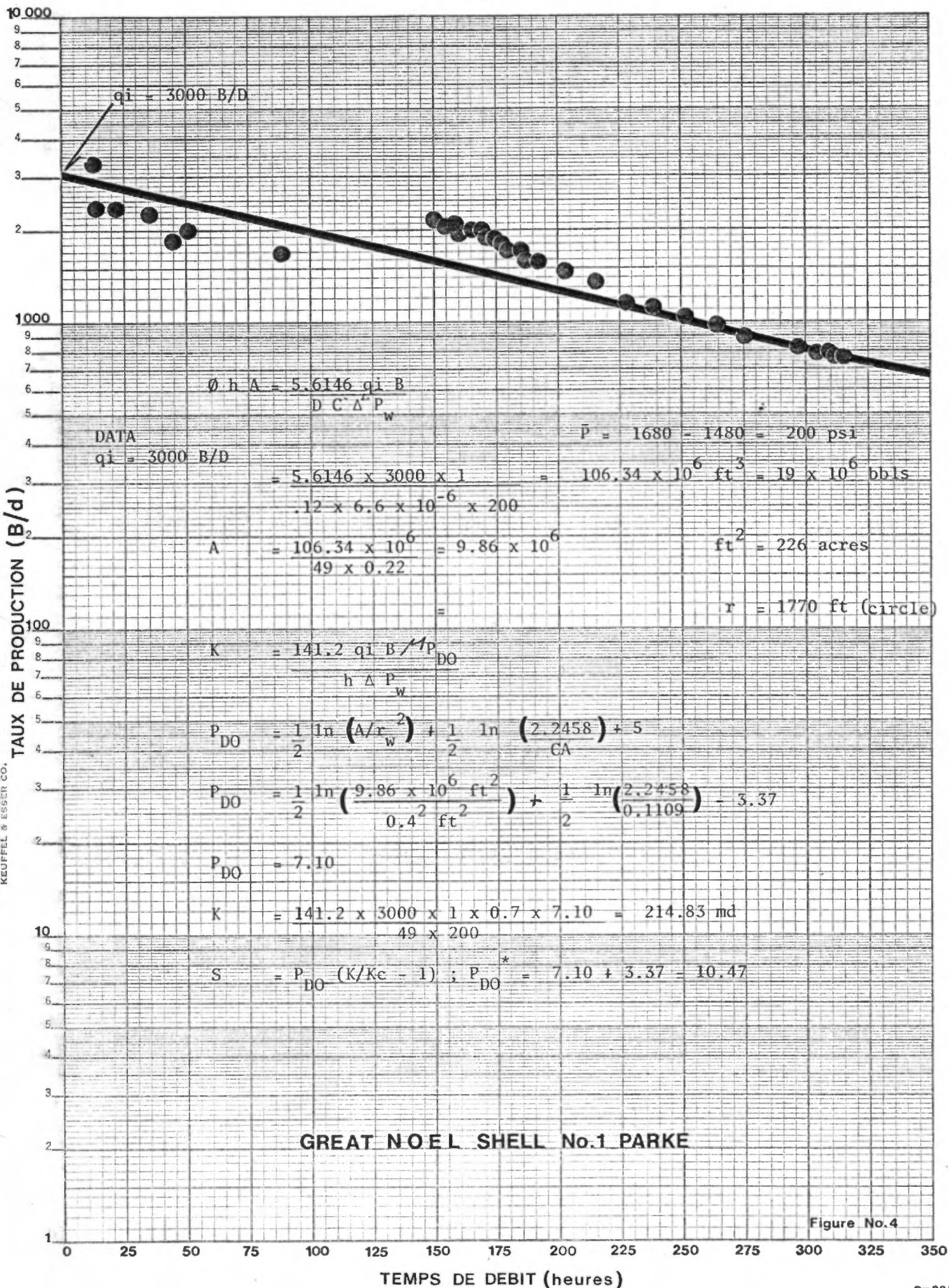
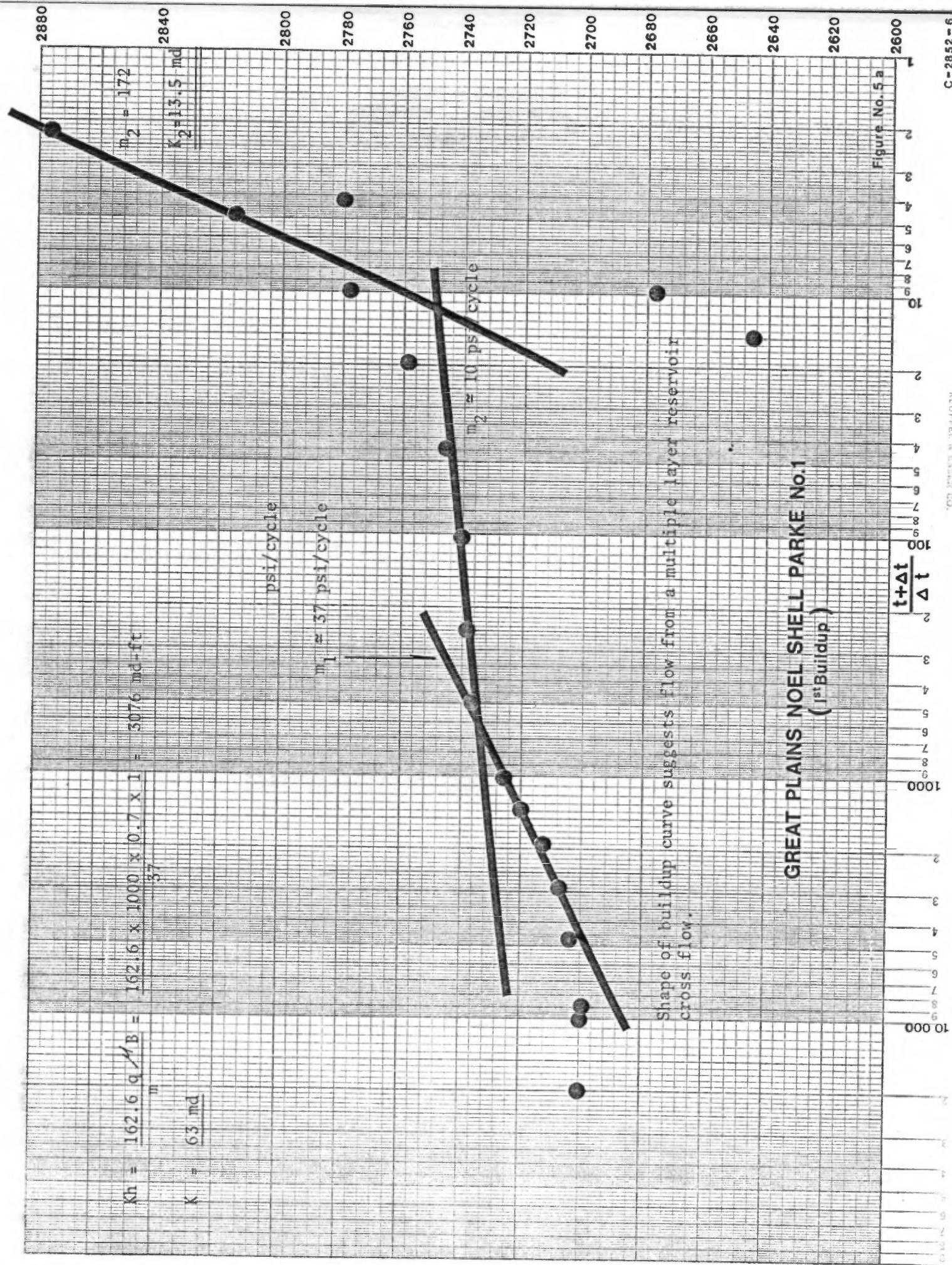


