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RATIO OF PRODUCED GAS TO PRODUCED WATER FROM DOE'S EDNA DELCAMBRE NO. 1 GEOPRESSURED-GEOTHERMAL AQUIFER GAS WELL TEST

MAST

by

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Abstract

A paper presented by the Institute of Gas Technology (IGT) at the Third Geopressured-Geothermal Energy Conference hypothesized that the high ratio of produced gas to produced water from the No. 1 sand in the Edna Delcambre No. 1 well was due to free gas trapped in pores by imbibition over geological time. This hypothesis was examined in relation to preliminary test data which reported only average gas to water ratios over the roughly 2-day steps in flow rate.

Subsequent public release of detailed test data revealed substantial departures from the previously reported computer simulation results. Also, data now in the public domain reveal the existence of a gas cap on the aquifer tested.

This paper describes IGT's efforts to match the observed gas/water production with computer simulation. Two models for the occurrence and production of gas in excess of that dissolved in the brine have been used. One model considers the gas to be dispersed in pores by imbibition, and the other model considers the gas as a nearby free gas cap above the aquifer. The studies revealed that the dispersed gas model characteristically gave the wrong shape to plots of gas production on the gas/water ratio plots such that no reasonable match to the flow data could be achieved. The free gas cap model gave a characteristically

better shape to the production plots and could provide an approximate fit to the data if the edge of the free gas cap is only about 400 feet from the well.

Because the geological structure maps indicate the free gas cap to be several thousand feet away and the computer simulation results match the distance to the nearby Delcambre Nos. 4 and 4A wells, it appears that the source of the excess free gas in the test of the No. 1 sand may be from these nearby wells. The gas source is probably a separate gas zone and is brought into contact with the No. 1 sand via a conduit around the No. 4 well.

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Introduction

The U.S. Department of Energy (DOE) test of the Edna Delcambre No. 1 well provided some of the first data in relation to the national program of evaluating the potential for obtaining natural gas from geopressured-geothermal aquifers. The reentry and testing of this old well was accomplished in the summer of 1977, and early reports on it were presented at the Third Geopressured-Geothermal Energy Conference in Lafayette, Louisiana, in November 1977. [1]

Two zones were tested in the well: The lower zone designated the No. 3 sand at 12,869-12,911 feet, and the upper zone designated the No. 1 sand at 12,583-12,605 feet. The details of the test procedure, data, and preliminary analysis are contained in a series of reports prepared by the contractors and DOE. [2,3] While both zones produced natural gas in excess of the amount that could be dissolved in the brine, the source of the excess gas in the upper zone was unknown since there was no prior evidence of free gas in the zone. Several speculations were advanced as to the source of this excess gas since the possible production of this excess gas would have significant implications on the economics and viability of this source of natural gas.

One of the theories of the excess gas is that the source was a nearby gas cap which was not initially in contact with the well, but became connected as pressure around the well was lowered during production. The gas would cone down into the well. Another theory is that the excess gas initially exists as a dispersed phase of small to microscopic-sized bubbles in the reservoir rock matrix. [3] With this theory, production of the excess, or free gas, would occur as the pressure was lowered around the well such that the expanding small bubbles would increase the gas saturation to the point where the gas would no longer be trapped, but would flow as controlled by the relative permeability. A third theory is that the gas is all initially dissolved, but as the pressure is lowered around the well by rapid production, gas exsolves from the solution and migrates to the top, where it is produced like a gas cap. A fourth theory is that the gas came from a zone above or below the perforated interval, the free gas having moved through a channel in the cement annulus between the well casing and the well bore wall. This could result from a poor cement job. A fifth theory is that the gas came from the nearby Edna Delcambre No. 4 or No. 4A well, which had flow paths in their well bores or annuli.

Of these theories, the first two have been given modest amounts of consideration. Qualitative and semi-quantitative plausibility arguments for the first theory, namely, the gas cap theory, have been reported by C. L. Matthews [4] following the Third Geopressured-Geothermal Energy Conference and the introduction of the dispersed gas phase theory by

Randolph. [1] The purpose of this report is to describe the progress made to date at the Institute of Gas Technology (IGT) to analyze the data concerning the Edna Delcambre No. 1 well test and the gas production in order to determine which model best describes the occurrence of the excess free gas from the No. 1 sand in the Delcambre No. 1 well and evaluate the possible occurrence of such dispersed gas in geopressured aquifers in general.

Production Test Data

The production test of the No. 1 sand consisted of a 5-step draw-down test followed by a buildup test and then three additional shorter term flow and shut-in tests. Figure 1 shows the resulting pressure and production data. Figure 2 shows the gas/water ratio. Note that the well produced essentially only brine with dissolved gas for the first three steps of the multi-step draw-down test. The excess gas did not occur until the fourth step at about 160 hours after the beginning of the test. Once the extra gas began production, it then continued through all the subsequent flow periods.

A Hewlett-Packard down-hole pressure gauge provided bottom-hole pressure for most of the test period. Production was through variable and fixed chokes and a gas/water separator. The produced gas was measured at two points in the separator system: one at "high stage" and one at "low stage". The flow data were obtained and reported by Otis Engineering. [5] Water and gas samples were taken and analyzed by McNeese State University. [6]

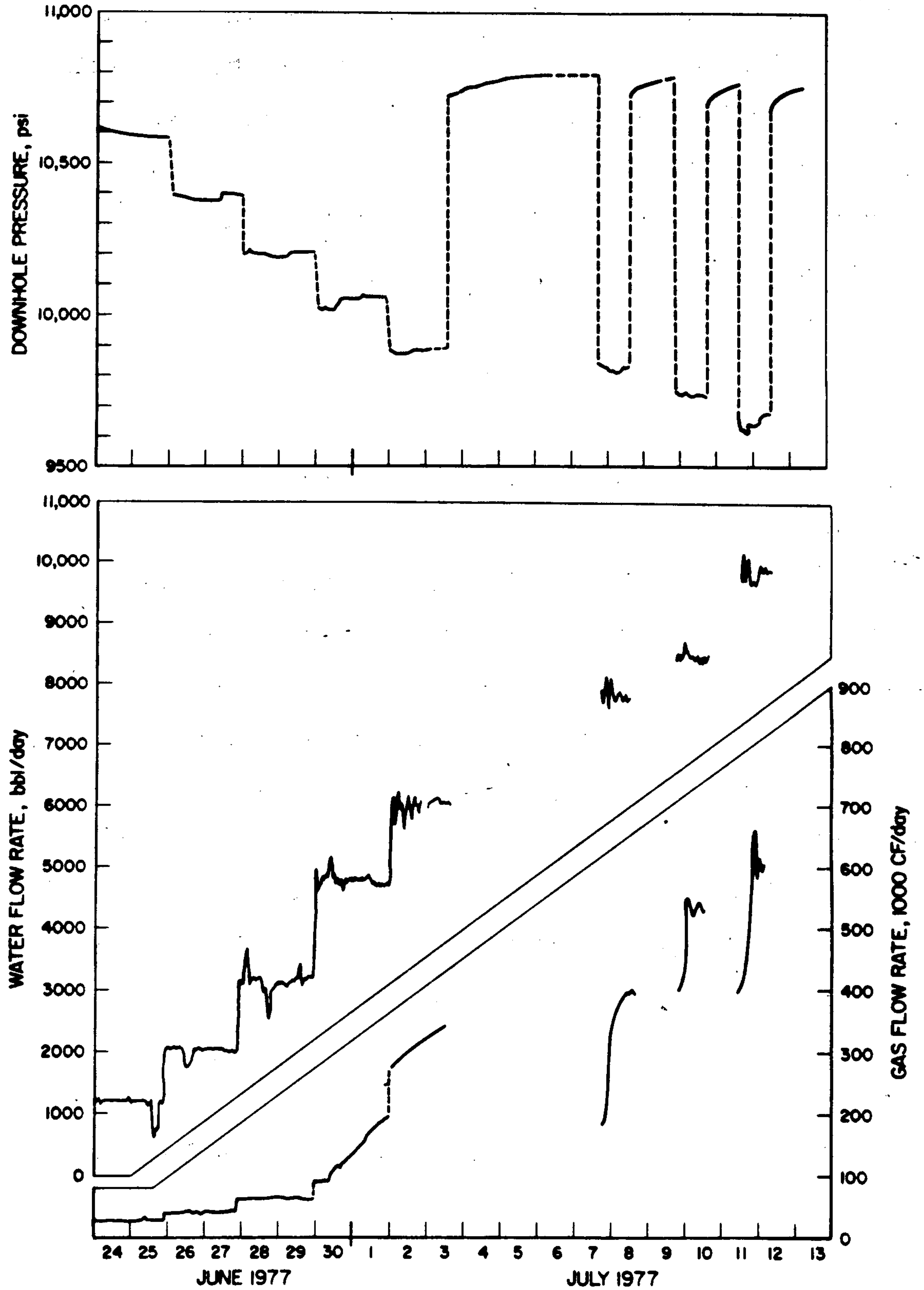

Figure 1. WELL TEST DATA FOR DELCAMBRE NO. 1, SAND NO. 1

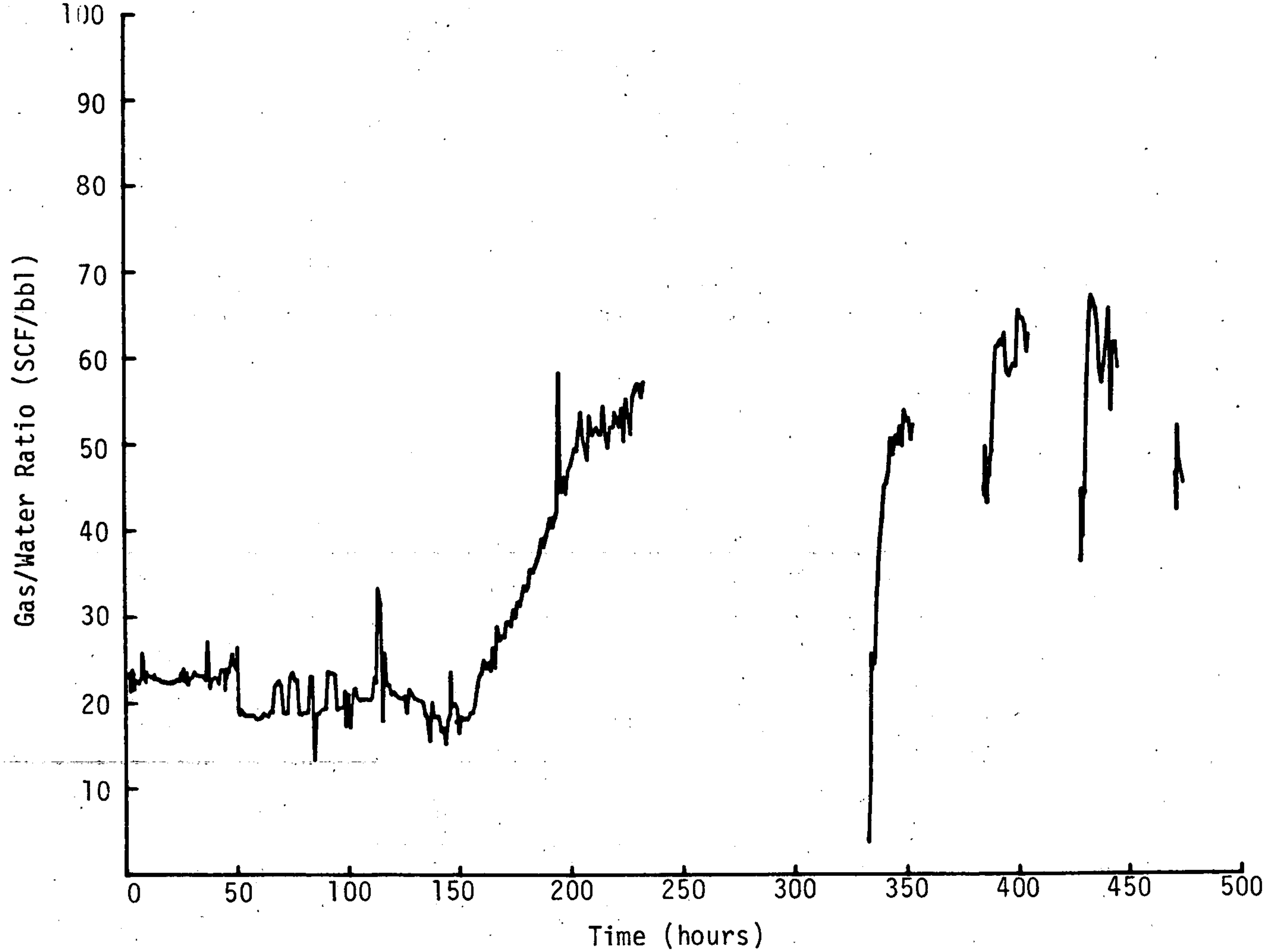

Figure 2. GAS/WATER RATIO FOR PRODUCTION TEST OF THE NO. 1 SAND

Area Drilling and Production

The Edna Delcambre No. 1 well is in an area which has had considerable exploration and production prior to the DOE test. It is possible that these other activities had an influence on the status of the reservoir around the test well. A summary of the drilling and gas production in the area by Don Clark [7] is as follows:

> "The Planulina sand zone of the Tigre Lagoon Field comprises several defined sand reservoirs of which several have produced gas in commercial quantities over the past 20 years. The Edna Delcambre No. 1 well was drilled by the Coastal States Gas Producing Company and was initially completed in the Planulina 8 geopressured gas sand with perforations between 13,716 feet to 13,726 feet. The initial bottom-hole pressure was measured at 11,736 psi on February 1, 1968. The well produced 5,551,490 MCF of gas before it was recompleted in the Planulina No. 7 sand in March 1970. The well produced 270,491 MCF of gas from the Planulina No. 7 sand."
>
> "The well was recompleted in the Planulina No. 6 gas sand in September 1971 and produced 4,058,307 MCF of gas before depleting the sand in March 1975, at which time it was temporarily abandoned."
>
> "Coastal States drilled the Delcambre No. 4, a 400-foot offset to the Delcambre No. 1 well and completed the well in the Planulina No. 8 sand during December 1969. The well produced 5,217,813 MCF of gas and blew out during a workover and was plugged and abandoned in October 1971."

"The Coastal States E. Delcambre No. 4A was directional drilled to kill the Delcambre No. 4 well which was blowing out underground. This well, after killing the blow out, was completed in the Planulina No. 1 sand in November 1971. This completion produced 3,666,867 MCF of gas before it was junked after killing E. Delcambre No. 4 well a second time. These underground mishaps may have some bearing on future tests conducted on the Delcambre No. 1 in the Planulina sand section."

"Union Oil Company, the offset operator to the Delcambre lease, drilled and completed the E. E. Broussard No. 8 well in the Planulina No. 8 sand in November 1968. This well produced 3,607,836 MCF of gas, 59,897 barrels of condensate, and 524,527 barrels of salt water before watering out in March 1971. The well was recompleted in the upper part of the No. 8 sand and produced 34,625 MCF of gas before sanding up. The well was completed in Planulina No. 7 sand during January 1972."

"The final completion of the well was in the Planulina No. 2 sand where it produced 331,628 MCF of gas and sanded up in 1974."

"Union E. Dugas No. 7 was completed in the Planulina No. 8 sand in April 1969 and, through December 1978, had produced 20,316,137 MCF of gas, 422,769 barrels of condensate, and 3,168,428 barrels of salt water."

"Union E. E. Broussard No. 9 was completed in the Planulina No. 6 sand in March 1969 and, through December 1978, had produced 15,199,921 MCF of gas. The Coastal States No. 4D well was opened in this No. 6 sand in December 1968 and produced

3,803,073 MCF of gas when communication between sand members resulted in the blowout and early abandonment of the well."

"The Planuline No. 1 sand was produced in the Eraste Thibodeaux No. 3 well from February 1967 to January 1969. The total production for this well was 799,229 MCF of gas along with some condensate and water."

"In retrospect, most all the sands in the Planulina Zone have been produced in commercial quantities from wells in the Tigre Lagoon Field. The No. 1 sand, designated by OHRW Engineering and perforated between 12,751 ft. to 12,605 ft., is the same sand designated by Union Oil Company as the Planulina No. 3 Sand. This sand has some 50 ft. of gas saturation in the E. Dugas No. 7 well and will be produced by this well in the very near future...This sand had not produced commercial gas at the time of the geopressured test of June 1977 in the Delcambre No. 1 well."

"The discussion of the geopressure production behavior of the Delcambre No. 1 well would not be reliable unless the above gas production history of this Planulina age sand section is made known to the reviewer. In other words, one should definitely expect a gas saturated aquifer as well as high possibilities of some minor free gas saturation in the relatively high structural position in the Planulina sands. The effect of the underground blowouts and inter-sand communication could change the normal saturation expected in the general well area."

Figure 3 is a structure map of the DOE No. 1 sand (the Planulina No. 3 sand) as reported by Matthews,[3] and Figure 4 is the structure map reported by Clark. There are some differences between these two maps, but the general features are similar. From the well location, there is a major north-south fault to the east and some additional faulting to the south. The zone slopes gently upwards to the north, where there is a gas cap in a structural high.

Wireline Well Logs

Figures 5 to 9 show the log data over the interval of the No. 1 sand (Planulina No. 3). Examination of these figures indicates that there are several sand layers or stringers within the perforated interval. Immediately above and below the perforated intervals are layers of shale. These shale layers would normally be expected to be the bounding and confining layers for the producing interval.