FIGURE 3





COMPARISON OF PRESSURE BUILDUP BEHAVIOR  
IN TWO LAYER RESERVOIR WITH AND WITHOUT  
CROSSFLOW ( After Russell and Prats )

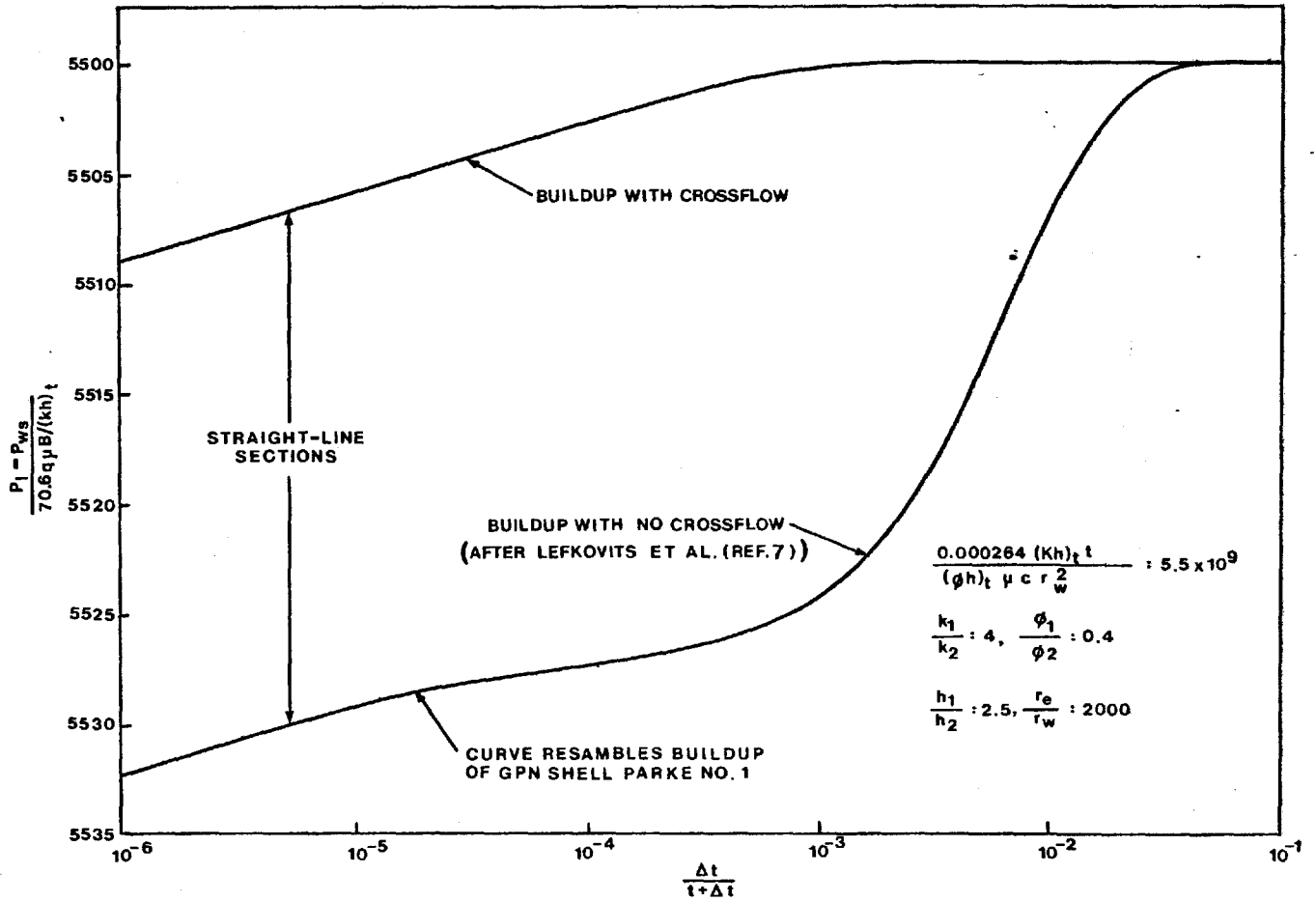


FIGURE 5 - B

1 st Buildup - Muskat Method

GREAT PLAINS NOEL SHELL PARKE NO 1

(Analysis of buildup following 1st flow test using Muskat's Method)

$$b = \frac{118.6 q B}{Kh} \approx Kh = \frac{118.6 q B}{B}$$

$$V_p = \frac{0.115 q B}{B h C}$$

$$Kh = \frac{118.6 \times 1000 \times 0.7 \times 1}{155}$$

Well did not produce at a stabilized rate previous to shut-in. Last rate was about 20 gal/min (822 B/D)  
Cum. 419651 gal = 11990 bbls.  
Actual produce time = 12 days