Within this perforated interval no free gas could be positively identified from the logs. [9] The statistical nature of the data were not sufficiently accurate to identify free gas of only a few percent. Note, however, that the interval of 12,550-12,565 feet, just above the boundary shale, has indications of a zone that might contain some free gas saturation. Further, the casing bond log indicates a possible poor bond across the shale layer between the top of the perforated interval and this overlying layer, which may contain free gas. This leaves open the speculation that the excess gas produced in the flow test came from these overlying layers via a flow channel through poor quality cement in the well bore annulus. Also, since the Edna Delcambre No. 4 well, which was drilled only a few hundred feet away, had an underground blowout,

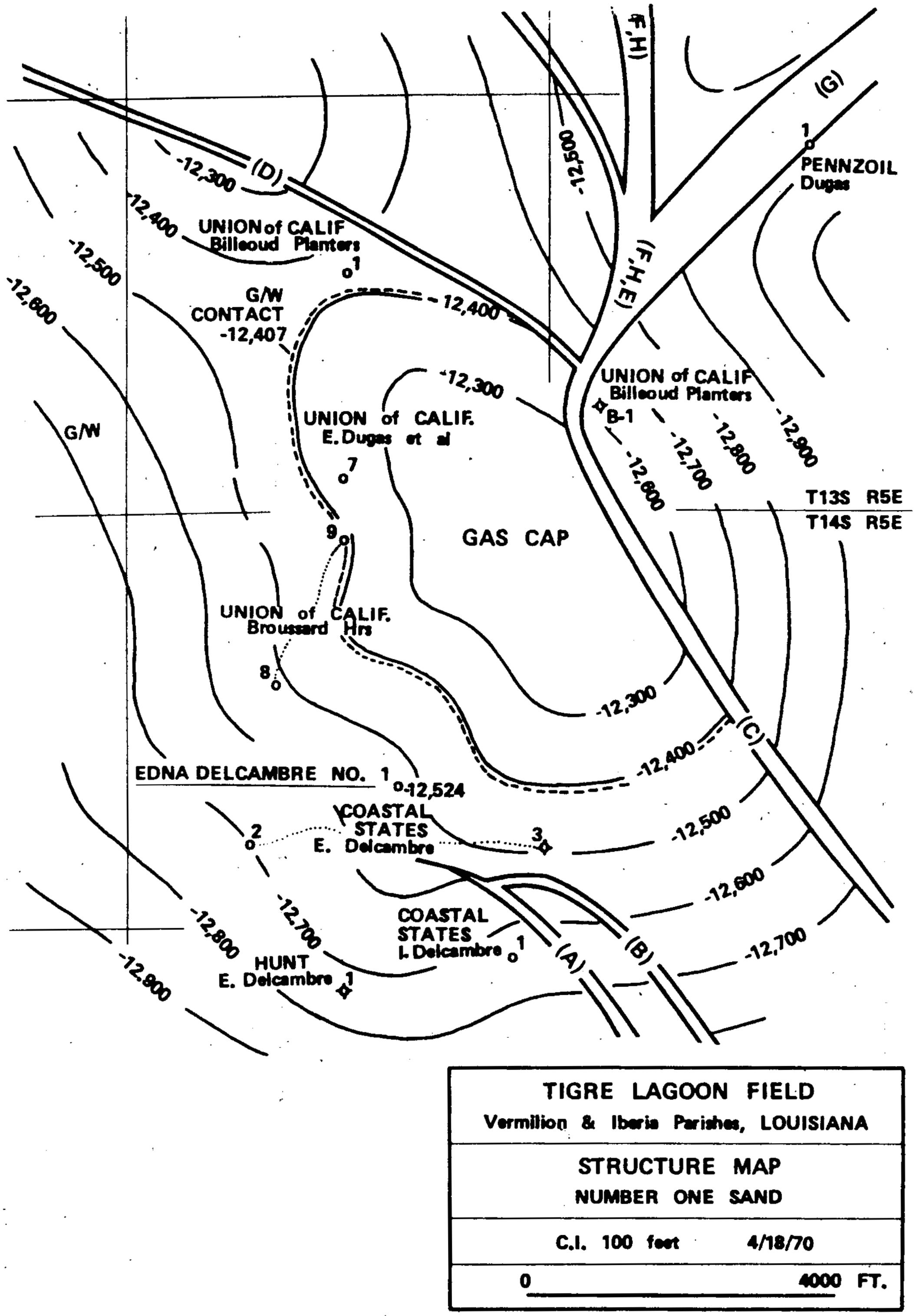

Figure 3. STRUCTURE MAP AS REPORTED BY MATTHEWS.[3] ORIGINAL SOURCE WAS FROM AN FPC FILING BY COASTAL STATES GAS

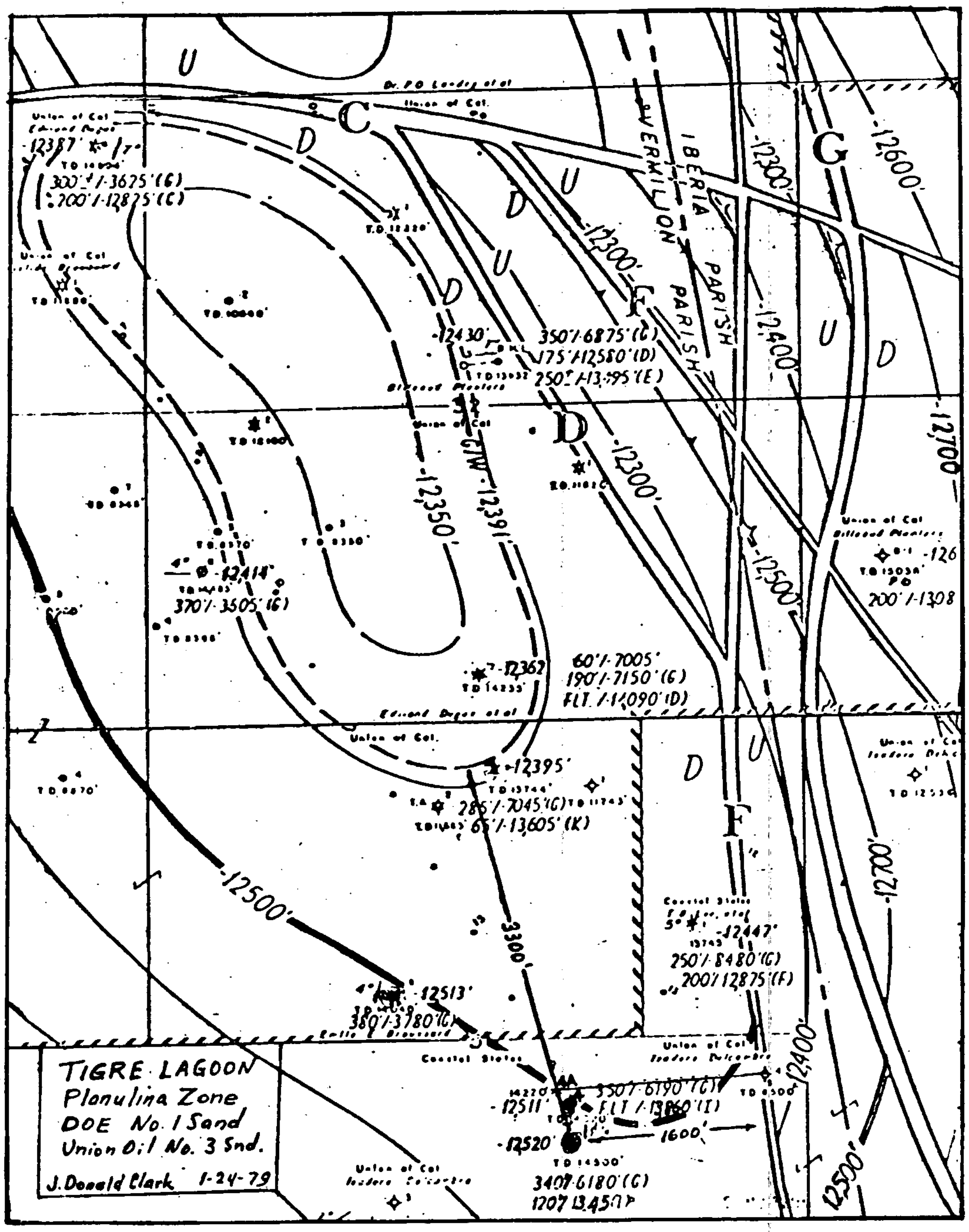

Figure 4. STRUCTURE MAP AS SUPPLIED BY J. DONALD CLARK

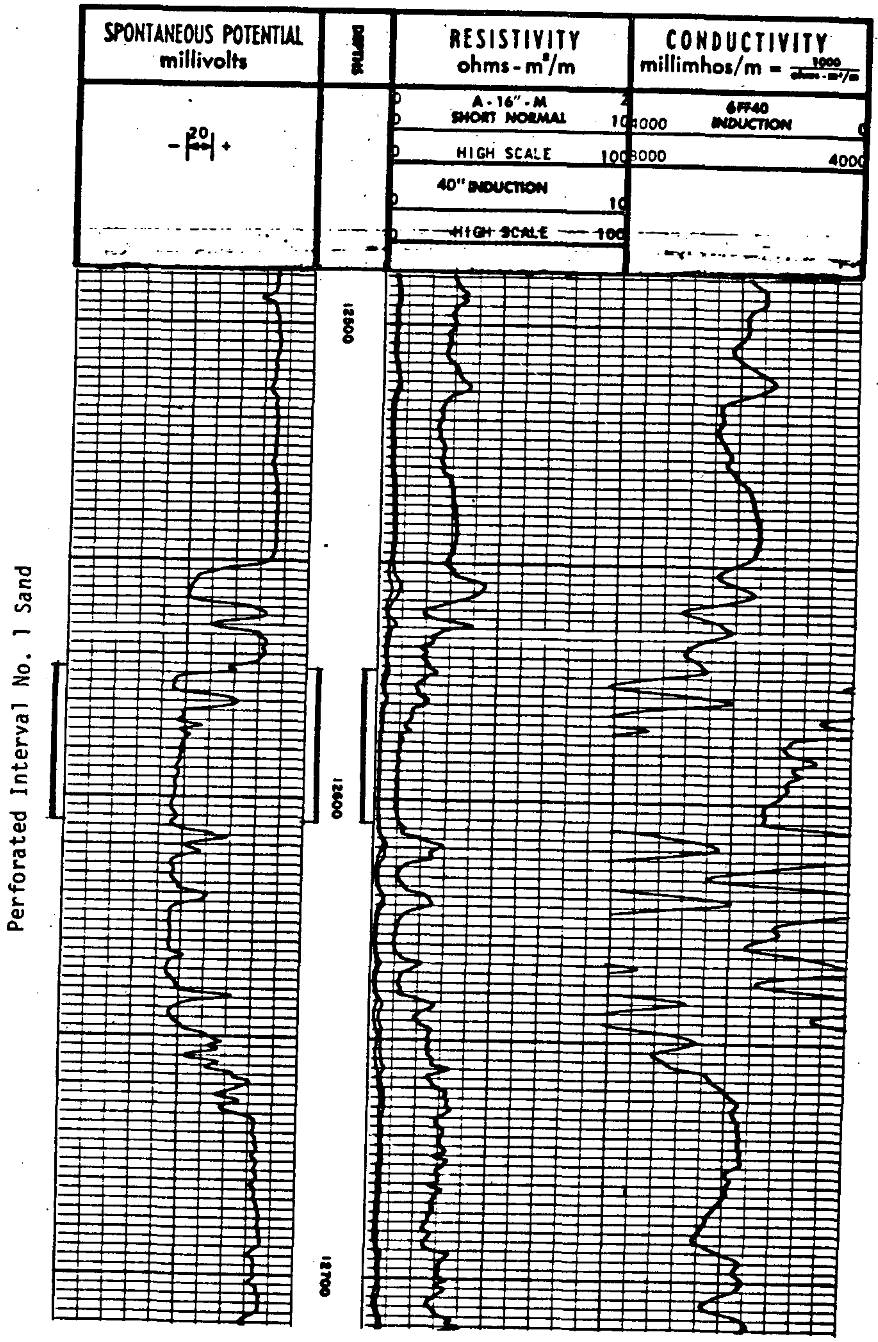

Figure 5. WELL LOG OF THE NO. 1 SAND

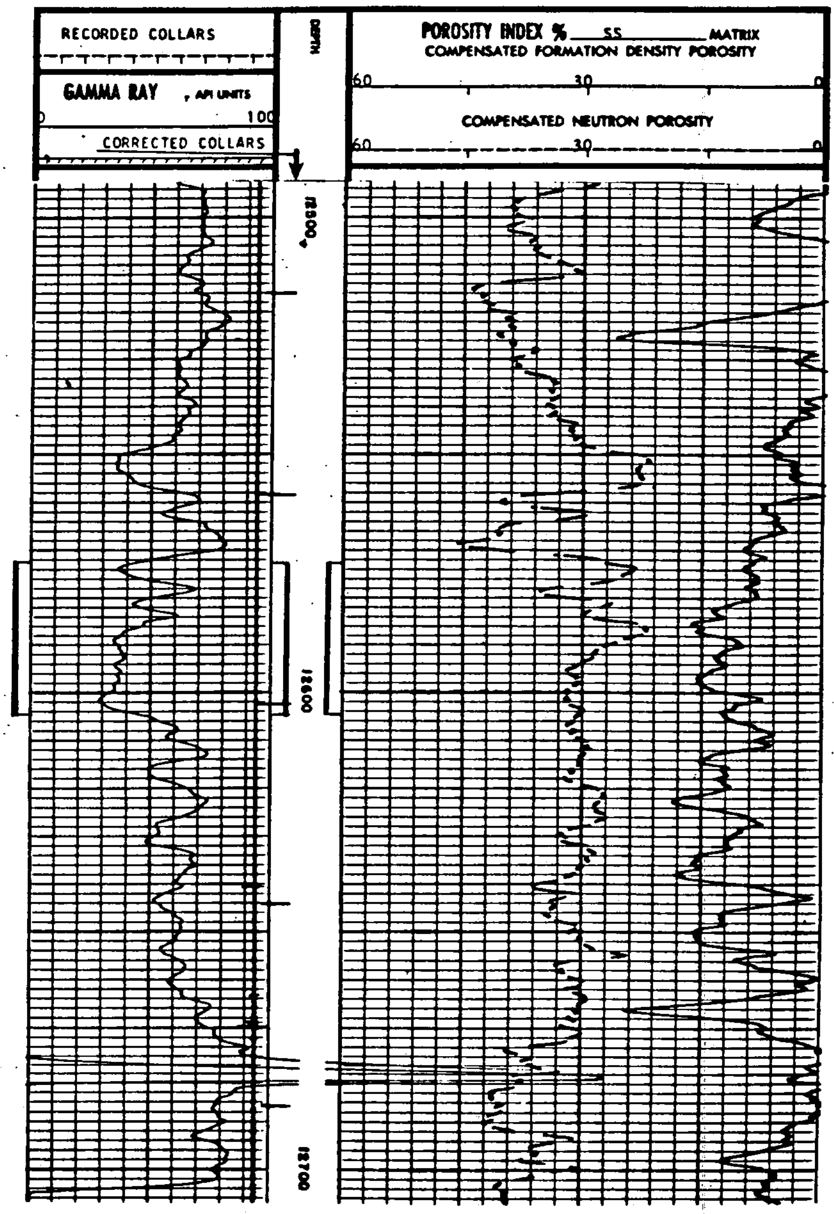

Figure 6. WELL LOG OF THE NO. 1 SAND

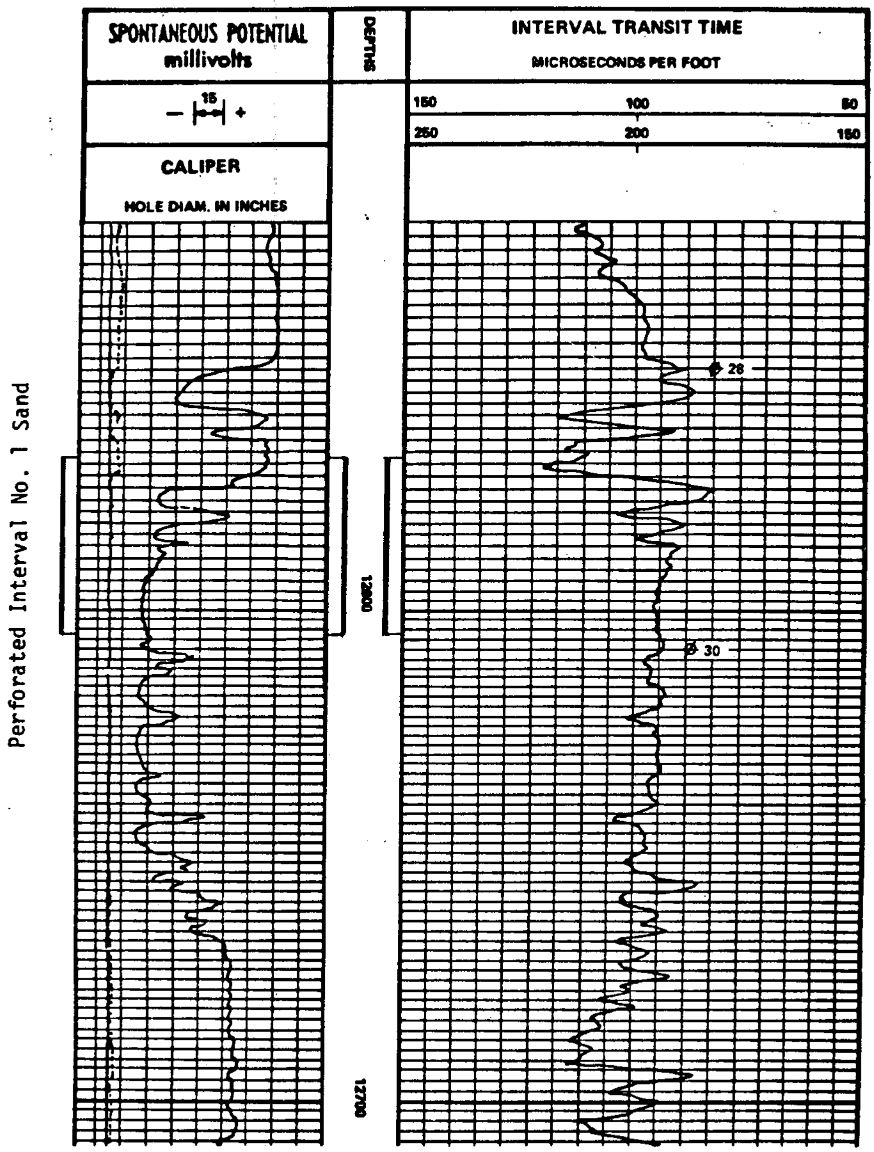

Figure 7. WELL LOG OF THE NO. 1 SAND

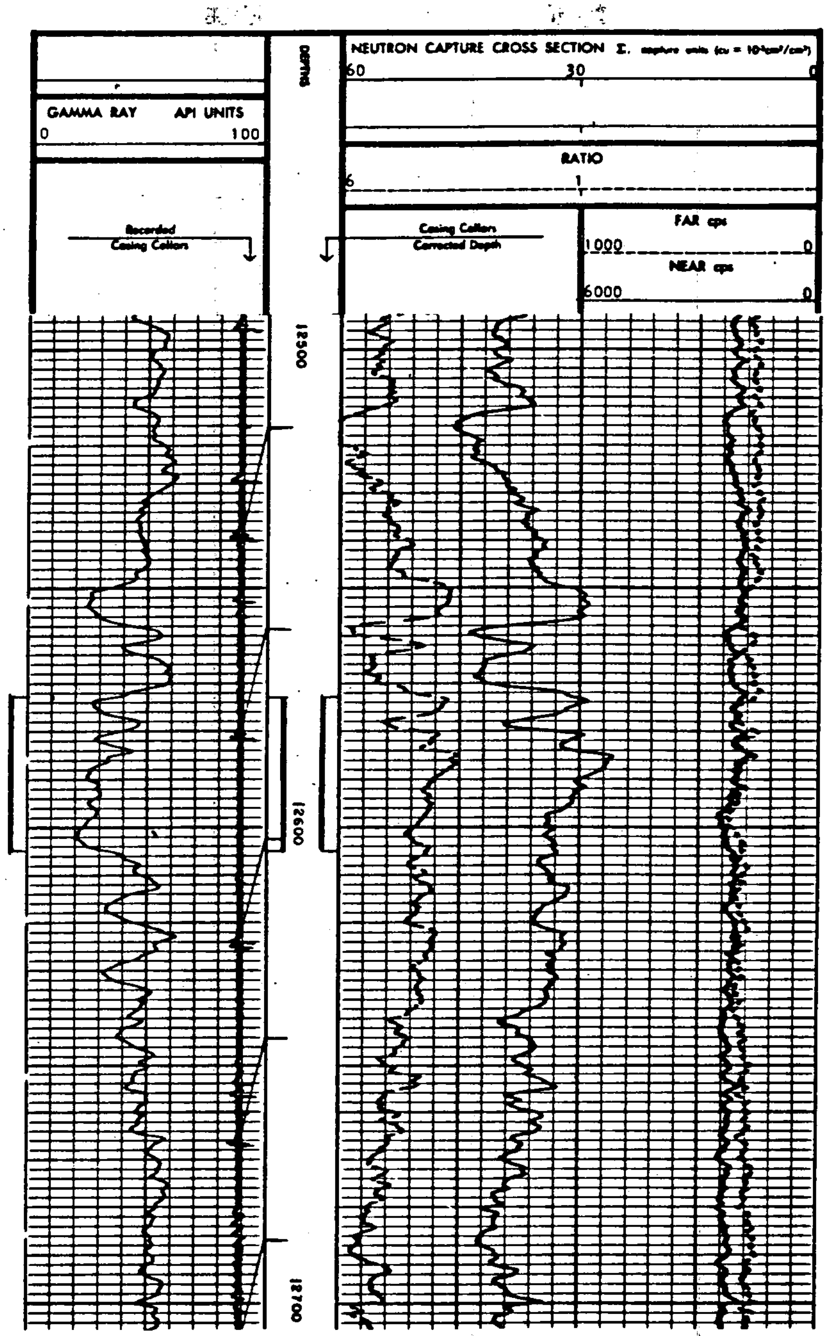

Figure 8. WELL LOG OF THE NO. 1 SAND

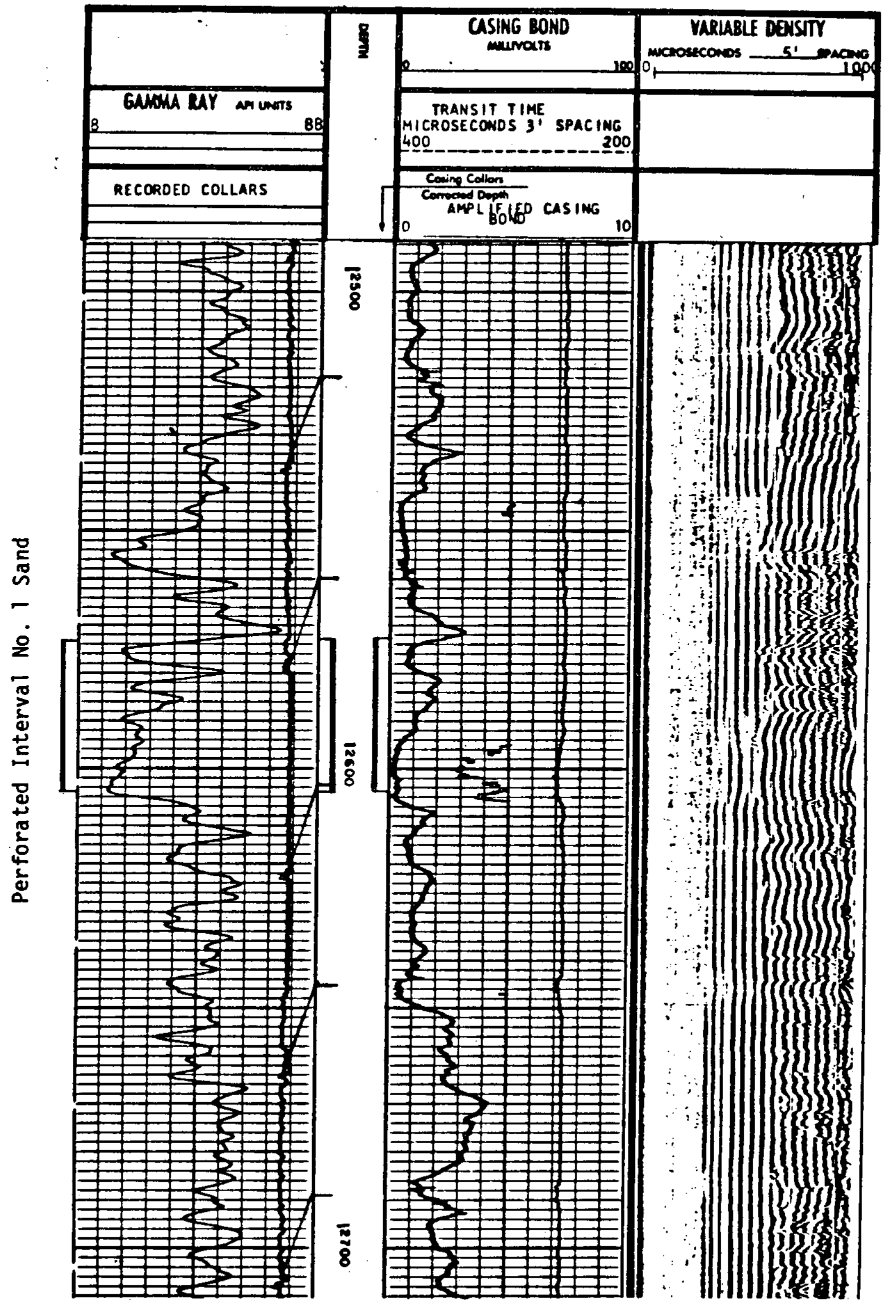

Figure 9. WELL LOG OF THE NO. 1 SAND

there is the additional possibility that some of these normally water-saturated layers had some gas forced into them from the No. 4 well.

Analysis of Test Data

The reported test data of pressure and flow of brine and natural gas were examined in some detail at IGT. Graphs were made of pressure versus the logarithm of time and other factors for multi-step draw-down analysis. The plots of pressure versus the logarithm of time were studied in particular for straight-line segments and breaks in the curves which would indicate pressure wave reflections from boundaries or flow discontinuations at some distance from the well.

The early time analyses were questionable since the brine flow rate for the first hour of the first draw-down test was missing, and the first 2 hours of pressure data for the first shut-in were missing. The use of the down-hole Hewlett-Packard pressure gauge, however, provided reasonably good bottom-hole pressure data. There were significant differences in the amount of gas measured between the high and low stages of the separator, and some judgment was required to determine which data was most accurate.