$$Kh = 535.6 \text{ md-ft}$$

$$\bar{q} \approx 1000 \text{ B/d}$$

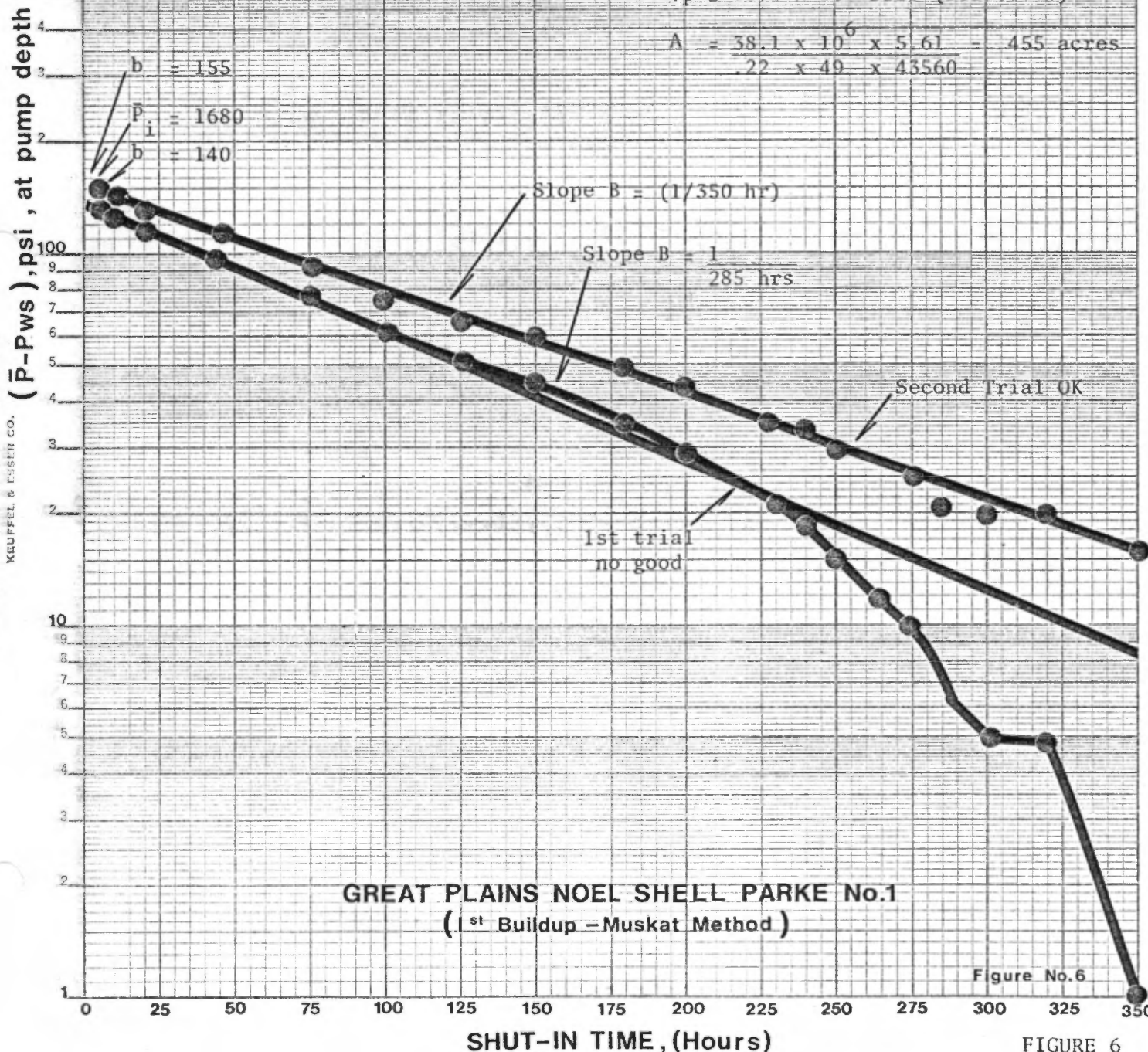
$$Kw \approx 11 \text{ md}$$

$$V_p = \frac{0.1115(1000)(1)}{}$$

$$\left(\frac{1}{350}\right)(155) (6.6 \times 10^{-6})$$

$$V_p = 58.1 \times 10^6 \text{ bbls (reservoir)}$$

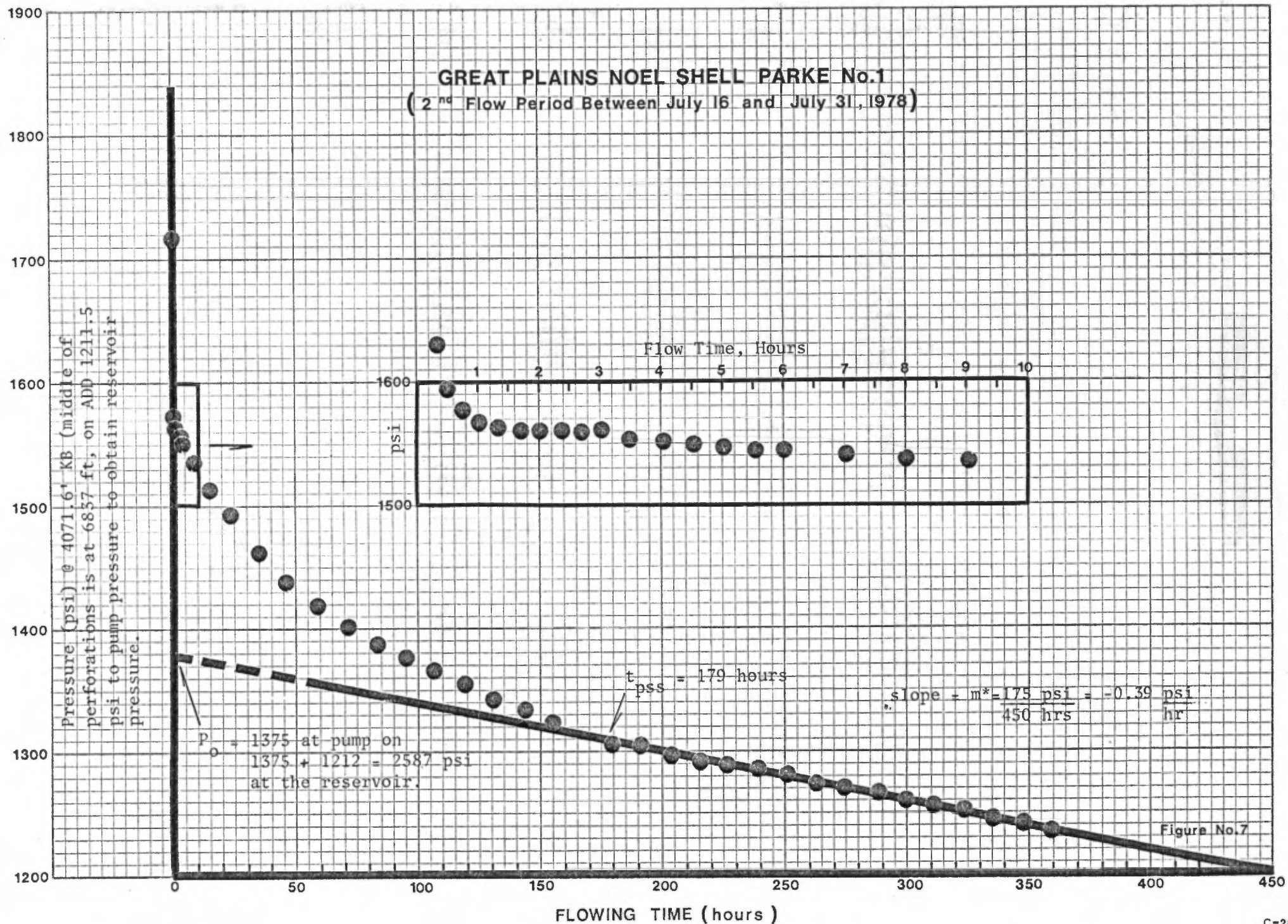
$$A = \frac{58.1 \times 10^6 \times 5.61}{.22 \times 49 \times 43560} = 455 \text{ acres}$$