Figure 10 plots the pressure data for the first step of the multi-step draw-down test. Note that the data can reasonably be fit with several straight-line segments. From the slopes and intercepts of these straight-line segments, the permeability-thickness is calculated to be about 3,000 md-ft. If an estimate is made for the missing brine flow data and this pressure is plotted against the summation function for the multi-step analysis based on supposition (see reference 8), then the results are seen in Figure 11. This plot has sufficient scatter such

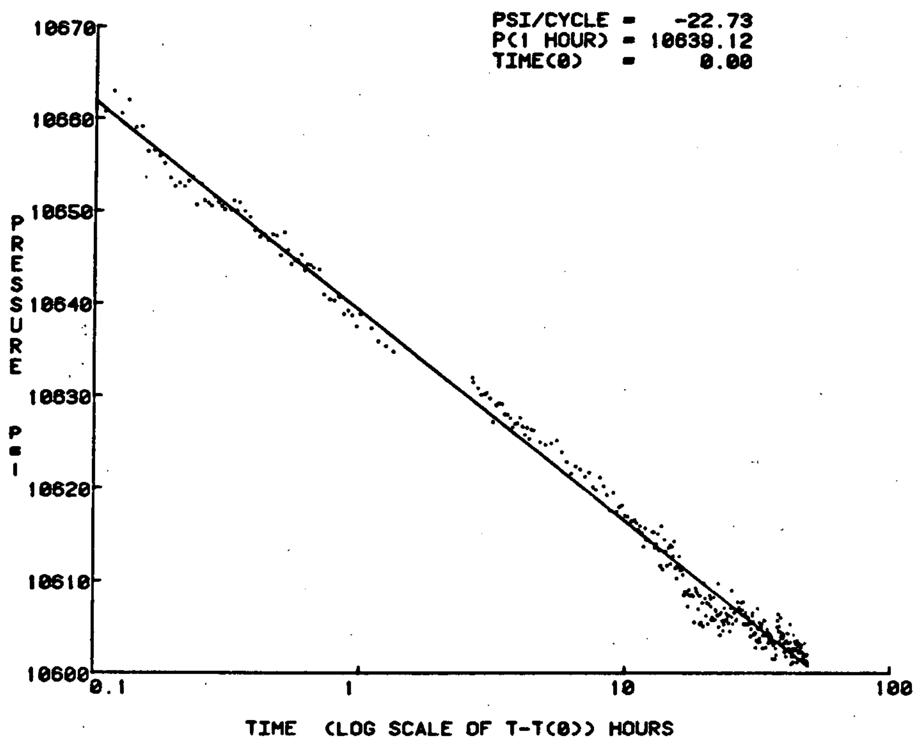

Figure 10. PLOT OF PRESSURE VERSUS LOG TIME FOR FIRST DRAW-DOWN

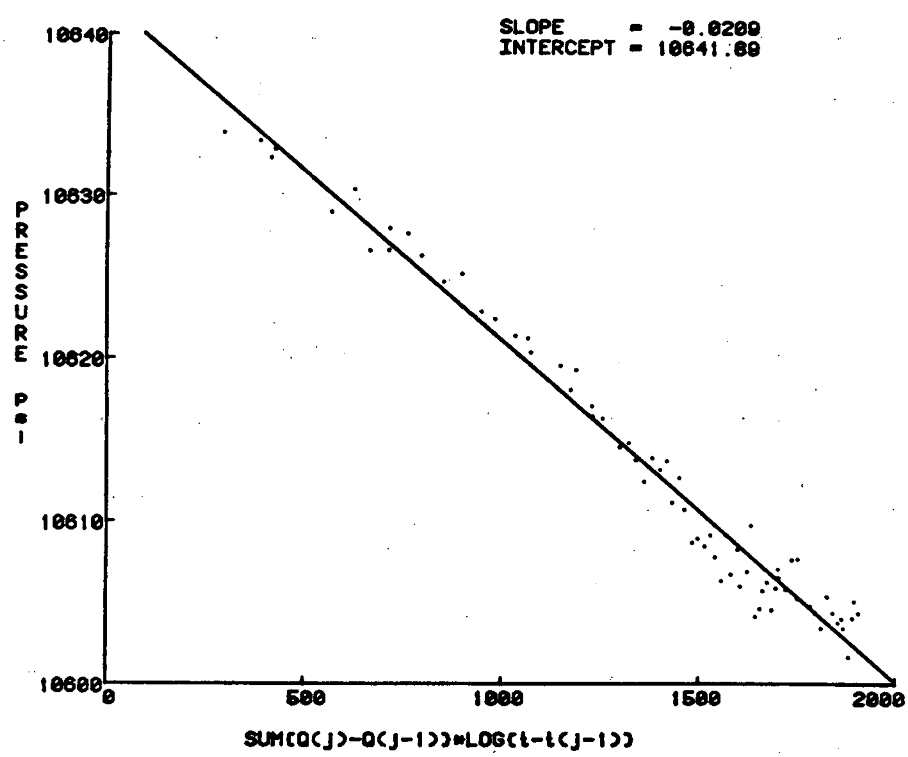

FIGURE 11. PLOT OF PRESSURE VERSUS THE SUMMATION FUNCTION FOR MULTI-RATE TESTS (See Appendix.)

that it is difficult to determine where straight-line segments should be fit. The plot also shows that there are probably some inaccuracies such that caution is indicated in analyzing the data.

The pressure build-up data for the shut-in periods are plotted in Figure 12. Although the first few hours of the first test are missing, the four plots are similar in shape and show the existence of a change in slope at about 5 hours. This corresponds to an apparent distance of about 1900 feet to a flow barrier. This distance is in general agreement with the geology of the area, which shows a major north-south fault about this distance from the well at the No. 1 sand horizon.

An analysis of these pressure data was also made by J. Donald Clark. [7] In his analysis, given in Table 1, he notes additional barriers both closer and more distant than 1900 feet. His analysis is based on data from nearby wells in addition to the DOE Delcambre No. 1 well. His analysis places a second sealing fault at an angle of about 60 degrees to the first fault and a third fault that cuts off the tip of the 60-degree pie-shaped producing area. Other flow boundaries are to the south and west of the well, such that the well is producing from inside the pie-shaped sector. Figure 13 is his analysis of the fault locations from the reservoir limit test analysis.

The many jogs in the pressure and flow data during the production periods indicate that there may have been occasional slugging of gas and brine into the well from the surrounding reservoir. The 5-step drawdown sequence could be approximately matched using a value of about 3,000 md-ft for the first 2 steps and about 5000 md-ft for the last 2 steps after the onset of the excess gas. The first increase occurred at

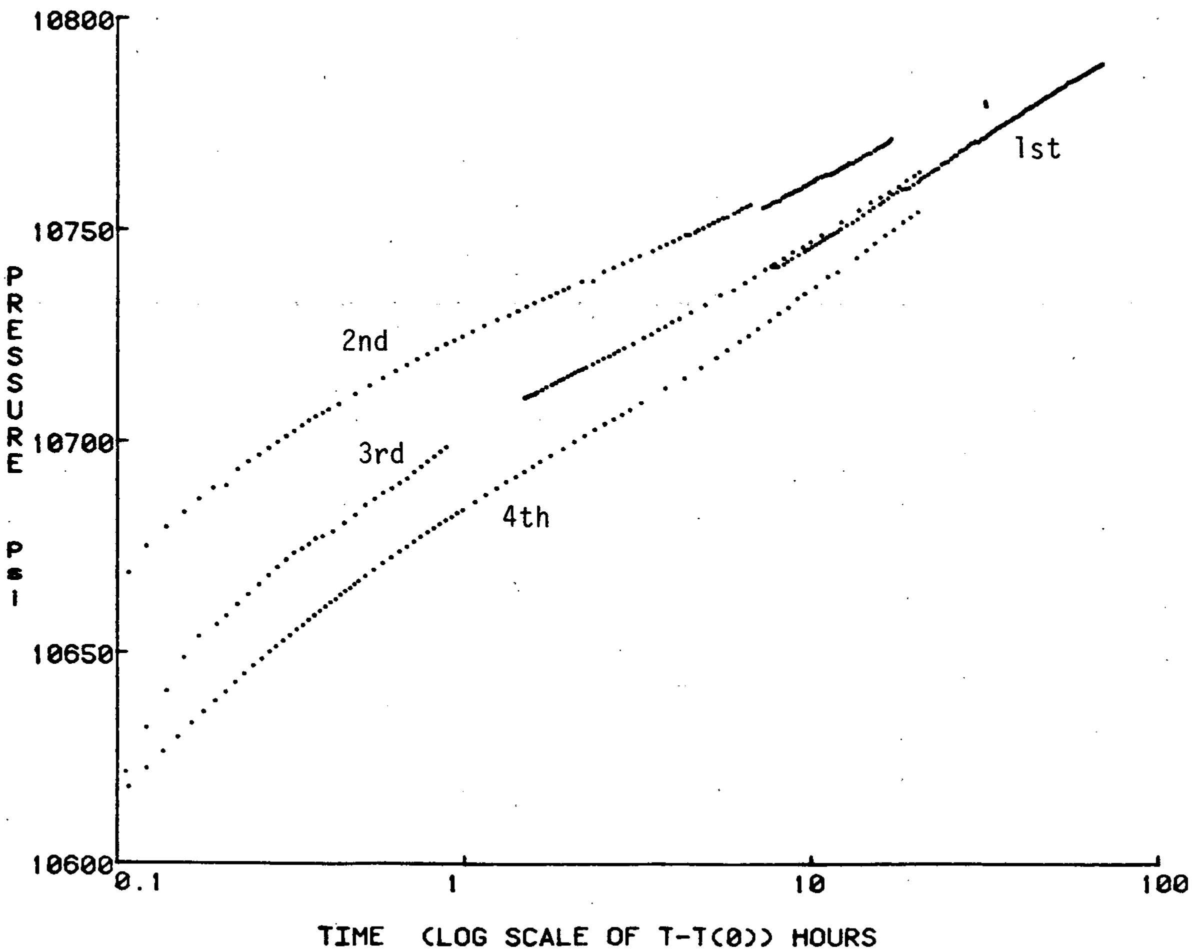

Figure 12. PRESSURE VERSUS LOGARITHM OF TIME FOR THE FOUR BUILDUP TESTS

Table 1. DELCAMBRE NO. 1 WELL NO. 1 SAND RESERVOIR LIMIT TEST*

Time, days	Distance, ft	Plot Slope, psi/cycle	Flow Angle, degrees
.004	154	24.5	360
.600	1886	49.0	180
.770	2137	12.5	gas zone
2.083	35.5		

*Analysis, by J. Donald Clark based on first draw-down test (June 23-24, 1977), of plot of pressure versus log time and the following data:

Assumed constant flow rate = 1163 bbl/day

Porosity = 0.293

Viscosity = 0.386

Height = 30 ft

Water volume factor = 1.04 Reservoir bbl/bbl

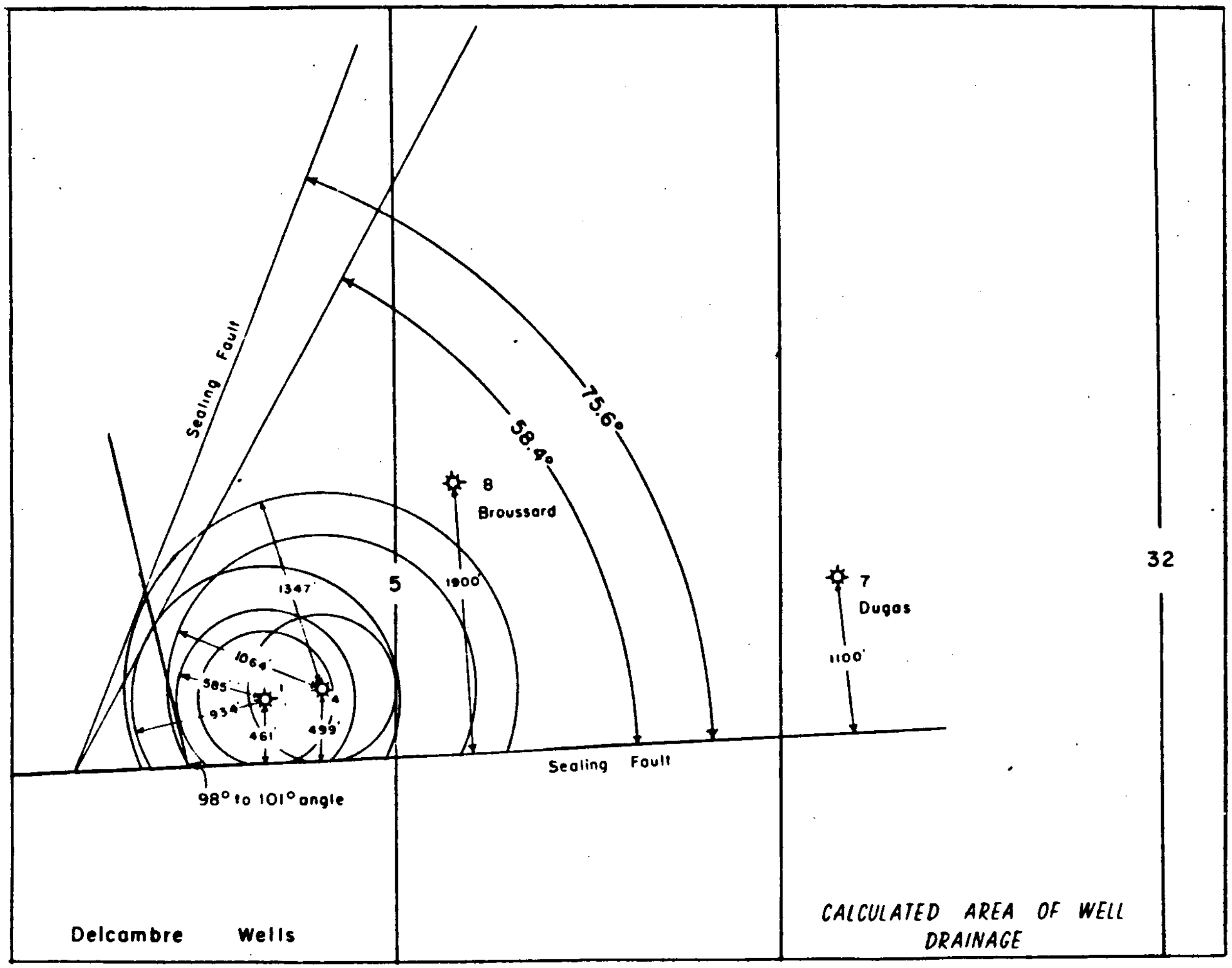

Figure 13. RESERVOIR LIMIT TEST ANALYSIS BY J. DONALD CLARK

about 85 hours in the latter part of the second step. It is also possible, from the complexity of the pressure data and the multiplicity of sands as evidenced by the well logs, that various layers could begin production at different times.

A tabulation of the various values for kh obtained from application of the multi-rate theory is given in Table 2. A tabulation of the data and plots of the data segments used for the piecewise analysis are given in Appendix A.

Water and Gas Composition

Both brine and gas samples were analyzed for their chemical constituents by McNeese State University. These reported analyses were evaluated for changes which would be associated with the onset of free gas. The brine data showed no observable change in the ion concentrations throughout the test. The composition of the minor constituents in the natural gas, however, had a significant change associated with the onset of the free gas. Figure 14 plots the percent of ethane, butane, and carbon dioxide over the test period. Note that when the excess gas was produced, the percentages of ethane and butane approximately doubled, while the percentage of carbon dioxide reduced almost in half. This is convincing evidence that the excess gas had a different composition and probably came from free gas in contact with the brine. Ethane and butane, being less soluble in water than methane, would preferentially concentrate in the free gas cap, and carbon dioxide would be concentrated in the brine rather than the gas cap. This difference in composition could also result if the gas was from a previously disconnected source.

Table 2A. PERMEABILITY-THICKNESS (kh) VALUES FROM MULTI-RATE TEST ANALYSIS TO DATA IN TABLE A-1

Time, hrs	Type of Test	kh, md-ft*
1- 41	draw-down	2,820
52- 85	draw-down	4,635
86- 98	draw-down	2,642
102-128	draw-down	3,073
148-157	draw-down	8,715
250-332	buildup	4,826
337-345	draw-down	10,244
360-385	buildup	7,035

*Using Equation A-1 with $\nu = 0.36$ and $\beta = 1.0$.

Table 2B. PERMEABILITIES-THICKNESS (kh) VALUES BY OTIS ENGINEERING DELCAMBRE NO. 1 WELL, SAND NO. 1 TEST SERIES (See Appendix)

Test Sequence Number	Date	Type of Test	kh, md-ft	$\overline{S}$
1	6/23-6/25	draw-down	2,939	0.11
			4,524	4.13
2	6/26-6/27	draw-down	5,878	11.79
3	6/28-6/29	draw-down	5,095	5.18
4	6/30-7/1	draw-down	--	
5	7/ 2-7/3	draw-down	1,406	-5.74
			2,716	-2.64
			5,181	3.68
6	7/ 3-7/7	buildup	8,697	12.96
			8,840	13.31
7	7/ 7-7/8	draw-down	6,181	5.06
8	7/ 8-7/9	buildup	11,677	17.85
			12,206	18.91
9	7/ 9-7/10	draw-down	6,666	5.42
10	7/10-7/11	buildup	11,417	15.42
11	7/11-7/12	draw-down	6,830	4.98
12	7/12-7/13	buildup	11,926	14.89

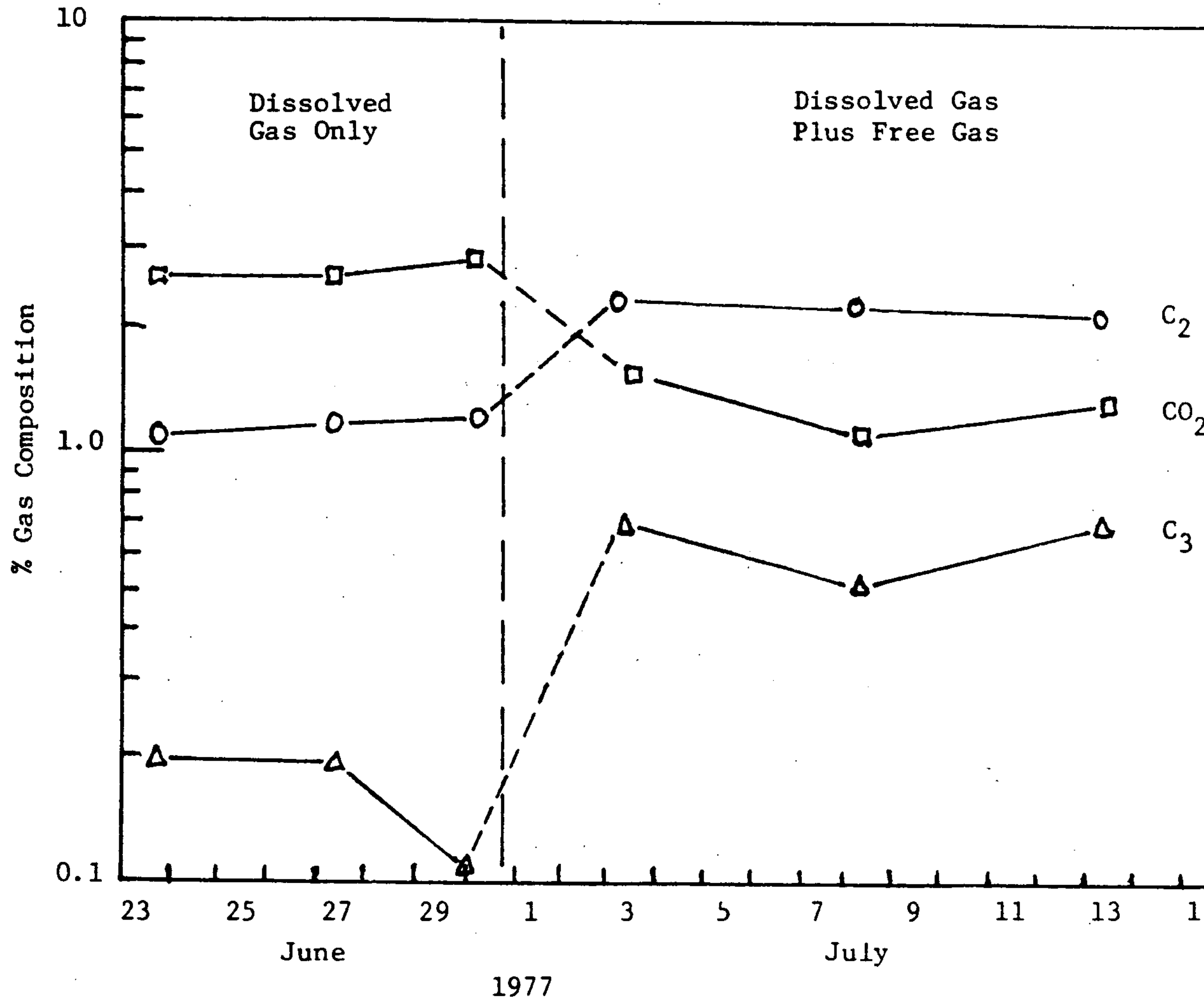

Figure 14. COMPOSITION OF ETHANE (C_2), PROPANE (C_3), AND CARBON DIOXIDE (CO_2) IN THE NATURAL GAS PRODUCED FROM THE EDNA DELCAMBRE NO. 1 WELL, SAND NO. 1 TEST

Gas Solubility and Saturation

Analysis of the gas and water flow rates during the first 2 steps of the draw-down test, before the excess gas began, gave the value of about 20.5 SCF/bbl (including the gas still dissolved in the brine at the separator temperature and pressure). In the recombination studies by McNeese State University, they reported solubilities of 22.8 to 24.0 SCF/bbl to be fully saturated, and they suggested that the aquifer might not be fully saturated. Methane solubility in brine was also recently reported by Blount. [12] For the conditions of the No. 1 sand (13.3% salt, 10,830 psi, 378^{0}K), the methane solubility, according to his equation, is 25.4 SCF/bbl. The Delcambre brine is about 89% NaCl, 5% other chlorides, and 6% other dissolved solids. The gas composition is 90+% methane. Blount's equation for methane in NaCl brine should, therefore, be reasonably close for the Delcambre gas solubility. The results of Blount and McNeese agree with each other to predict a higher gas solubility in the Delcambre brine than was found from the well test. The conclusion is that the Delcambre No. 1 brine was slightly undersaturated, assuming the gas and water flow measurements were accurate. This argues against the possible existence of a dispersed free gas phase (or even a free gas cap) in the main brine producing zones in the No. 1 sand.

Modeling the Dispersed Gas Phase Hypothesis

The occurrence of a dispersed gas phase of small bubbles trapped within the rock matrix was postulated on the basis of discontinuous cycles of pressurization and pressure release of growth faults in the reservoir (Randolph, Ref. 1). On each cycle of pressure release, additional amounts of natural gas is postulated to be released and remain as free gas. During repressurization, additional gas migrates in with the inflowing saturated brine, so that the now free and trapped gas does not redissolve. The free gas does not flow because its concentration is below the critical saturation point. Through repeated cycles of fault leakage and repressurization as saturated brine migrated through, the postulated dispersed gas phase would be developed.

An argument against the occurrence of a dispersed gas phase has been given by C. Matthews (see Ref. 4) where he presents plausibility analyses to show that migrating gas in the brine, or released from the brine, would move to the upper part of the reservoir layer and would not remain dispersed through the matrix. Capillary and diffusion forces being fast enough during the geological time for reservoir formation and gas migration to cause gas movement to the top of the sands and updip.

To model the dispersed gas phase hypothesis with computer reservoir simulators, the relative permeability equations by Corey and Pirson [12, 13] were considered, but with a modification at the critical gas saturation point. The modification, shown in Figure 15, is where the relative permeability to gas drops rapidly to zero rather than curving smoothly to zero, as given by the Corey equation. The initial amount of free gas in the dispersed phase is then placed at a value between this cutoff and full water saturation. With this initial condition the free gas is not initially produced with the brine, but as the pressure decreases in the reservoir near the well and the gas saturation increases, the critical saturation point is reached. When this occurs, the free gas begins to be produced.

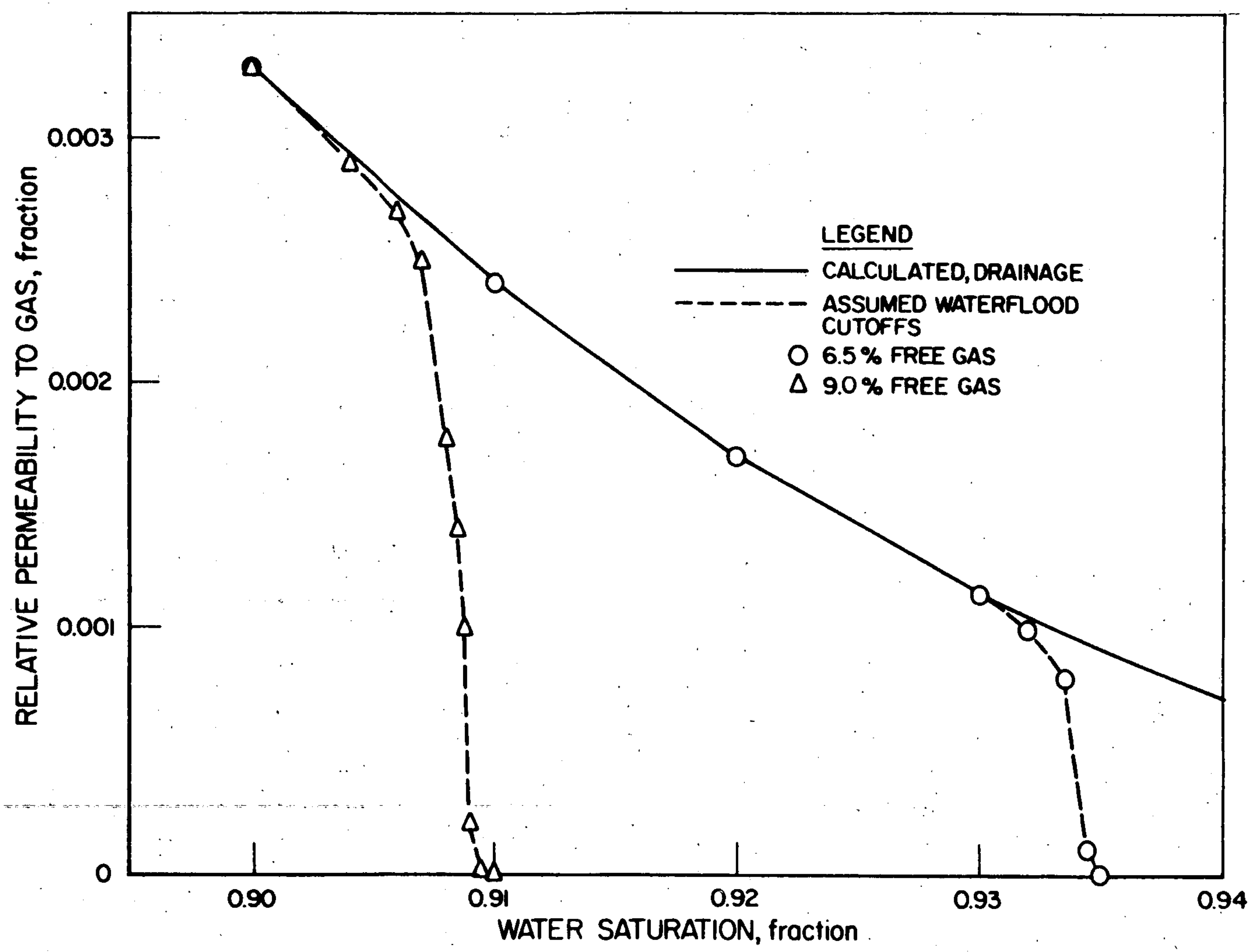

Figure 15. WATERFLOOD CUTOFFS OF CALCULATED DRAINAGE RELATIVE PERMEABILITY TO GAS

For the reservoir simulator, input values for the relative permeabilities and saturations were adjusted by trial and error in an attempt to have the free gas begin at the time observed in the field test and to approximate the produced gas with time. The computer simulator used was Intercomp's 2D Radial Coning Model.