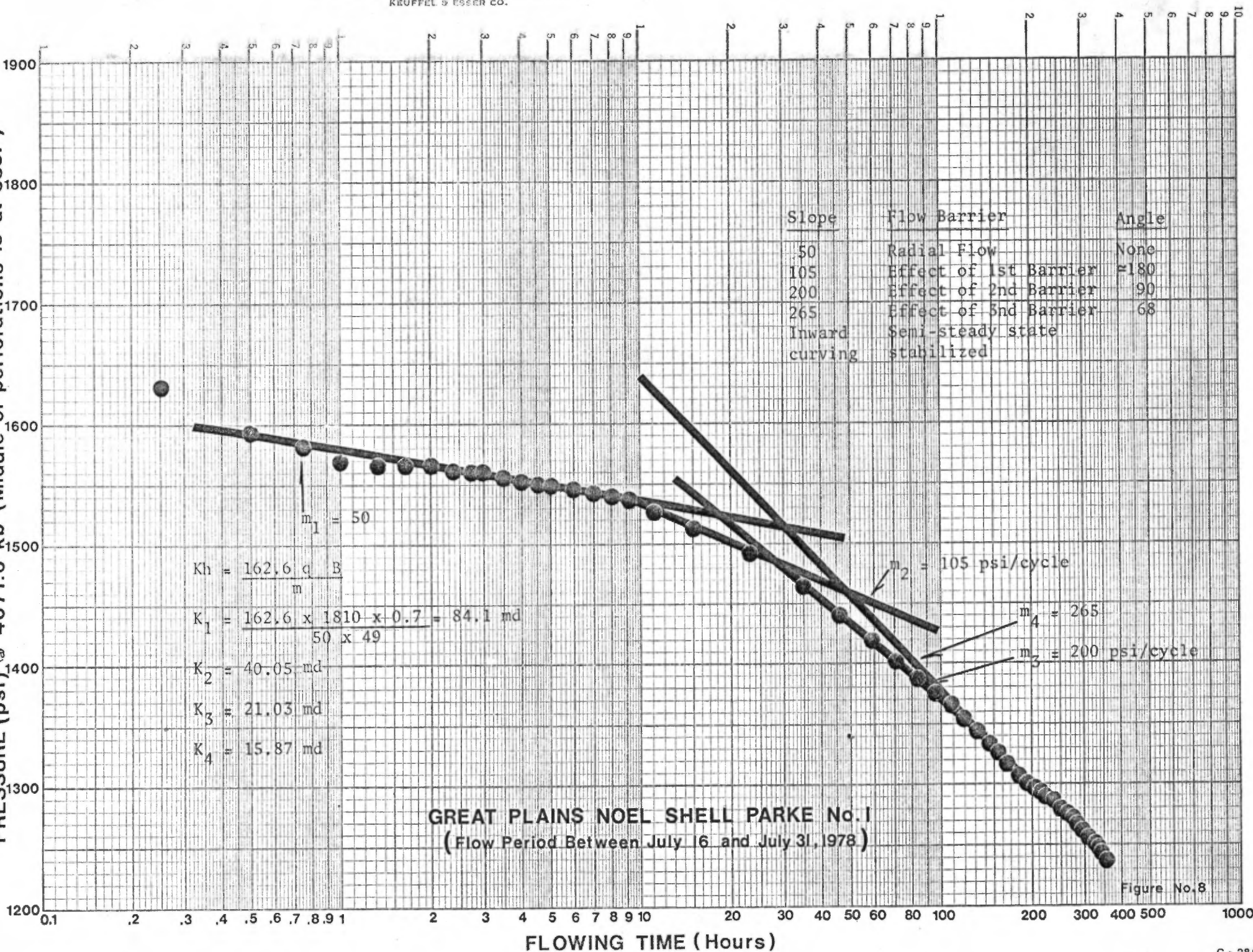
GREAT PLAINS NOEL SHELL PARKE No.1  
(1<sup>st</sup> Buildup - Muskat Method)

Figure No.6

FIGURE 6



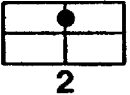
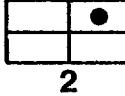
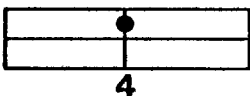
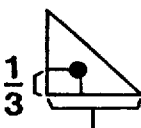
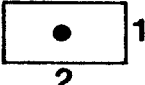
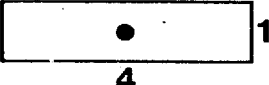
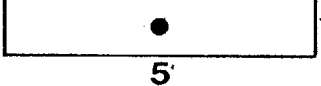
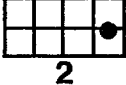
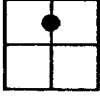
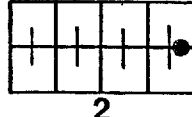
PRESSURE (psi) @ 4071.6 kb (Middle of perforations is at 6837')



GREAT PLAINS NOEL SHELL PARKE No.1  
(Flow Period Between July 16 and July 31, 1978)

Figure No.8

## EFFECT OF RESERVOIR HETEROGENEITIES

| In bounded reservoirs                                                               | Stabilized conditions<br>for $\frac{kt}{\phi\mu c_A} >$ |       |     | In water-drive reservoirs                                                             | Stabilized conditions<br>for $\frac{kt}{\phi\mu c_A} >$ |       |     |
|-------------------------------------------------------------------------------------|---------------------------------------------------------|-------|-----|---------------------------------------------------------------------------------------|---------------------------------------------------------|-------|-----|
|                                                                                     | $\ln C_A$                                               | $C_A$ |     |                                                                                       | $\ln C_A$                                               | $C_A$ |     |
|    | 3.45                                                    | 31.6  | 0.1 |    | 2.38                                                    | 10.8  | 0.3 |
|    | 3.43                                                    | 30.9  | 0.1 |    | 1.58                                                    | 4.86  | 1.0 |
|    | 3.45                                                    | 31.6  | 0.1 |    | 0.73                                                    | 2.07  | 0.8 |
|    | 3.32                                                    | 27.6  | 0.2 |     | 1.00                                                    | 2.72  | 0.8 |
|   | 3.30                                                    | 27.1  | 0.2 |     | -1.46                                                   | 0.232 | 2.5 |
|  | 3.09                                                    | 21.9  | 0.4 |     | -2.16                                                   | 0.115 | 3.0 |
|  | 3.12                                                    | 22.6  | 0.2 |  | 1.22                                                    | 3.39  | 0.6 |
|  | 1.68                                                    | 5.38  | 0.7 |  | 1.14                                                    | 3.13  | 0.3 |
|  | 0.86                                                    | 2.36  | 0.7 |  | -0.50                                                   | 0.607 | 1.0 |
|  | 2.56                                                    | 12.9  | 0.6 |  | -2.20                                                   | 0.111 | 1.2 |
|  | 1.52                                                    | 4.57  | 0.5 |  | -2.32                                                   | 0.098 | 0.9 |
|                                                                                     |                                                         |       |     | In reservoirs of unknown production character                                         |                                                         |       |     |
|                                                                                     |                                                         |       |     |  | 2.95                                                    | 19.1  | 0.1 |
|                                                                                     |                                                         |       |     |  | 3.22                                                    | 25    | 0.1 |