Some of the earlier calculations, as reported by Randolph, indicated that the free gas required to match the hypothesis needed to be about 6.5% or 5 times the amount of gas dissolved in the brine. This amount of free gas was not observed from analysis of the well logs. The well log analysis by Henry Dunlap [9] indicated possible 100% water saturation. The analysis of the data in the Otis Engineering report [5] indicated a possible gas saturation of 2% to 4% based on their modifications of the relative permeability curves and estimated values for the critical saturation. This was a calculated value rather than a measured value, however, and dependent on the theory.

Figures 16 and 17 show representative results of the trial-and-error matching attempts using modified Pirson and Corey relative permeability curves and various initial dispersed free gas saturations. A good fit to the data was not obtained. Further, the general shapes of the plots for gas production or the gas/water ratio are systematically at variance with the observed data. In the well test, the gas continually increases throughout the 4th and 5th steps of the draw-down test. The computer calculations of the dispersed gas model, however, indicate that a sharp increase in gas followed by a tail off to give a "saw tooth" appearance to the gas/water ratio plot. Since the theoretical model of the dispersed gas phase yields a characteristically different pattern for the gas/water ratio through a

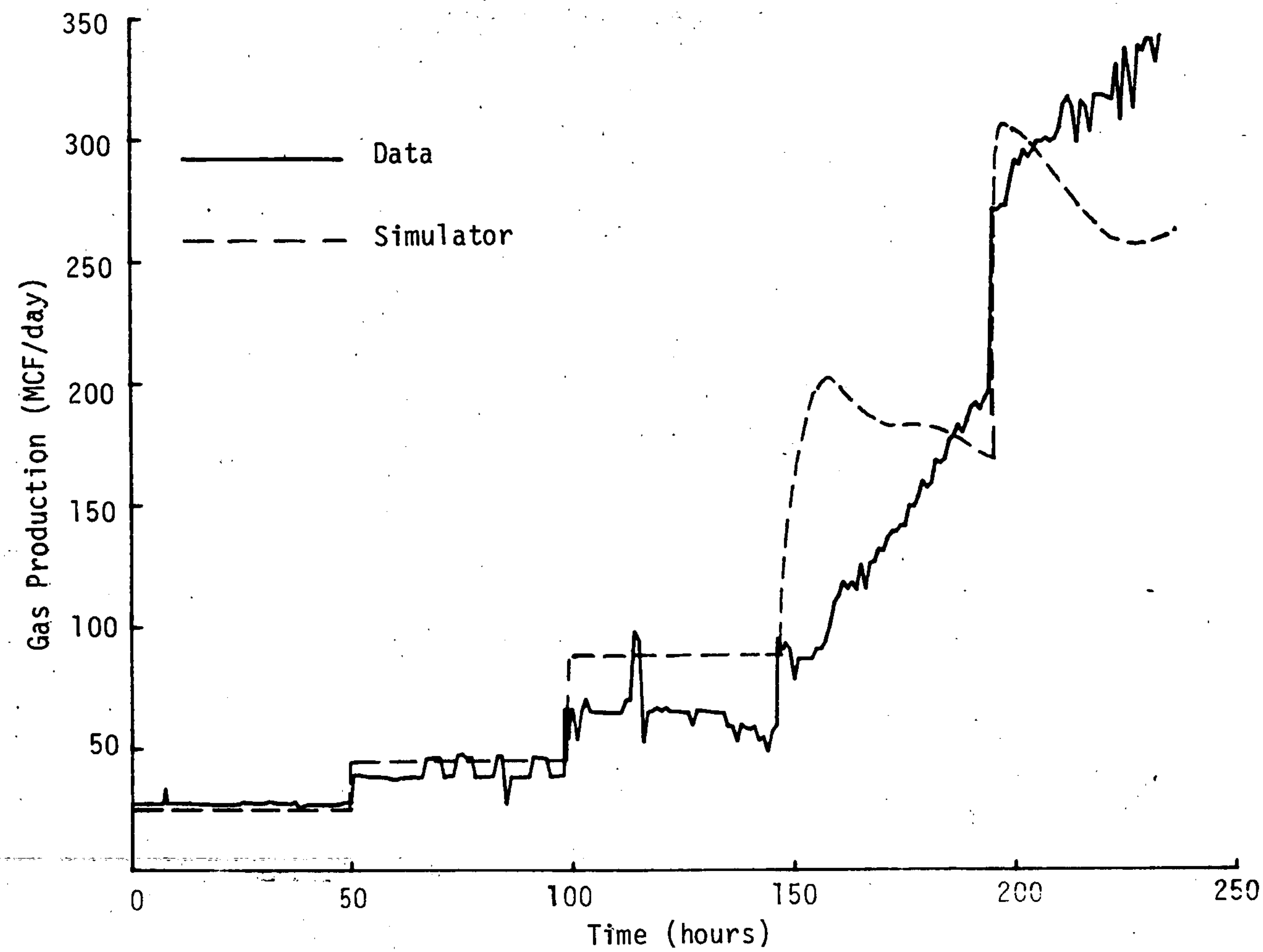

Figure 16. COMPUTER SIMULATOR MATCH TO GAS PRODUCTION FOR DISPERSED GAS PHASE MODEL

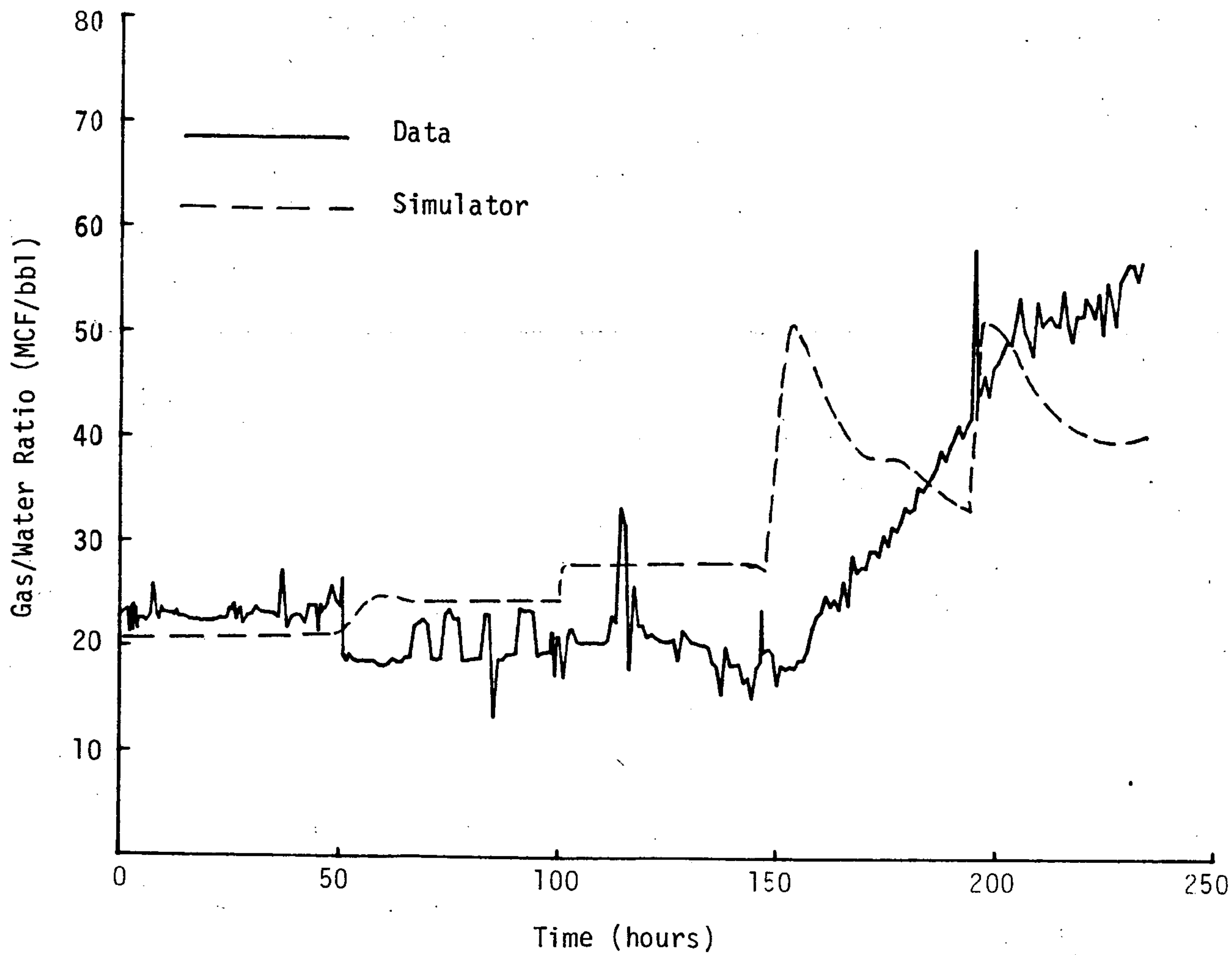

Figure 17. COMPUTER SIMULATOR MATCH TO GAS/WATER RATIO FOR DISPERSED GAS PHASE MODEL

multi-step draw-down test, a good fit to the data cannot be expected. It was possible, however, to get larger amounts of free gas to be produced in the computer calculation during the 4th and 5th draw down step by judicious selection of the initial gas saturation and shape to the relative permeability to gas. Because of the characteristically different shapes of the plots between the data and theoretical computer calculations, it is clear that the theoretical model does not fit this data.

A study of expected gas production from aquifers containing initial immobile free gas was recently reported by John C. Martin. [10] His study was directed to the question of how to identify such gas in addition to predicting the expected production. The study consisted of a computer simulation study where the key parameters were varied over a range of typical values to represent geopressured-geothermal aquifers. His results also indicated the saw-tooth shape in the gas/water ratio plots for multi-step flow tests, which suggested that such a shape on the gas/water ratio plot would be evidence of the postulated immobile free gas.

This study also shows that a saw-tooth shape to a plot of the gas/water ratio may result from a multi-rate draw-down test if the reservoir and test conditions are right. This condition occurred for the cases of a sharp cut-off of the relative permeability to a gas curve that Randolph previously used as well as the smooth relative permeability curves that Martin used as long as the initial gas saturation was close enough to the critical gas saturation value.

Modeling the Free Gas Cap Hypothesis

Modeling the free gas cap hypothesis was done using INTERCOMP's BETA II reservoir simulator. This model allows full 3-dimensional simulation of the reservoir including dip angles to the grid block system. The program was used in the radial flow mode with the well in the center. The angle of dip was approximately 3^{o} with the grid block mesh being 15 horizontal, 5 vertical, and 3 angular for 180^{o}. This grid was rather coarse, but adequate to calculate the general features of a gas cap and its coning down into the producing well. Based on the structure maps shown in Figures 3 and 4, the formation slopes upward to the north, and the major fault at about 1900 feet, as deduced by the geology and reservoir limit test, is to the east.

The distance from the well to the edge of the free gas cap was determined by adjusting the gas/water contact elevation in several computer runs until the free gas broke through to the well bore at the right time of about 160 hours. Using a permeability of about 100 md and a height of 30 ft to match the 3000 md-ft - kh deduced from the reservoir engineering analysis of the data, the resulting distance to the edge of the free gas was in the range of about 400 ft. An exact distance cannot be stated because of the coarseness of the grid in the computer model, the effect of capillary pressure spreading out the contact zone and the uncertainty in the assumptions of the reservoir physical properties. This result is judged accurate enough to state that the free gas source, assuming a free gas cap model, is only a few hundred feet from the well and not thousands of feet as indicated in the geological structure maps.

The discrepancy between the computer match of only a few hundred feet to the free gas source and the geological structure maps, which shows the caps to be thousands of feet away, raise the possibility that the source of the free gas is not the gas cap, but rather the Edna Delcambre No. 4 well, which is only about 400 feet away and had a history of gas production and trouble with underground blow outs. There is the distinct possibility that the free gas originated from some other zone and its flow path was up, or down, the Nos. 4 or 4A well casing or annulus and then into the No. 1 sand when the pressure in the No. 1 sand was lowered during the test. This possibility is also in agreement with the fact that the water composition remains constant, but the gas chemical composition changes when the excess free gas breaks through.

Figures 18 and 19 show the gas production and gas/water ratios obtained from the free gas cap model computer runs made to this report date. This is an early match since by the time of the deadline for submittal of this report the necessary number of trial and error runs had not been made to get a more precise match. From the few runs made, however, it was evident that the free gas cap, or source, a few hundred feet away from the well, gave the characteristically better shape to the plots of gas production for reservoir parameters and are in the range as determined by reservoir engineering analysis of the test production data. Additional computer runs are needed to get a better match to the data for the gas cap hypothesis and to determine whether computer simulation can adequately distinguish between the gas cap hypothesis and the No. 4 well source hypothesis.

Conclusions

Since the Edna Delcambre No. 1 well was the first DOE well tested under the geopressured-geothermal-gas program, there was considerable interest in its results. When the well unexpectedly produced natural gas in quantities above the amount dissolved in the brine, there was a lively concern as to the origin of the gas and whether it was a general phenomena that could be

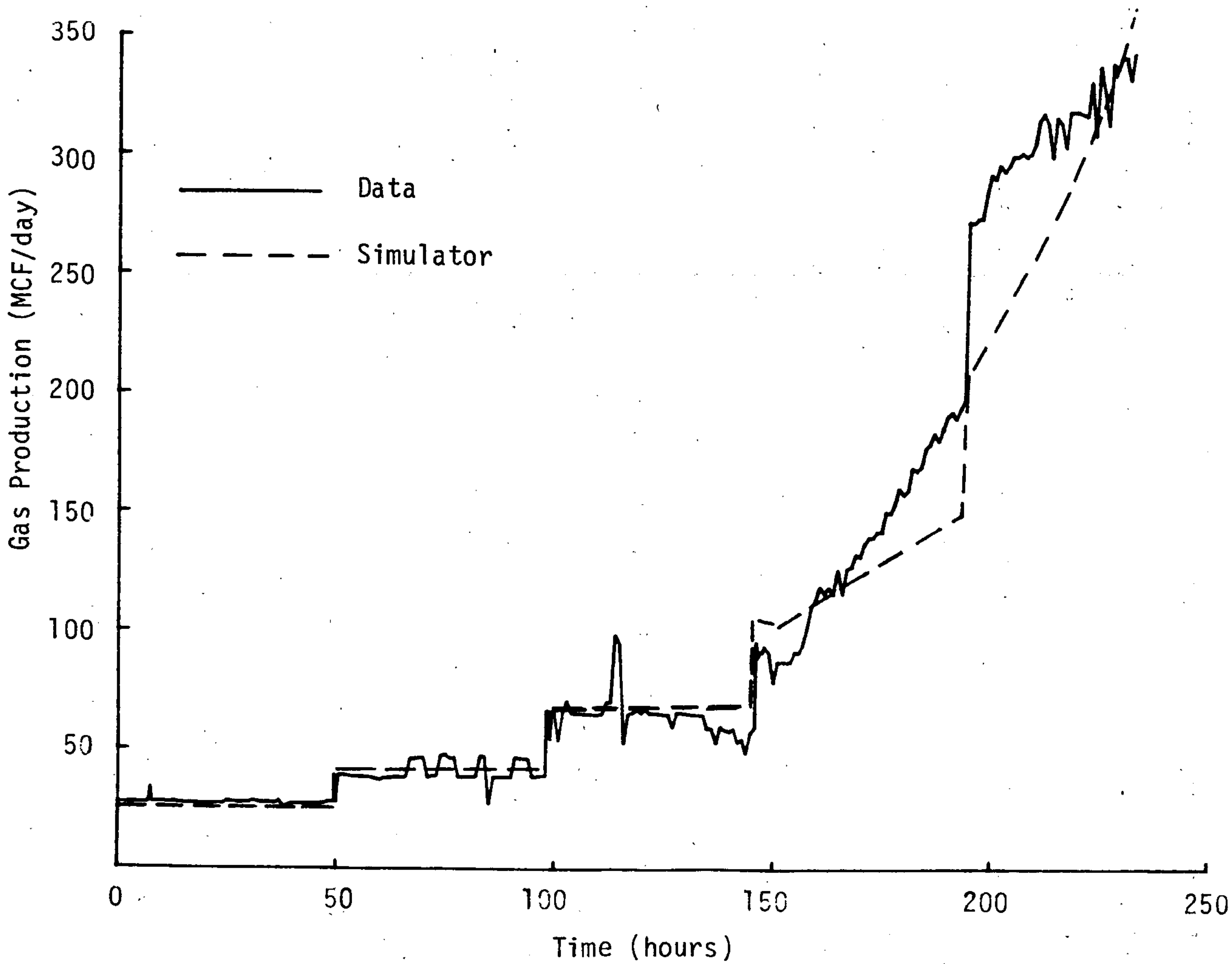

Figure 18. COMPUTER SIMULATOR MATCH TO GAS PRODUCTION FOR FREE GAS CAP MODEL

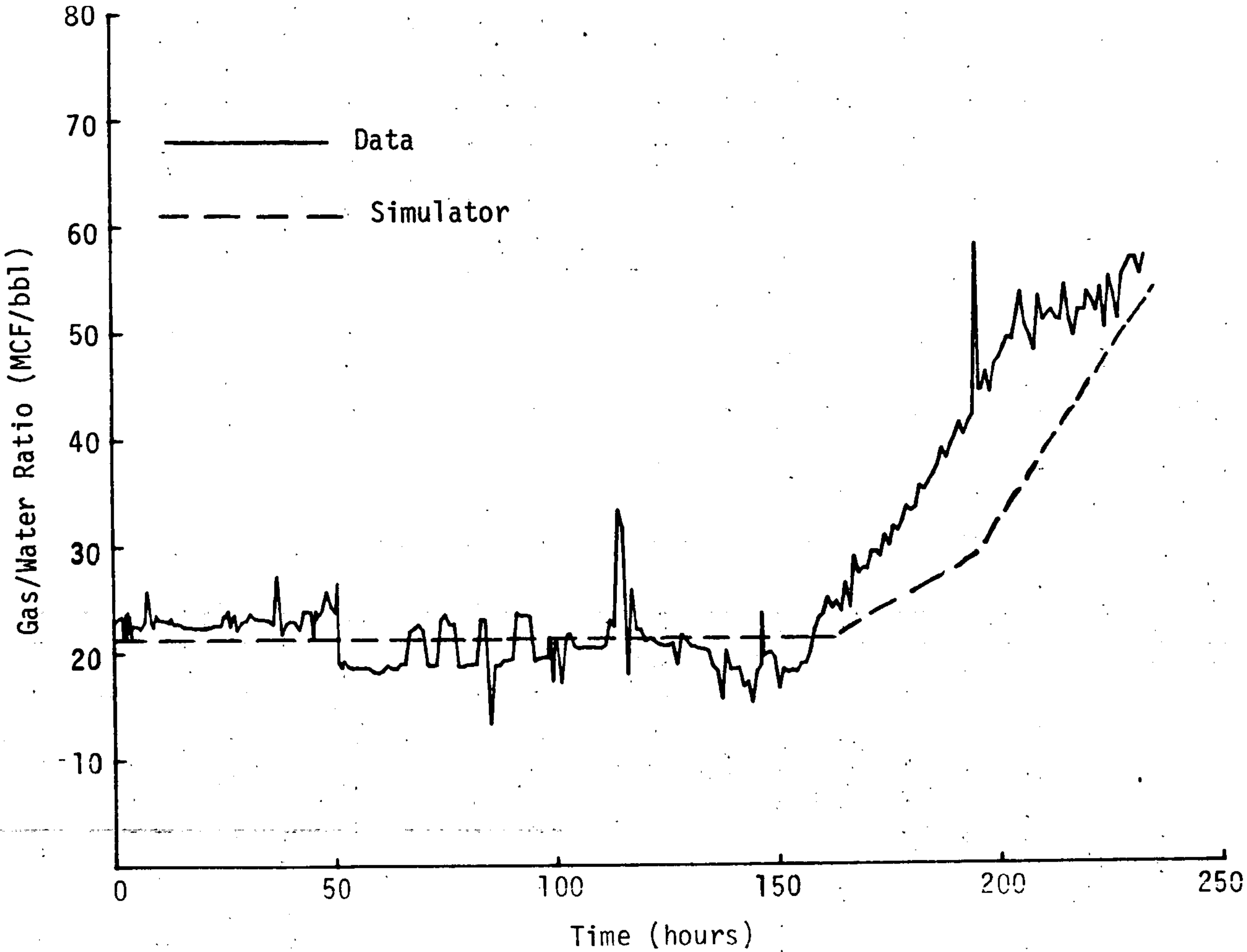

Figure 19. COMPUTER SIMULATOR MATCH TO GAS/WATER RATIO FOR FREE GAS CAP MODEL

expected in other geothermal wells. The possible occurrence of extra gas has a strong influence on the economics of the resource.

The test data have now been analyzed by several groups or persons. It is found that the geological structure near the well is complex, including nearby faults and gas caps. The flow tests first successfully produced brine and dissolved gas from which important engineering parameters such as dissolved gas content and reservoir characteristics were obtained. The subsequent production of the excess gas complicated the test and raised technical issues of whether the extra gas might be from a dispersed phase throughout the reservoir matrix or whether it was from a free gas cap. Other suggested possibilities were that the extra gas exsolved from solution as the water "level" was lowered through production, or that it came from another zone via a channel around the well casing in the nearby No. 4 well.

Detailed examination of the data by usual reservoir engineering techniques and computer modeling to simulate the observed pressure and flow data indicate that the permeability-thickness of the No. 1 sand interval to be initially about 3000 md-ft. The effective permeability-thickness then increased during the test. There are numerous breaks and offsets in the pressure data which both indicate the erratic behavior of the flow and complicate the analysis using routine analytic reservoir engineering methods.

Computer modeling was performed to test both the theory of a dispersed, but originally immobile free gas phase and the theory of a nearby free gas cap or zone. These studies indicated that plots of the gas/water ratio versus time would yield stair-step or saw-toothed shaped curves which were characteristically the wrong shape to match the experimental data from the production test of the No. 1 sand in the Edna Delcambre No. 1 well. Computer results for the free gas cap model gave gas production and gas/water ratio values which were characteristically a better shape to match the experimental data. By judicious selection of the various reservoir parameters based on reservoir engineering analyses of test data, it was possible to get an approximate match of the computed gas production to the measured gas production. The computed fit did not determine a unique solution to the problem, but it did provide a consistent set of reservoir parameters which were in line with the measured values. In this study, the postulated free gas cap was required to have its edge about 400 feet from the well.

For these computer studies, it is apparent that the initially dispersed but immobile gas model is not correct for the No. 1 sand in the Edna Delcambre No. 1 well. The free gas cap model is more consistent with the data, but in view of the computer simulation studies along with the data, this model does not appear to be correct either. The most likely source of the excess gas now appears to be from a yet undetermined gas zone which became connected to the No. 1 sand via a conduit around the No. 4 or No. 4A well.

Because the dispersed but immobile free gas model produces characteristic stair-step and saw-tooth gas/water ratio plots for multiple rate draw-down tests, it may be possible to identify such reservoirs by a multiple rate test. The authors are not aware of any such test data, but it might be found in tests of abandoned watered-out geopressured gas wells where flooding of the gas cap creates a dispersed free gas phase by imbibition and capillary affects trap free gas in the pores of the rock. Such reservoirs may not be found where they were formed over geologic time periods and equilibrium thermodynamic principles apply. They may, however, be found as left behind from production of gas caps on top of aquifers which were recently flooded by intrusion of water, or in the upper edge of an aquifer where the capillary pressures spread out the gas like a transition zone.

Finally, the Department of Energy program of completing both old and new geopressured-geothermal aquifers should provide additional data from which detailed analysis should give better understanding of the physical mechanisms which control production. As these physical parameters become better understood, improved production and economic projections can be made.

Acknowledgment

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Appendix. Multirate Test Analysis

The theory behind multiple flow rate analysis is given in Reference 8. The equation that relates the down hole well bore pressure to flow rate and time is—

$$\frac{P_t - P_o}{q_n} = \frac{162.2\nu B}{kh} \left[\sum_{j=1}^{n} \frac{(q_j - q_{j-1})}{q_n} \log (t - t_{j-1}) + \overline{S} \right] \qquad \text{(A-1)}$$

where:

P_t = well bore pressure at time t [psi]

P_o = initial well bore pressure [psi]

q_n = flow rate for nth increment [bbl/day]

t = time (hours)

B = volume factor (vol/vol)

$\overline{S}$ = composite skin factor (dimensionless)

k = permeability

ν = viscosity (cp)

Subscript j for summing up flow increments.

So long as the composite skin factor ($\overline{S}$) and the permeability-thickness (kh) remain constant for a large reservoir, it is seen that a plot of $(P_t - P_o)/q_n$ versus the summation term in the square brackets will give a straight line with slope (m') and intercept (b') of—

$$m' = \frac{162.2\nu B}{kh}$$

$$b' = m'\overline{S}$$

A tabulation of the data taken from the well test reports for the Edna Delcambre No. 1 sand is given in Table A-1. Also included in the table are the cumulative gas production, cumulative brine production and the summation function in Equation A-1 excluding $\overline{S}$. The pressure is plotted versus the sun (q,t) function in Figure A-1. If the data were ideal and met the conditions of the theory used to obtain Equation A-1 then a series of parallel straight line segments would have resulted. Note in Figure A-1, however, that there are jogs and offsets in the data and that the various segments of the plot are not parallel to each other. The pieces of the data that do yield straight line plots give a variety of slopes and hence kh values. Figure 11 shows a plot of the data for the first draw down test and the resulting least squares fit to the data. Table A-2 gives the results of making such plots for the draw-down and build up tests using the data in Table A-1.

A similar multi-rate analysis was performed by Otis Engineering in their well test report. Their analysis was different, however, in that for their summation function they made all the qj's constant and equal to the average flow rate over the plot interval. They then selected small segments out of the plots from which to get the kh. The results they reported are given in Table 2B. In examining the fits they selected to obtain the reported kh's, there appears to be some difficulty in how the segments were selected for the straight line fits.

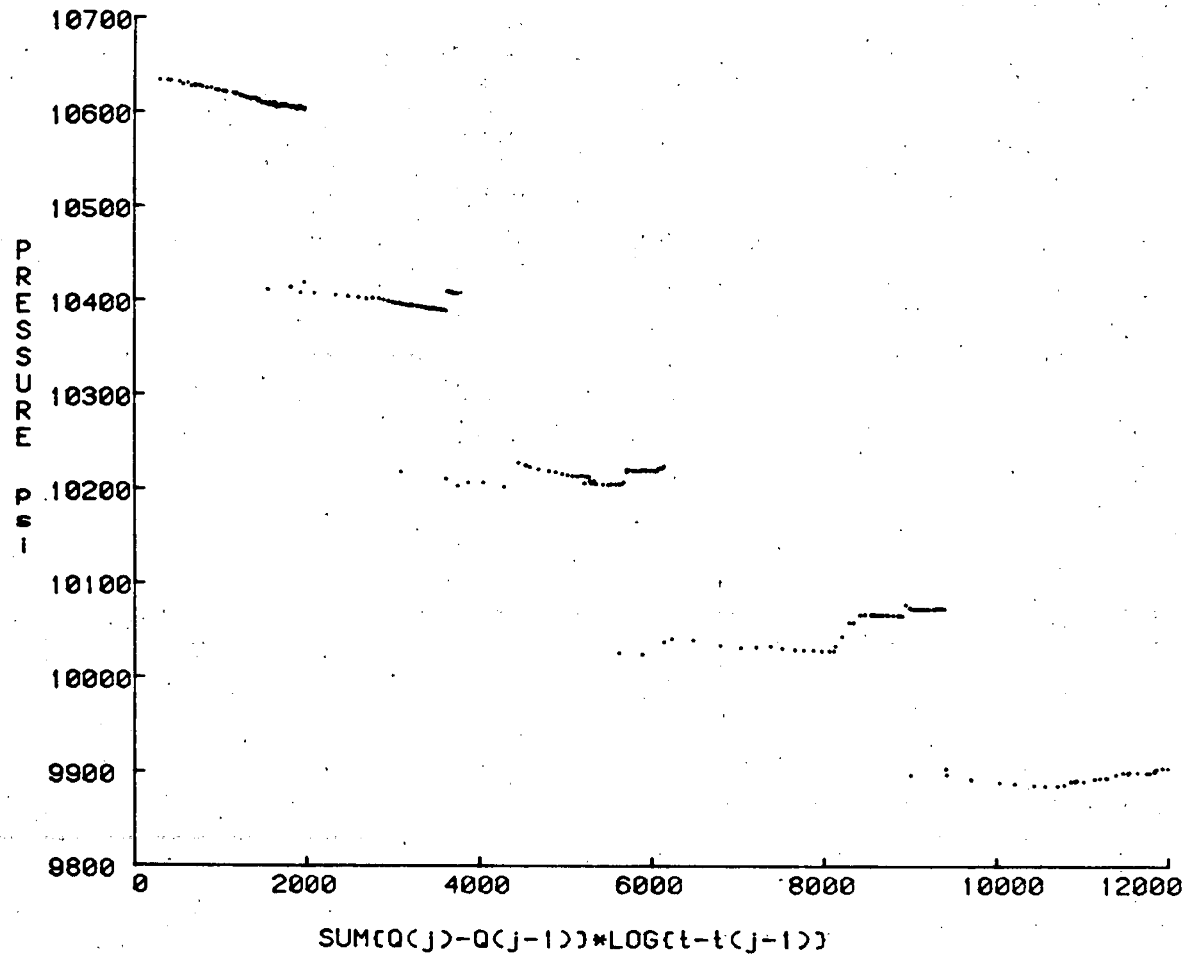

Figure A-1. PLOT OF PRESSURE VERSUS THE FIVE STEPS OF THE MULTI-RATE DRAW-DOWN TEST. DATA FROM TABLE A-1.

Table A-1. TABULATION OF MULTI-RATE FLOW TEST DATA FOR THE DOE EDNA DELCAMBRE NO. 1 WELL, SAND NO. 1. TIME ZERO IS AT 20:00 HOURS ON JUNE 23, 1977.

HOURS	BBLS/DAY	MCF/DAY	P(psi)	SUM BBLS	SUM MCF	SUM(e,t)
0.000	1200.00	27.40	10818.43	0.00	0.00	0.00
1.750	1163.64	27.40	10633.86	84.17	2.00	291.65
2.000	1183.03	27.40	10633.34	98.40	2.28	383.13
2.250	1289.70	27.40	10632.82	111.28	2.57	421.89
2.500	1241.21	27.40	10632.30	124.46	2.85	412.01
2.750	1153.94	27.40	10631.00	136.93	3.14	521.86
3.000	1280.00	27.40	10630.33	149.61	3.43	622.83
3.250	1144.24	27.40	10628.95	162.24	3.71	566.17
3.500	1241.21	27.40	10627.96	174.66	4.00	712.49
3.750	1163.64	27.40	10626.59	187.18	4.28	663.43
4.000	1270.30	27.40	10627.65	199.86	4.57	758.91
4.250	1221.82	27.40	10626.60	212.84	4.85	710.62
4.500	1212.12	27.40	10626.28	225.52	5.14	793.17
5.000	1216.97	27.40	10624.65	250.82	5.71	849.72
5.500	1212.12	27.40	10625.17	276.12	6.28	896.55
6.000	1231.51	27.40	10622.81	301.58	6.85	944.63
6.500	1212.12	27.40	10622.37	327.03	7.42	980.04
7.000	1192.73	27.40	10621.33	352.08	7.99	1030.35
7.500	1309.09	33.82	10620.31	378.14	8.63	1069.87
8.000	1110.30	27.52	10621.18	403.35	9.27	1061.87
8.500	1202.42	27.55	10619.24	427.44	9.84	1184.63
9.000	1226.67	27.55	10619.50	452.74	10.42	1144.82
9.500	1163.64	27.58	10618.00	477.44	10.99	1171.10
10.000	1192.73	27.64	10617.01	502.18	11.57	1225.32
10.500	1192.73	27.64	10616.41	527.03	12.14	1227.56
11.000	1197.57	27.64	10616.24	551.93	12.72	1252.48
11.500	1197.57	27.58	10615.31	576.88	13.29	1273.67
12.000	1197.57	27.58	10614.49	601.83	13.87	1296.62
12.500	1202.42	27.49	10614.76	626.83	14.44	1318.05
13.000	1202.42	28.11	10613.70	651.88	15.02	1336.99
13.500	1202.42	27.35	10612.39	676.93	15.60	1357.99
14.000	1197.57	27.29	10613.83	701.93	16.17	1377.63
14.500	1197.57	27.35	10613.13	726.88	16.74	1397.81
15.000	1202.42	27.35	10613.66	751.88	17.31	1414.31
15.500	1202.42	27.26	10611.10	776.93	17.87	1429.29
16.000	1212.12	27.26	10612.64	802.08	18.44	1446.85
16.500	1207.27	27.16	10610.67	827.28	19.01	1460.47
17.000	1212.12	27.19	10608.66	852.49	19.58	1480.72
17.500	1207.27	27.16	10608.92	877.69	20.14	1494.84
18.000	1207.27	27.16	10608.42	902.84	20.71	1512.96
18.500	1212.12	27.03	10609.12	928.04	21.27	1527.09
19.000	1207.27	27.03	10607.77	953.24	21.83	1539.68
19.500	1207.27	27.02	10606.31	978.40	22.40	1556.35
20.000	1212.12	27.02	10609.12	1003.60	22.96	1569.16
20.500	1202.42	27.02	10606.73	1028.75	23.52	1580.54
21.000	1212.12	27.03	10608.24	1053.90	24.09	1597.55
21.500	1202.42	27.03	10606.00	1079.05	24.65	1604.93
22.000	1207.27	27.03	10606.89	1104.15	25.21	1621.77
22.500	1202.42	27.16	10609.72	1129.25	25.78	1630.19
23.000	1197.57	27.16	10604.13	1154.25	26.34	1643.64
23.500	1202.42	27.16	10604.62	1179.25	26.91	1655.11
24.000	1202.42	27.16	10605.72	1204.30	27.47	1662.49
24.500	1197.57	27.16	10606.25	1229.30	28.04	1673.39
25.000	1192.73	28.05	10604.54	1254.20	28.62	1685.29
25.500	1192.73	27.94	10605.90	1279.05	29.20	1695.48
26.000	1163.64	27.94	10606.54	1303.60	29.78	1703.17
26.500	1231.51	27.72	10605.83	1328.55	30.36	1720.28
27.000	1192.73	27.72	10607.06	1353.80	30.94	1699.66
27.500	1163.64	27.49	10607.64	1378.34	31.51	1735.26
28.000	1241.21	27.49	10607.69	1403.39	32.09	1749.26
29.000	1200.00	27.49	10605.26	1454.25	33.23	1750.66
30.000	1197.57	27.58	10604.79	1504.20	34.38	1783.68
31.000	1197.57	28.44	10604.38	1554.10	35.55	1796.69
32.000	1197.57	27.87	10603.41	1604.00	36.72	1810.92
33.000	1192.73	27.64	10605.38	1653.80	37.88	1825.67
34.000	1192.73	27.64	10604.35	1703.49	39.03	1840.36
35.000	1197.57	27.64	10603.75	1753.29	40.18	1853.38
36.000	1195.15	27.15	10603.42	1803.14	41.32	1864.71
37.000	1044.85	28.43	10601.63	1849.81	42.48	1881.44
38.000	1183.03	25.73	10605.09	1896.22	43.61	1894.65
39.000	1173.33	26.70	10604.01	1945.31	44.70	1862.44
40.000	1178.18	27.10	10604.05	1994.30	45.82	1890.35
41.000	1180.60	27.10	10604.36	2043.44	46.95	1905.49
42.000	1219.39	27.07	10605.29	2093.44	48.08	1920.18
43.000	1127.27	26.94	10602.66	2142.33	49.20	1934.01
44.500	1123.64	26.88	10602.46	2212.67	50.88	1951.99
45.000	1253.33	26.94	10603.00	2237.43	51.45	1950.58
45.250	1175.76	26.94	10602.63	2250.09	51.73	1871.42
45.500	1127.27	27.02	10603.27	2262.08	52.01	1956.63
45.750	1166.06	27.02	10602.77	2274.02	52.29	1985.18
46.000	1146.67	27.07	10602.87	2286.07	52.57	1949.93
46.500	1151.51	27.15	10602.96	2310.01	53.13	1966.29
47.000	1132.12	27.21	10601.75	2333.80	53.70	1965.54
48.000	1088.48	28.02	10601.94	2380.06	54.85	1973.21
49.000	1158.79	28.17	10601.05	2426.88	56.02	1975.35
50.000	1175.76	28.00	10602.46	2475.51	57.19	1966.98
50.500	1469.09	39.00	10418.23	2503.06	57.89	1972.85
50.750	2055.76	39.35	10413.50	2521.42	58.30	1803.63
51.000	2065.45	39.31	10410.66	2542.89	58.71	1544.79
51.500	2109.09	39.27	10407.39	2586.37	59.53	1920.12
52.000	2036.36	39.27	10407.09	2629.55	60.34	2100.11
53.000	2067.88	38.83	10405.04	2715.06	61.97	2352.95
54.000	2072.73	38.43	10403.88	2801.32	63.58	2491.39
55.000	2063.03	38.43	10402.70	2887.48	65.18	2607.34
56.000	2072.73	38.43	10401.03	2973.65	66.78	2700.97
57.000	2058.18	38.35	10402.28	3059.71	68.38	2776.14
58.000	2067.88	38.35	10401.51	3145.67	69.98	2844.80
59.000	2070.30	37.68	10399.99	3231.88	71.57	2900.51
60.000	2056.45	37.28	10398.60	3317.85	73.13	2954.68
61.000	2075.15	38.05	10397.79	3403.93	74.70	3004.20
62.000	2019.39	38.05	10396.69	3489.23	76.28	3045.17
63.000	2062.42	38.30	10396.38	3574.27	77.87	3090.06
64.000	2089.09	38.67	10395.77	3660.76	79.48	3113.69
65.000	2020.60	38.39	10394.87	3746.38	81.08	3154.24
66.000	2020.60	38.28	10394.27	3830.57	82.68	3197.92
67.000	2107.88	46.34	10394.96	3916.58	84.44	3215.02
68.000	2080.00	46.34	10393.85	4003.82	86.37	3237.37
69.000	2055.76	46.57	10393.46	4089.99	88.31	3287.15
70.000	2118.79	46.81	10392.84	4176.96	90.25	3317.71
71.000	2031.51	38.32	10392.54	4263.42	92.03	3339.67
72.000	2077.57	39.02	10392.02	4349.03	93.64	3382.12
73.000	2063.03	39.02	10391.94	4435.29	95.26	3390.34