PROBABLE SHAPE  
OF PARKE  
RESERVOIR

Table of drainage area shapes  
(after Dietz)

FIGURE 9

**PROBABLE SHAPE AND DIMENSIONS OF  
PARK RESERVOIR BASED ON EARLOUGHER'S METHOD**

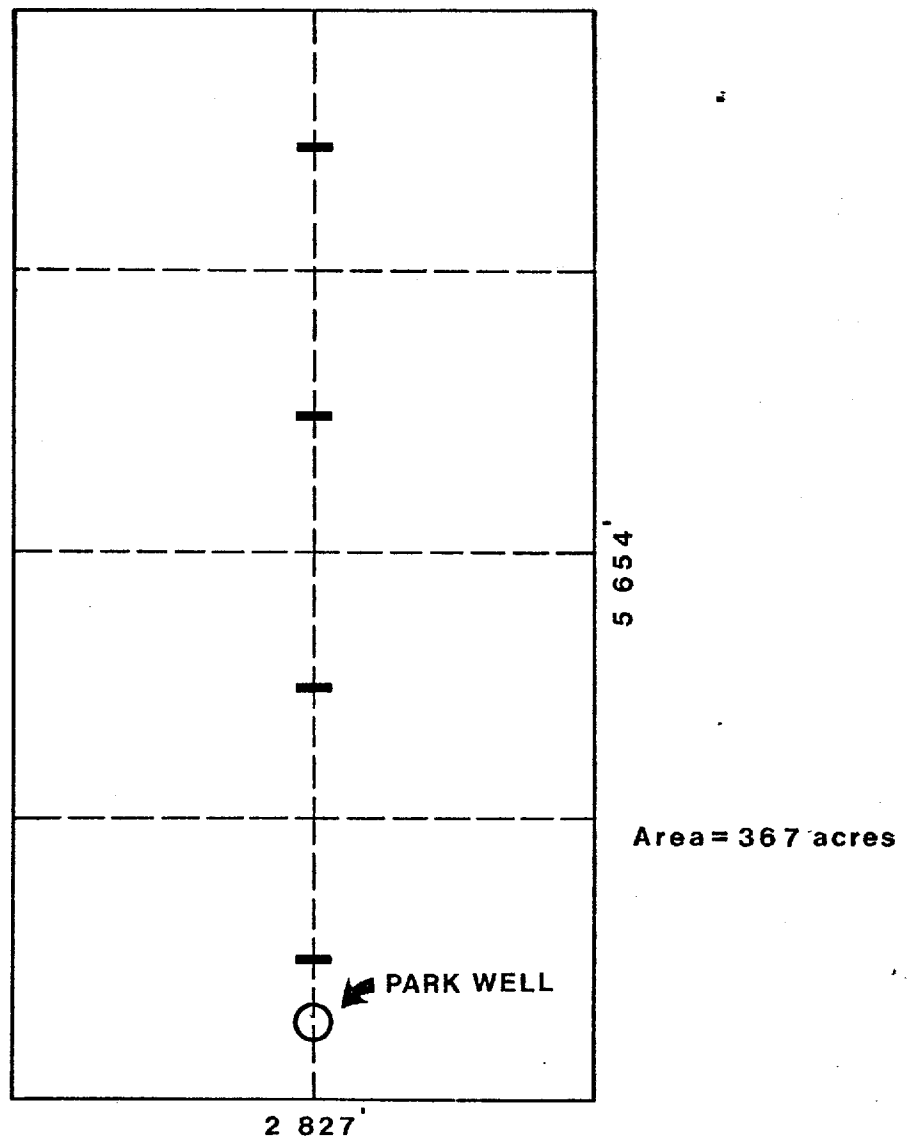


**FIGURE 10**

# GPR NOEL SHELL No. 1 PARKE

Reservoir limit test (July 16-31, 1978)

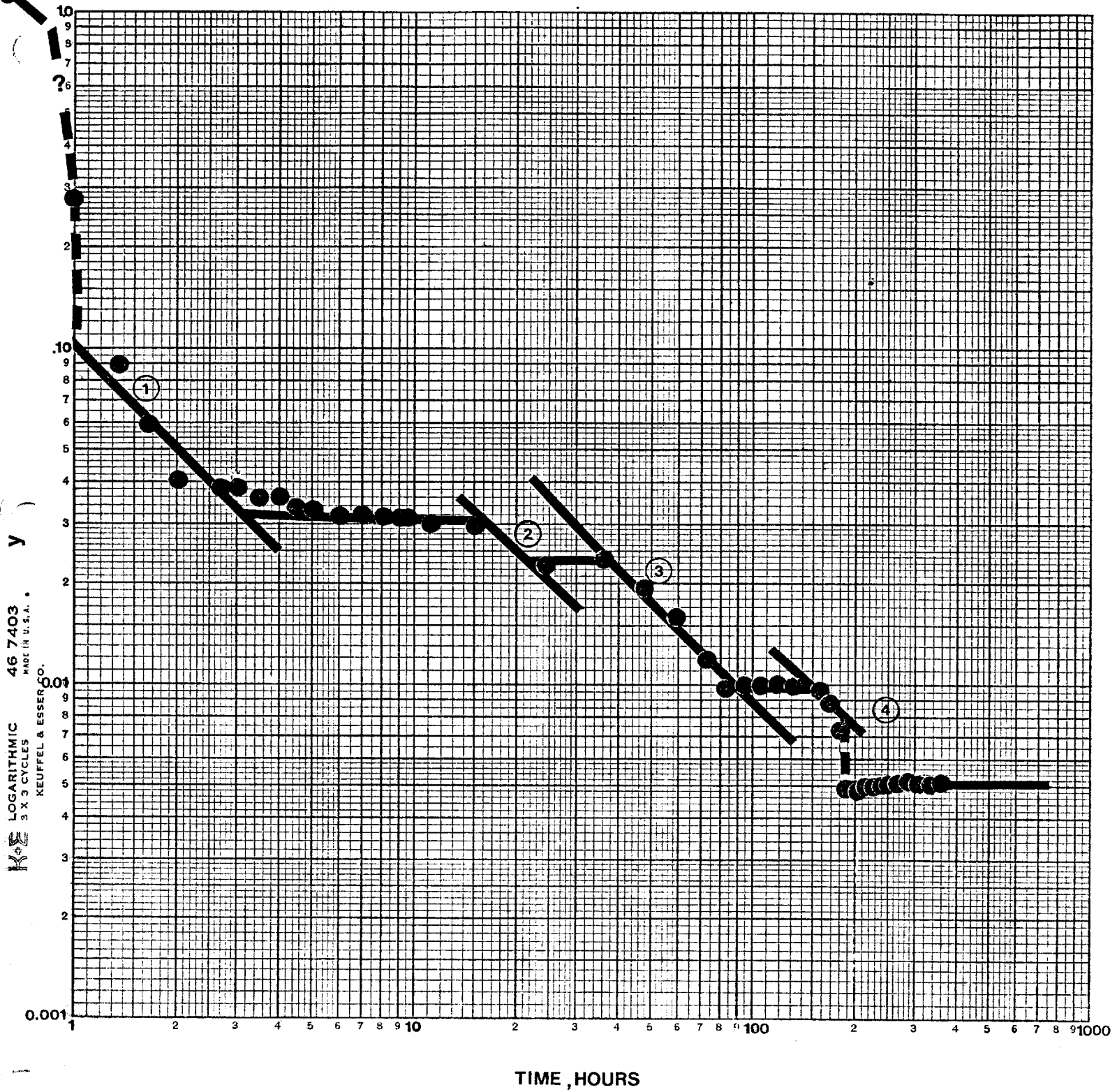
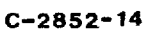