Table A-1 continued

HOURS	BBLS/DAY	MCF/DAY	P(psi)	SUM BBLS	SUM MCF	SUM(e,t)
74.000	2065.45	47.67	10391.31	4521.30	97.07	3419.64
75.000	2043.63	48.15	10390.43	4606.91	99.07	3440.92
76.000	2058.18	46.51	10391.43	4692.36	101.04	3463.12
77.000	2060.00	46.85	10391.43	4778.15	102.98	3478.08
78.000	2063.03	38.52	10390.72	4864.05	104.76	3499.53
79.000	2063.03	38.60	10390.02	4950.01	106.37	3520.25
80.000	2048.48	38.71	10390.12	5035.67	107.98	3540.97
81.000	2050.91	38.75	10390.05	5121.07	109.59	3560.69
82.000	2050.91	38.83	10389.22	5206.53	111.21	3575.33
83.000	2048.48	47.39	10389.61	5291.93	113.01	3591.94
84.000	2048.48	47.29	10388.93	5377.28	114.98	3608.54
85.000	2048.48	27.35	10388.70	5462.64	116.53	3624.21
86.000	2050.91	38.60	10409.30	5548.04	117.91	3639.95
87.000	2048.48	38.56	10408.91	5633.44	119.51	3655.56
88.000	1997.57	38.52	10408.78	5717.74	121.12	3671.70
89.000	1995.15	38.52	10408.20	5800.92	122.73	3686.57
90.000	1983.03	38.48	10408.10	5883.80	124.33	3686.05
91.000	1975.76	46.92	10407.80	5966.27	126.11	3690.98
92.000	1978.18	46.39	10407.70	6048.65	128.05	3694.95
93.000	1973.33	46.39	10407.55	6130.97	129.99	3699.56
94.000	1978.18	46.14	10407.49	6213.29	131.91	3707.18
95.000	2007.27	38.48	10406.57	6296.32	133.68	3714.19
96.000	2000.00	38.91	10407.24	6379.81	135.29	3723.82
97.000	1997.57	39.03	10406.78	6463.09	136.91	3742.21
98.000	2000.00	39.03	10406.69	6546.37	138.54	3754.91
98.250	3100.00	66.52	10203.05	6572.94	139.09	3756.30
98.500	3122.42	66.52	10218.34	6605.34	139.78	3097.64
99.000	3141.82	54.43	10210.56	6670.40	141.04	3622.21
99.500	3156.36	66.32	10206.34	6736.20	142.30	3873.30
100.000	3151.51	66.19	10206,95	6801.91	143.68	4045.44
101.000	3149.09	54.00	10202.01	6933.17	146.18	4290.79
102.000	3129.69	65.87	10227.61	7063.98	148.68	4458.81
102.583	3130.28	68.00	10224.64	7140.01	150.31	4542.23
103.000	3246.90	70.59	10223.30	7195.41	151.51	4588.11
104.000	3166.01	65.23	10220.71	7329.02	154.34	4689.25
105.000	3199.84	65.11	10218.74	7461.64	157.06	4812.17
106.000	3170.84	65.04	10217.44	7594.36	159.77	4885.84
107.000	3175.68	64.92	10215.81	7726.58	162.47	4965.80
108.000	3166.01	64.92	10214.70	7858.70	165.18	5027.28
109.000	3173.26	64.74	10213.49	7990.77	167.88	5087.11
110.000	3175.68	64.68	10213.07	8123.04	170.58	5139.66
111.000	3139.42	64.92	10214.02	8254.60	173.28	5191.88
112.000	3047.58	70.12	10213.30	8383.50	174.09	5241.20
113.000	3129.76	70.12	10212.58	8512.19	179.01	5276.41
114.000	2953.33	98.38	10208.14	8638.92	182.52	5285.90
115.000	2984.75	94.33	10208.04	8762.63	186.54	5331.21
116.000	2960.58	53.12	10206.93	8886.49	189.61	5316.88
117.000	2513.47	65.11	10206.75	9000.54	192.07	5331.30
118.000	2984.75	65.78	10206.22	9115.08	194.80	5341.74
119.000	3033.08	67.08	10205.42	9240.45	197.57	5222.51
120.000	3124.92	65.55	10205.28	9368.75	200.33	5303.26
121.000	3141.84	66.95	10204.83	9499.30	203.09	5363.72
122.000	3110.42	65.23	10204.61	9629.56	205.84	5434.85
123.000	3151.51	65.29	10203.90	9760.02	208.56	5492.14
124.000	3166.01	65.04	10205.01	9891.43	211.28	5529.02
125.000	3150.00	64.80	10204.30	10023.21	213.98	5574.12

HOURS	BBLS/DAY	MCF/DAY	P(psi)	SUM BBLS	SUM MCF	SUM(e,t)
126.000	3117.67	64.80	10204.48	10153.79	216.68	5620.09
127.000	3168.42	59.55	10205.01	10284.75	219.27	5653.38
128.000	3045.17	65.67	10206.92	10414.20	221.88	5675.45
129.000	3103.17	65.55	10217.43	10542.29	224.62	5715.19
130.000	3182.93	65.36	10220.26	10673.25	227.34	5711.70
131.000	3170.84	64.86	10219.55	10805.62	230.06	5738.14
132.000	3187.76	64.68	10219.11	10938.09	232.76	5785.72
133.000	3187.76	64.56	10218.56	11070.92	235.45	5818.74
134.000	3214.34	64.50	10218.64	11204.29	238.14	5853.66
135.000	3168.42	59.04	10219.85	11337.27	240.71	5884.35
136.000	3245.76	59.04	10219.45	11470.90	243.17	5920.63
137.000	3383.52	52.87	10219.25	11609.01	245.50	5938.10
138.000	2975.08	59.83	10219.14	11741.48	247.85	5981.94
139.000	3180.51	58.34	10219.14	11869.72	250.31	6058.16
140.000	3158.76	57.86	10219.45	12001.79	252.73	5990.19
141.000	3192.59	59.10	10218.87	12134.11	255.17	6025.61
142.000	3187.76	53.27	10218.74	12267.03	257.51	6044.13
143.000	3185.34	54.67	10221.35	12399.80	259.76	6072.72
144.000	3190.18	48.51	10221.57	12532.63	261.91	6095.48
145.000	3158.76	57.08	10221.77	12664.90	264.11	6116.21
146.000	3173.26	59.43	10223.69	12796.81	266.54	6137.81
146.250	4040.89	95.49	10037.78	12834.39	267.34	6131.23
146.500	4562.92	88.94	10026.10	12879.20	268.30	5615.88
147.000	4610.94	91.22	10024.51	12974.76	270.18	5883.25
147.500	4596.75	91.05	10040.93	13070.67	272.08	6227.87
148.000	4669.26	93.36	10039.58	13167.19	274.00	6474.41
149.000	4681.34	90.87	10033.94	13362.00	277.84	6786.01
150.000	4751.43	78.62	10031.54	13558.51	281.37	7023.74
151.000	4724.84	86.92	10032.49	13755.94	284.82	7207.30
152.000	4828.77	86.92	10033.66	13954.97	288.44	7377.11
153.000	4761.10	86.92	10031.09	14154.76	292.06	7507.53
154.000	4823.93	86.92	10029.43	14354.45	295.68	7652.93
155.000	4823.93	90.95	10029.10	14555.44	299.39	7752.37
156.000	4819.10	90.78	10028.83	14756.34	303.17	7864.01
157.000	4741.76	94.14	10028.12	14955.52	307.03	7960.45
158.000	4604.36	100.85	10027.81	15150.24	311.09	8045.80
159.000	4751.43	109.99	10028.72	15345.15	315.48	8101.24
160.000	4809.43	112.80	10033.72	15544.33	320.12	8119.41
161.000	4736.93	118.59	10043.72	15743.21	324.94	8198.29
162.000	4814.27	115.73	10058.46	15942.20	329.83	8281.43
163.000	4800.00	118.49	10057.62	16142.50	334.70	8329.71
164.000	4861.21	115.42	10066.55	16343.77	339.58	8403.57
165.000	4765.93	125.91	10067.17	16544.34	344.61	8462.60
166.000	4807.02	115.73	10066.85	16743.77	349.64	8536.43
167.000	4359.91	126.13	10066.78	16934.75	354.68	8570.93
168.000	4662.01	127.13	10066.13	17122.71	359.95	8624.07
169.000	4761.10	132.21	10066.44	17319.02	365.36	8538.48
170.000	4749.01	131.27	10066.55	17517.15	370.85	8597.28
171.000	4652.34	136.59	10065.90	17713.01	376.43	8669.14
172.000	4744.18	139.26	10066.25	17908.77	382.17	8720.43
173.000	4838.43	139.39	10066.05	18108.41	387.98	8737.05
174.000	4596.75	141.77	10065.79	18304.97	393.84	8790.02
175.000	4746.60	141.77	10065.74	18499.63	399.74	8862.52
176.000	4739.34	150.14	10065.45	18697.25	405.83	8846.73
177.000	4780.43	149.48	10065.36	18895.58	412.07	8899.13
178.000	4770.76	153.82	10077.59	19094.56	418.39	8938.69

Table A-1 continued

HOURS	BBLS/DAY	MCF/DAY	P(psi)	SUM BBLS	SUM MCF	SUM(e,t)
179.000	4775.60	160.11	10073.99	19293.45	424.93	8987.63
180.000	4756.26	157.35	10072.38	19492.03	431.54	9026.71
181.000	4763.51	159.41	10072.68	19690.35	438.14	9065.04
182.000	4751.43	168.68	10072.62	19888.58	444.97	9095.23
183.000	4768.35	167.40	10072.53	20084.91	451.98	9128.41
184.000	4722.43	169.34	10072.71	20284.64	458.99	9156.77
185.000	4836.02	176.88	10072.52	20483.77	466.20	9190.85
186.000	4785.26	178.72	10072.58	20684.21	473.61	9208.83
187.000	4698.26	183.13	10072.51	20881.79	481.15	9265.50
188.000	4722.43	179.82	10072.64	21078.05	488.71	9294.14
189.000	4703.09	184.93	10073.58	21274.42	496.31	9297.65
190.000	4727.26	190.20	10073.21	21470.88	504.13	9318.86
191.000	4642.67	192.26	10072.84	21666.09	512.10	9335.04
192.000	4705.51	189.40	10073.61	21860.84	520.05	9361.48
193.000	4683.76	193.95	10073.35	22056.45	528.03	9360.68
194.000	4683.76	197.45	10073.11	22251.61	536.19	9388.75
195.000	4678.92	272.49	9903.69	22446.67	545.98	9406.37
195.500	6119.34	271.80	9897.45	22559.15	551.65	9417.31
196.000	6104.84	271.57	9897.09	22686.48	557.31	8991.94
197.000	5923.58	273.51	9892.51	22937.07	568.66	9697.48
198.000	6194.26	273.74	9889.05	23189.53	580.06	10031.82
199.000	6051.67	283.87	9887.74	23444.65	591.68	10204.69
200.000	6158.01	292.32	9886.44	23699.02	603.68	10429.30
201.000	6003.33	290.26	9885.50	23952.38	615.82	10555.21
202.000	6003.33	296.51	9885.21	24202.52	628.05	10701.39
203.000	5969.50	293.57	9886.97	24451.96	640.34	10775.76
204.000	5773.74	296.46	9890.57	24696.61	652.63	10854.24
205.000	5592.48	299.95	9890.92	24933.40	665.06	10919.58
206.000	5938.08	299.95	9891.47	25173.62	677.56	10926.20
207.000	6097.59	301.61	9890.53	25424.37	690.09	10900.51
208.000	6232.93	299.95	9890.46	25681.25	702.62	11008.84
209.000	5652.90	301.25	9892.93	25928.87	715.15	11134.18
210.000	5993.66	305.65	9893.89	26171.51	727.79	11268.72
211.000	6112.09	315.02	9893.59	26423.71	740.72	11197.23
212.000	6124.17	318.40	9893.82	26678.63	753.92	11285.15
213.000	6143.51	313.88	9897.55	26934.21	767.09	11386.03
214.000	5875.24	299.69	9899.85	27184.60	779.87	11467.68
215.000	5829.32	317.01	9900.16	27428.45	792.72	11543.10
216.000	6148.34	314.12	9898.53	27677.98	805.87	11528.33
217.000	6147.00	304.21	9899.54	27934.13	818.75	11527.44
218.000	6147.00	319.30	9899.88	28190.26	831.74	11637.88
219.500	6146.19	319.30	9898.89	28574.42	851.70	11747.84
220.000	5955.00	319.30	9899.33	28700.48	858.35	11779.02
221.000	6000.00	318.02	9900.30	28949.54	871.62	11835.72
222.000	6116.92	317.32	9901.71	29201.97	884.86	11830.51
223.000	6138.67	332.10	9903.25	29457.30	898.39	11859.49
224.000	6153.17	309.06	9904.47	29713.38	911.75	11925.29
225.000	6145.92	338.57	9904.07	29969.61	925.24	11984.01
226.000	6129.00	327.51	9902.71	30225.34	939.12	12038.77
227.000	6131.42	313.56	9904.74	30480.76	952.47	12085.17
228.000	6145.92	339.84	9905.42	30736.54	966.09	12123.79
229.000	6017.83	337.55	9905.61	30989.95	980.20	12163.10
230.000	6017.83	342.60	9962.05	31240.69	994.37	12205.63
231.000	6020.25	342.29	10035.27	31491.49	1008.64	12204.69
232.000	6017.83	332.85	10108.49	31742.28	1022.70	12222.02
233.000	6022.67	344.15	10181.71	31993.13	1036.81	12243.30
233.010	0.00	0.00		31994.38	1036.88	12233.84
235.000	0.00	0.00		31994.38	1036.88	10491.82
240.000	0.00	0.00		31994.38	1036.88	7335.39
245.000	0.00	0.00	10750.43	31994.38	1036.88	6050.42
250.000	0.00	0.00	10758.69	31994.38	1036.88	5259.22
255.000	0.00	0.00	10764.22	31994.38	1036.88	4698.90
260.000	0.00	0.00	10769.44	31994.38	1036.88	4271.78
265.000	0.00	0.00	10773.14	31994.38	1036.88	3930.85
270.000	0.00	0.00	10776.51	31994.38	1036.88	3649.92
275.000	0.00	0.00	10779.57	31994.38	1036.88	3412.97
280.000	0.00	0.00	10782.10	31994.38	1036.88	3209.51
285.000	0.00	0.00	10784.29	31994.38	1036.88	3032.29
290.000	0.00	0.00	10786.25	31994.38	1036.88	2876.13
295.000	0.00	0.00	10788.06	31994.38	1036.88	2737.19
300.000	0.00	0.00	10789.67	31994.38	1036.88	2612.55
305.000	0.00	0.00	10790.91	31994.38	1036.88	2499.96
310.000	0.00	0.00	10792.16	31994.38	1036.88	2397.62
315.000	0.00	0.00	10793.41	31994.38	1036.88	2304.11
320.000	0.00	0.00	10794.66	31994.38	1036.88	2218.26
325.000	0.00	0.00	10795.91	31994.38	1036.88	2139.10
330.000	0.00	0.00	10797.16	31994.38	1036.88	2065.85
332.490	0.00	0.00	10797.79	31994.38	1036.88	2031.35
332.500	7890.00	30.00	10797.79	31996.02	1036.88	2031.22
333.500	7895.17	82.46	9865.83	32324.88	1039.23	2017.71
333.750	7132.03	183.24	9859.59	32403.15	1040.61	2775.87
334.000	7650.21	182.15	9876.58	32480.14	1042.51	3858.29
334.500	7951.70	198.56	9846.86	32642.66	1046.48	4318.89
335.000	7226.24	181.25	9843.40	32800.76	1050.44	4973.76
335.500	8083.60	197.59	9844.65	32960.24	1054.38	5881.48
336.500	7348.72	239.71	9843.78	33281.75	1063.49	6565.00
337.000	7532.44	257.86	9844.90	33436.76	1068.68	7258.98
337.500	7588.97	278.23	9844.29	33594.27	1074.26	7385.37
338.000	7725.58	300.53	9842.38	33753.80	1080.29	7649.18
339.000	7245.09	299.97	9841.51	34065.69	1092.80	8176.54
340.000	7447.65	335.58	9839.25	34371.79	1106.04	8666.36
341.000	7459.43	339.22	9837.13	34682.35	1120.10	8938.47
342.000	7548.93	353.74	9836.13	34995.03	1134.53	9280.84
343.000	7322.81	371.02	9831.69	35304.85	1149.63	9586.96
344.000	7584.26	369.67	9830.44	35615.42	1165.06	9890.28
345.000	7421.74	377.98	9827.52	35928.04	1180.64	10090.70
346.000	7563.06	377.98	9820.99	36240.23	1196.39	10373.71
347.000	7391.12	384.47	9820.51	36551.77	1212.27	10567.24
348.000	7424.09	369.33	9840.56	36860.42	1227.98	10800.30
349.000	7445.29	401.52	9837.96	37170.20	1244.04	10954.97
350.000	7442.94	392.30	9834.41	37480.37	1260.58	11124.32
351.000	7405.25	391.95	9834.26	37789.71	1276.91	11291.74
352.000	7471.20	377.25	9834.88	38099.64	1292.94	11448.08
353.070	7470.00	390.00	9874.82	38432.70	1310.04	11596.47
353.100	0.00	0.00	10656.77	38437.37	1310.29	11603.17
355.000	0.00	0.00	10736.66	38437.37	1310.29	9797.94
360.000	0.00	0.00	10755.57	38437.37	1310.29	6219.19
365.000	0.00	0.00	10764.73	38437.37	1310.29	4945.71
370.000	0.00	0.00	10772.16	38437.37	1310.29	4226.95
375.000	0.00	0.00	10775.22	38437.37	1310.29	3749.64
380.000	0.00	0.00	10778.29	38437.37	1310.29	3403.13
384.500	0.00	0.00	10781.04	38437.37	1310.29	3160.59