Figure No. 11

$$r_4 = 1438 \sqrt{290/24} = 4998 \text{ ft}$$





GREAT PLAINS NOEL SHELL PARKE NO.  
2nd Flow Period between July 16 and July 31, 1978

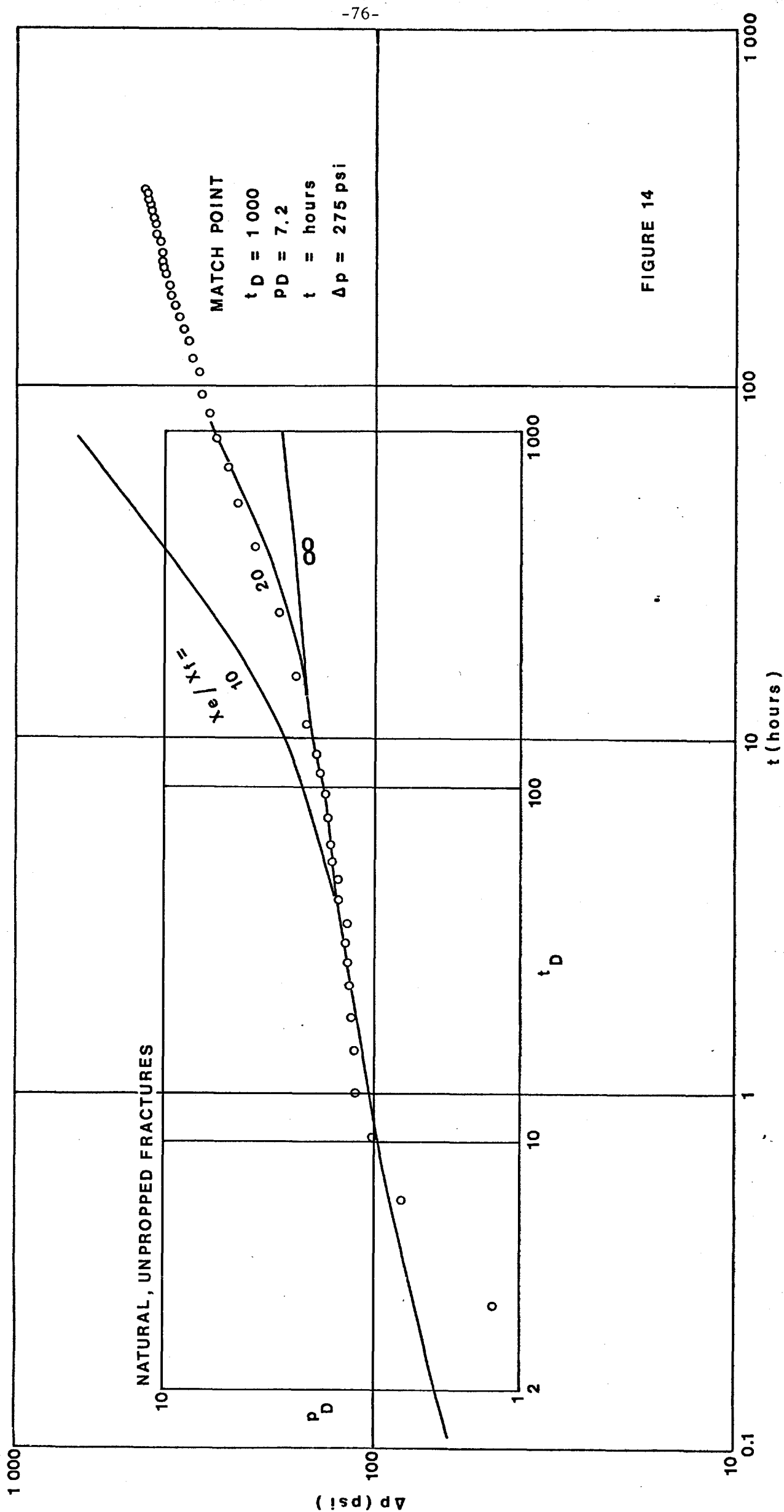
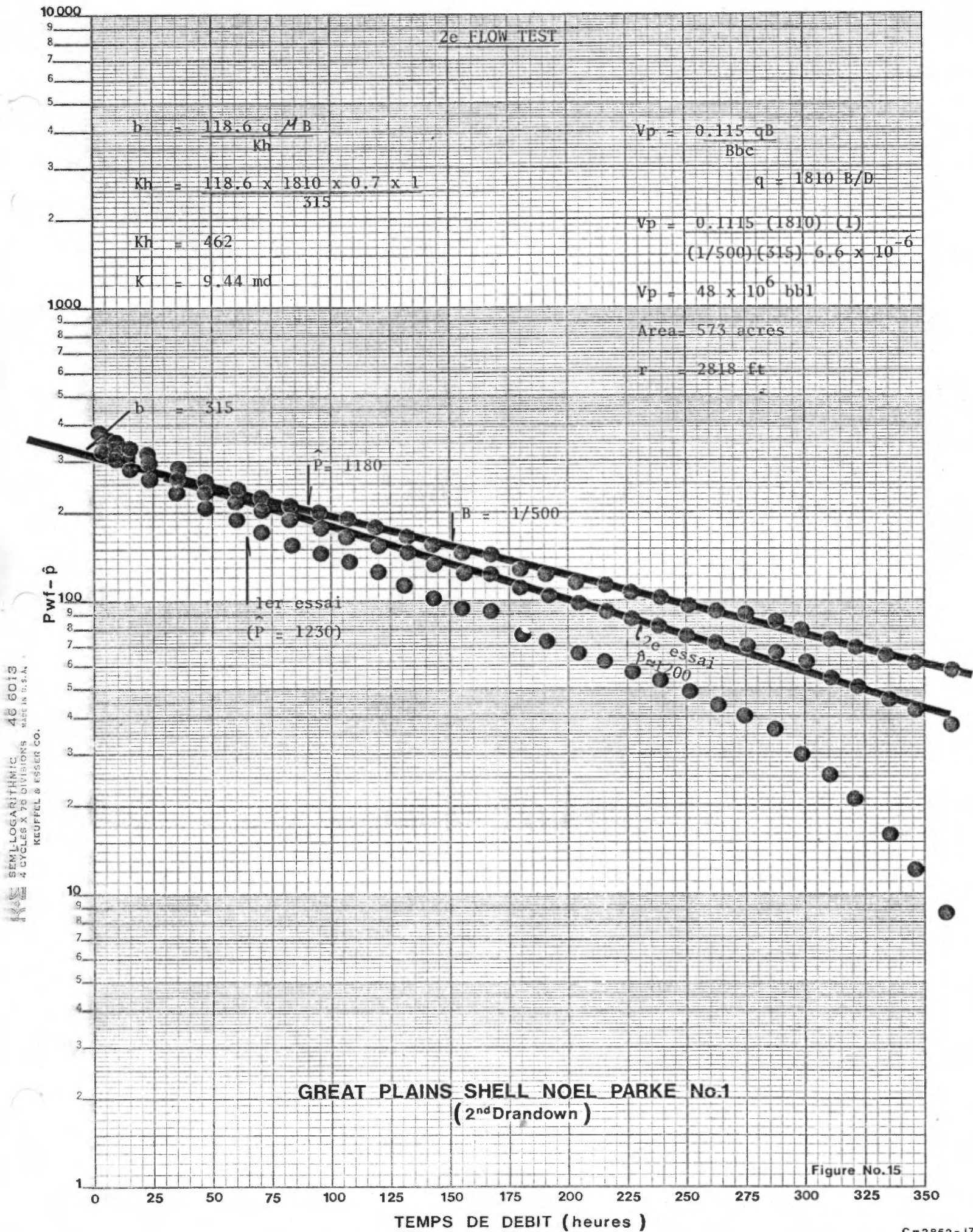
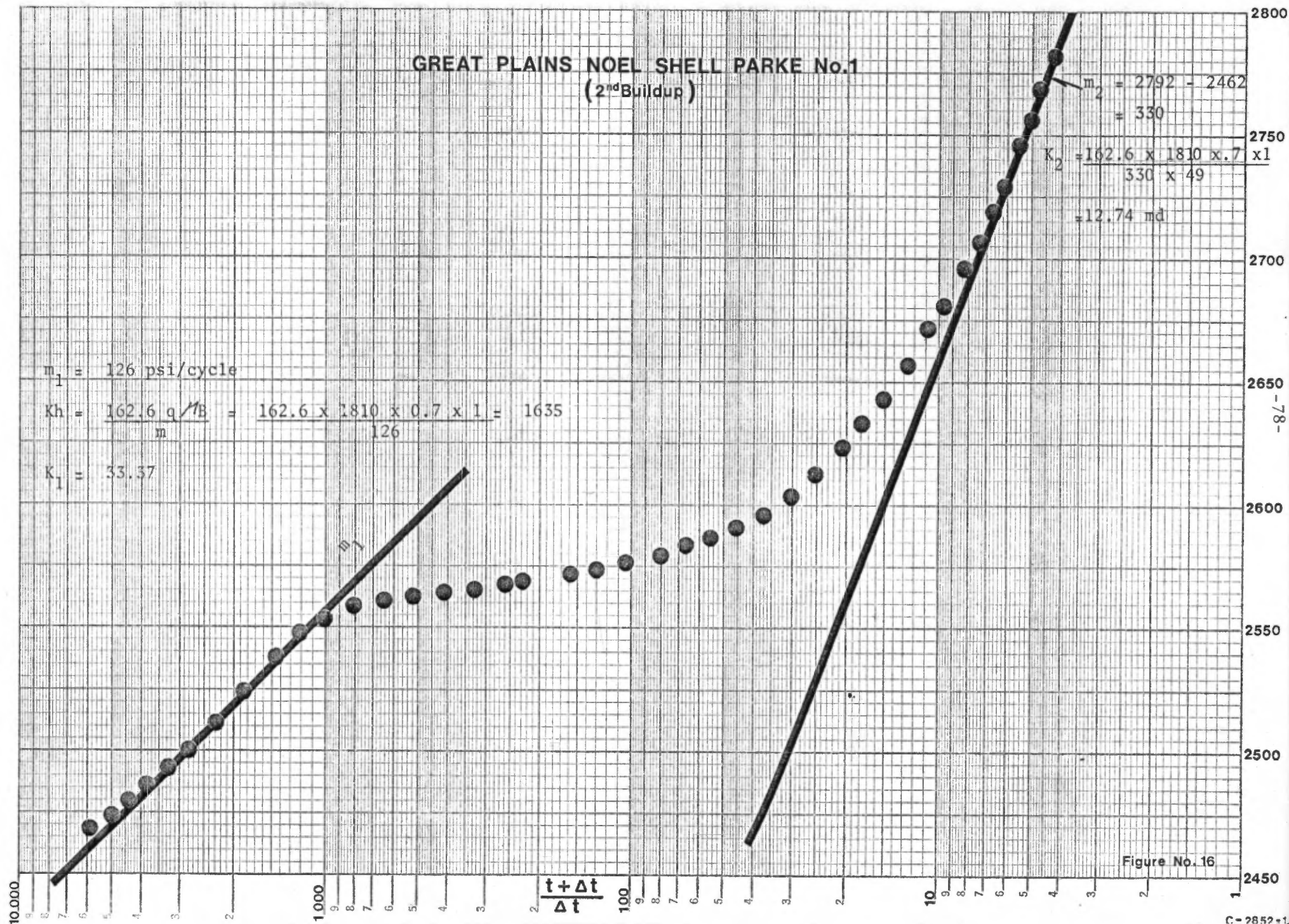
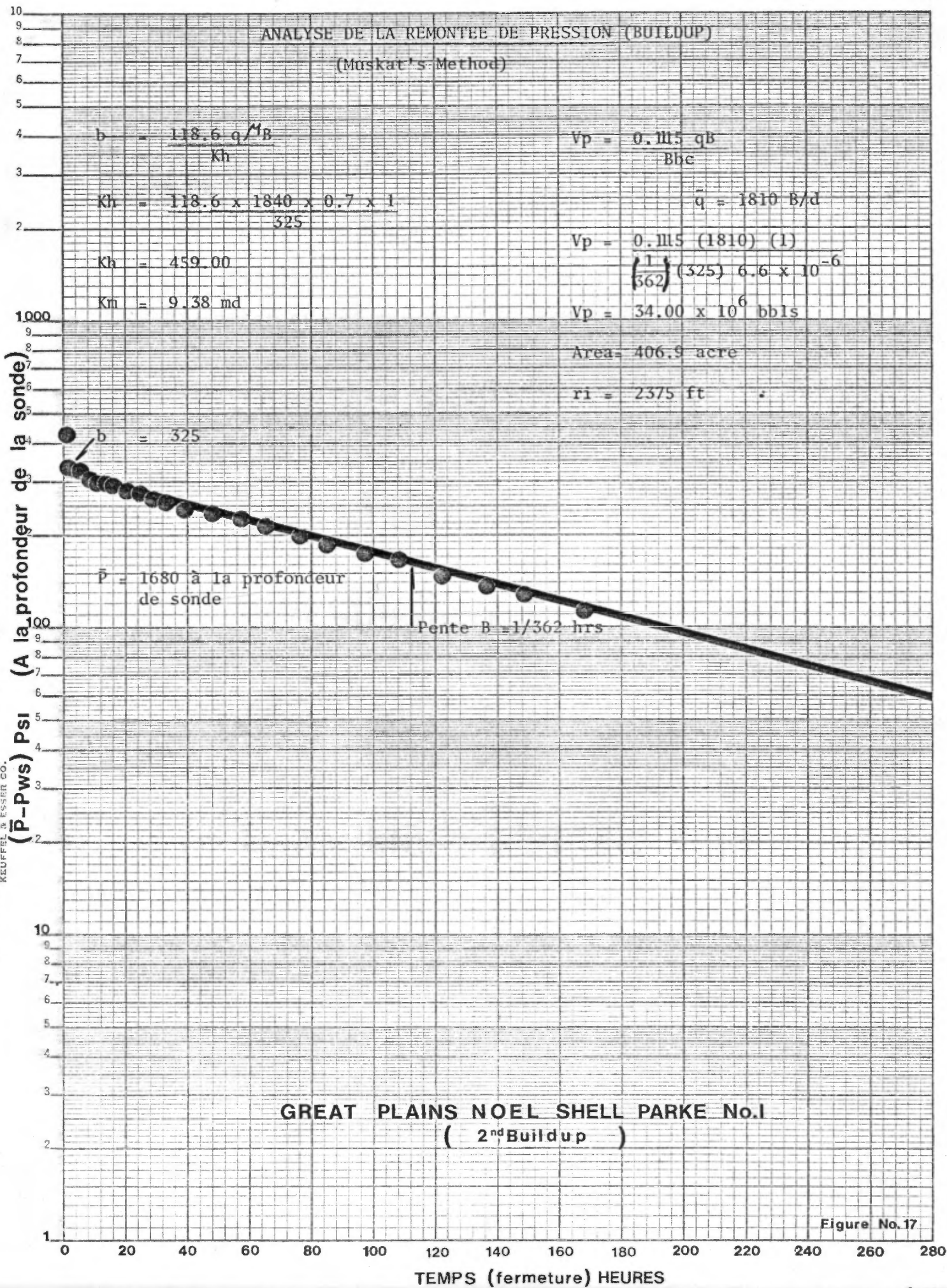


FIGURE 14



SEMI-LOGARITHMIC 46 6013  
 4 CYCLES X 70 DIVISIONS  
 KEUFFEL & ESSER CO.





GREAT PLAINS SHELL NOËL PARKE No. 1

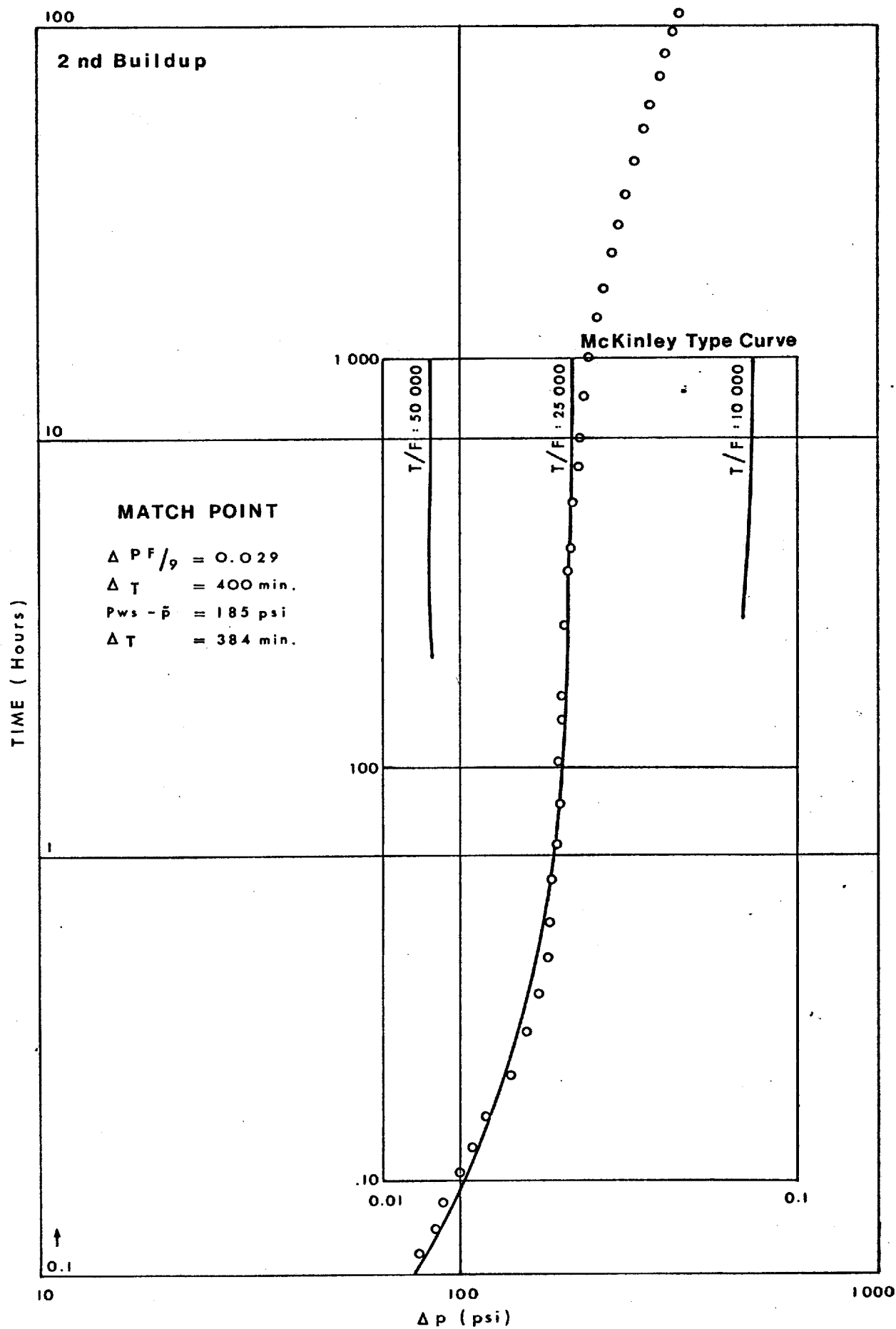


FIGURE 18