Table A-1 continued

HOURS	BBLS/DAY	MCF/DAY	P(psi)	SUM BBLS	SUM MCF	SUM(a,t)
384.590	8000.00	360.00	9757.08	38452.37	1310.96	3156.25
385.000	8319.89	366.18	9792.31	38591.77	1317.16	38.94
385.250	8233.35	409.42	9777.72	38677.98	1321.20	1488.66
385.500	8430.05	378.43	9769.75	38764.77	1325.31	2741.41
386.000	8678.27	374.84	9758.91	38942.98	1333.15	4235.72
386.500	8528.40	395.27	9750.74	39122.22	1341.18	5289.45
387.000	8528.40	394.08	9752.85	39299.89	1349.40	6257.17
387.500	8495.62	409.55	9752.86	39477.23	1357.77	6935.41
388.000	8504.98	417.83	9750.33	39654.32	1366.39	7516.58
389.000	8512.01	474.21	9749.32	40008.84	1384.97	8421.07
390.000	8423.02	515.06	9750.09	40361.65	1405.58	9140.09
391.000	8399.61	514.60	9748.22	40712.12	1427.03	9733.52
392.000	8430.05	522.52	9756.12	41062.74	1448.64	10209.07
393.000	8394.92	515.23	9753.58	41413.26	1470.26	10621.29
394.000	8425.36	529.79	9750.19	41763.68	1492.03	10998.27
395.000	8561.18	499.46	9745.66	42117.57	1513.47	11323.40
396.000	8364.48	484.22	9742.18	42470.19	1533.97	11629.33
397.000	8469.86	496.76	9743.74	42820.90	1554.40	11947.14
398.000	8385.56	496.76	9746.69	43172.06	1575.10	12165.48
399.000	8444.10	497.65	9744.99	43522.67	1595.82	12413.59
400.000	8248.40	539.97	9753.42	43870.43	1617.44	12612.60
401.000	8364.48	539.97	9754.02	44216.54	1639.93	12822.89
402.000	8341.06	538.03	9750.73	44564.57	1662.39	12957.33
403.000	8343.41	532.27	9751.31	44912.16	1684.69	13138.54
404.000	8446.44	512.25	9749.87	45261.95	1706.45	13297.53
404.800	8446.44	530.00	9748.36	45543.50	1723.82	13410.39
404.900	0.00	0.00	10599.42	45561.10	1724.93	13430.68
405.000	0.00	0.00	10657.60	45561.10	1724.93	21896.78
410.000	0.00	0.00	10733.82	45561.10	1724.93	8220.60
415.000	0.00	0.00	10748.17	45561.10	1724.93	6285.14
420.000	0.00	0.00	10757.49	45561.10	1724.93	5284.92
427.000	0.00	0.00	10731.98	45561.10	1724.93	4443.77
427.900	0.00	0.00	10716.18	45561.10	1724.93	4361.69
427.950	9900.00	360.00	9776.57	45571.41	1725.30	4357.25
428.250	10000.00	370.34	9694.19	45695.78	1729.87	-845.57
428.500	9868.94	441.87	9667.73	45799.27	1734.10	1678.72
428.750	9980.00	403.03	9652.72	45902.65	1738.50	3377.45
429.000	9970.00	391.51	9644.65	46006.55	1742.64	4436.94
429.250	9950.00	435.70	9643.27	46110.30	1746.94	5363.38
429.500	9934.61	434.09	9638.29	46213.87	1751.47	6121.13
430.000	9873.63	437.77	9633.87	46420.20	1760.56	7291.48
431.000	9791.54	555.45	9639.84	46829.90	1781.25	8924.08
432.000	9634.41	615.81	9642.69	47234.60	1805.65	10055.02
433.000	9690.70	652.05	9652.09	47637.21	1832.06	10901.75
434.000	9662.55	643.50	9657.86	48040.40	1859.05	11545.52
435.000	9791.54	643.50	9655.45	48445.70	1885.87	12115.42
436.000	9704.77	620.33	9651.98	48851.87	1912.20	12596.41
437.000	9728.22	568.50	9645.73	49256.72	1936.96	13059.01
438.000	9953.37	568.50	9649.37	49666.76	1960.65	13433.02
439.000	9826.72	580.82	9663.71	50078.84	1984.59	13780.54
440.000	9843.14	612.39	9663.11	50488.63	2009.45	14162.46
441.000	9864.25	648.84	9662.55	50899.20	2035.73	14450.84
442.000	9749.33	525.33	9680.53	51307.82	2060.19	14725.51
443.000	9894.74	611.83	9689.55	51717.07	2083.88	14985.01
444.000	9885.36	611.27	9691.61	52129.15	2109.36	15189.00
445.000	9843.14	578.69	9690.15	52540.16	2134.15	15434.26
446.010	0.00	0.00	9688.79	52747.28	2146.33	15651.88
450.000	0.00	0.00	10712.48	52747.28	2146.33	10436.69
466.300	0.00	0.00	10754.62	52747.28	2146.33	5395.81

Table A-1 continued

HOURS	BBLS/DAY	MCF/DAY	P(psi)	SUM BBLS	SUM MCF	SUM(e,t)
0.000	1200.00	27.40	10818.43	0.00	0.00	0.00
1.750	1163.64	27.40	10633.86	86.17	2.00	291.65
2.000	1183.03	27.40	10633.34	98.40	2.28	383.13
2.250	1289.70	27.40	10632.82	111.28	2.57	421.89
2.500	1241.21	27.40	10632.30	124.46	2.85	412.01
2.750	1153.94	27.40	10631.00	136.93	3.14	521.86
3.000	1280.00	27.40	10630.33	149.61	3.43	622.83
3.250	1144.24	27.40	10628.95	162.24	3.71	566.17
3.500	1241.21	27.40	10627.96	174.66	4.00	712.49
3.750	1163.64	27.40	10626.59	187.18	4.28	663.43
4.000	1270.30	27.40	10627.65	199.86	4.57	758.91
4.250	1221.82	27.40	10626.60	212.84	4.85	710.62
4.500	1212.12	27.40	10626.28	225.52	5.14	793.17
5.000	1216.97	27.40	10624.65	250.82	5.71	849.72
5.500	1212.12	27.40	10625.17	276.12	6.28	896.55
6.000	1231.51	27.40	10622.81	301.58	6.85	944.63
6.500	1212.12	27.40	10622.37	327.03	7.42	980.04
7.000	1192.73	27.40	10621.33	352.08	7.99	1030.35
7.500	1309.09	33.82	10620.31	378.14	8.63	1069.87
8.000	1110.30	27.52	10621.18	403.35	9.27	1061.87
8.500	1202.42	27.55	10619.24	427.44	9.84	1184.63
9.000	1226.67	27.55	10619.50	452.74	10.42	1144.82
9.500	1163.64	27.58	10618.00	477.64	10.99	1171.10
10.000	1192.73	27.64	10617.01	502.18	11.57	1225.32
10.500	1192.73	27.64	10616.41	527.03	12.14	1227.56
11.000	1197.57	27.64	10616.24	551.93	12.72	1252.48
11.500	1197.57	27.58	10615.31	576.88	13.29	1273.67
12.000	1197.57	27.58	10614.49	601.83	13.87	1296.62
12.500	1202.42	27.49	10614.76	626.83	14.44	1318.05
13.000	1202.42	28.11	10613.70	651.88	15.02	1336.99
13.500	1202.42	27.35	10612.39	676.93	15.60	1357.99
14.000	1197.57	27.29	10613.83	701.93	16.17	1377.63
14.500	1197.57	27.35	10613.13	726.88	16.74	1397.81
15.000	1202.42	27.35	10613.66	751.88	17.31	1414.31
15.500	1202.42	27.26	10611.10	776.93	17.87	1429.29
16.000	1212.12	27.26	10612.64	802.08	18.44	1446.85
16.500	1207.27	27.16	10610.67	827.28	19.01	1460.47
17.000	1212.12	27.19	10608.66	852.49	19.58	1480.72
17.500	1207.27	27.16	10608.92	877.69	20.14	1494.84
18.000	1207.27	27.16	10608.42	902.84	20.71	1512.96
18.500	1212.12	27.03	10609.12	928.04	21.27	1527.09
19.000	1207.27	27.03	10607.77	953.24	21.83	1539.68
19.500	1207.27	27.02	10606.31	978.40	22.40	1556.35
20.000	1212.12	27.02	10609.12	1003.60	22.96	1569.16
20.500	1202.42	27.02	10606.73	1028.75	23.52	1580.54
21.000	1212.12	27.03	10608.24	1053.90	24.09	1597.55
21.500	1202.42	27.03	10606.00	1079.05	24.65	1604.93
22.000	1207.27	27.03	10606.89	1104.15	25.21	1621.77
22.500	1202.42	27.16	10609.72	1129.25	25.78	1630.19
23.000	1197.57	27.16	10604.13	1154.25	26.34	1643.64
23.500	1202.42	27.16	10604.62	1179.25	26.91	1655.11
24.000	1202.42	27.16	10605.72	1204.30	27.47	1662.49
24.500	1197.57	27.16	10606.25	1229.30	28.04	1673.39
25.000	1192.73	28.05	10604.54	1254.20	28.62	1685.29
25.500	1192.73	27.94	10605.90	1279.05	29.20	1695.48
26.000	1163.64	27.94	10606.54	1303.60	29.78	1703.17

HOURS	BBLS/DAY	MCF/DAY	P(psi)	SUM BBLS	SUM MCF	SUM(e,t)
26.500	1231.51	27.72	10605.83	1328.55	30.36	1720.28
27.000	1192.73	27.72	10607.06	1353.80	30.94	1699.66
27.500	1163.64	27.49	10607.64	1378.34	31.51	1735.26
28.000	1241.21	27.49	10607.69	1403.39	32.09	1749.26
29.000	1200.00	27.49	10605.26	1454.25	33.23	1750.66
30.000	1197.57	27.58	10604.79	1504.20	34.38	1783.68
31.000	1197.57	28.44	10604.38	1554.10	35.55	1796.69
32.000	1197.57	27.87	10603.41	1604.00	36.72	1810.92
33.000	1192.73	27.64	10605.38	1653.80	37.88	1825.67
34.000	1192.73	27.64	10604.35	1703.49	39.03	1840.36
35.000	1197.57	27.64	10603.75	1753.29	40.18	1853.38
36.000	1195.15	27.15	10603.42	1803.14	41.32	1866.71
37.000	1044.85	28.43	10601.63	1849.81	42.48	1881.44
38.000	1183.03	25.73	10605.09	1896.22	43.61	1894.65
39.000	1173.33	26.70	10604.01	1945.31	44.70	1862.44
40.000	1178.18	27.10	10604.05	1994.30	45.82	1890.35
41.000	1180.60	27.10	10604.36	2043.44	46.95	1905.49
42.000	1219.39	27.07	10605.29	2093.44	48.08	1920.18
43.000	1127.27	26.94	10602.66	2142.33	49.20	1934.01
44.500	1123.64	26.88	10602.46	2212.67	50.88	1951.99
45.000	1253.33	26.94	10603.00	2237.43	51.45	1950.58
45.250	1175.76	26.94	10602.63	2250.09	51.73	1871.42
45.500	1127.27	27.02	10603.27	2262.08	52.01	1956.63
45.750	1166.06	27.02	10602.77	2274.02	52.29	1985.18
46.000	1146.67	27.07	10602.87	2286.07	52.57	1949.93
46.500	1151.51	27.15	10602.96	2310.01	53.13	1966.29
47.000	1132.12	27.21	10601.75	2333.80	53.70	1965.54
48.000	1088.48	28.02	10601.94	2380.06	54.85	1973.21
49.000	1158.79	28.17	10601.05	2426.88	56.02	1975.35
50.000	1175.76	28.00	10602.46	2475.51	57.19	1966.98
50.500	1469.09	39.00	10418.23	2503.06	57.89	1972.85
50.750	2055.76	39.35	10413.50	2521.42	58.30	1803.63
51.000	2065.45	39.31	10410.66	2542.89	58.71	1544.79
51.500	2109.09	39.27	10407.39	2586.37	59.53	1920.12
52.000	2036.36	39.27	10407.09	2629.55	60.34	2100.11
53.000	2067.88	38.83	10405.04	2715.06	61.97	2352.95
54.000	2072.73	38.43	10403.88	2801.32	63.58	2491.39
55.000	2063.03	38.43	10402.70	2887.48	65.18	2607.34
56.000	2072.73	38.43	10401.03	2973.65	66.78	2700.97
57.000	2058.18	38.35	10402.28	3059.71	68.38	2776.14
58.000	2067.88	38.35	10401.51	3145.67	69.98	2844.80
59.000	2070.30	37.68	10399.99	3231.88	71.57	2900.51
60.000	2056.45	37.28	10398.60	3317.85	73.13	2954.68
61.000	2075.15	38.05	10397.79	3403.93	74.70	3004.20
62.000	2019.39	38.05	10396.69	3489.23	76.28	3045.17
63.000	2062.42	38.30	10396.38	3574.27	77.87	3090.06
64.000	2089.09	38.67	10395.77	3660.76	79.48	3113.69
65.000	2020.60	38.39	10394.87	3746.38	81.08	3154.24
66.000	2020.60	38.28	10394.27	3830.57	82.68	3197.92
67.000	2107.88	46.34	10394.96	3916.58	84.44	3215.02
68.000	2080.00	46.34	10393.85	4003.82	86.37	3237.37
69.000	2055.76	46.57	10393.46	4089.99	88.31	3287.15
70.000	2118.79	46.81	10392.84	4176.96	90.25	3317.71
71.000	2031.51	38.32	10392.54	4263.42	92.03	3339.67
72.000	2077.57	39.02	10392.02	4349.03	93.64	3382.12
73.000	2063.03	39.02	10391.94	4435.29	95.26	3390.34

Table A-1 continued

HOURS	BBLS/DAY	MCF/DAY	P(psi)	SUM BBLS	SUM MCF	SUM(e,t)
74.000	2065.45	47.67	10391.31	4521.30	97.07	3419.64
75.000	2043.63	48.15	10390.43	4606.91	99.07	3440.92
76.000	2058.18	46.51	10391.43	4692.36	101.04	3463.12
77.000	2060.00	46.85	10391.43	4778.15	102.98	3478.08
78.000	2063.03	38.52	10390.72	4864.05	104.76	3499.53
79.000	2063.03	38.60	10390.02	4950.01	106.37	3520.25
80.000	2048.48	38.71	10390.12	5035.67	107.98	3540.97
81.000	2050.91	38.75	10390.05	5121.07	109.59	3560.69
82.000	2050.91	38.83	10389.22	5206.53	111.21	3575.33
83.000	2048.48	47.39	10389.61	5291.93	113.01	3591.96
84.000	2048.48	47.29	10388.93	5377.28	114.98	3608.54
85.000	2048.48	27.35	10388.70	5462.64	116.53	3624.21
86.000	2050.91	38.60	10409.30	5548.04	117.91	3639.95
87.000	2048.48	38.56	10408.91	5633.44	119.51	3655.56
88.000	1997.57	38.52	10408.78	5717.74	121.12	3671.70
89.000	1995.15	38.52	10408.20	5800.92	122.73	3686.57
90.000	1983.03	38.48	10408.10	5883.80	124.33	3686.05
91.000	1975.76	46.92	10407.80	5966.27	126.11	3690.98
92.000	1978.18	46.39	10407.70	6048.65	128.05	3694.95
93.000	1973.33	46.39	10407.55	6130.97	129.99	3699.56
94.000	1978.18	46.14	10407.49	6213.29	131.91	3707.18
95.000	2007.27	38.48	10406.57	6296.32	133.68	3714.19
96.000	2000.00	38.91	10407.24	6379.81	135.29	3723.82
97.000	1997.57	39.03	10406.78	6463.09	136.91	3742.21
98.000	2000.00	39.03	10406.69	6546.37	138.54	3754.91
98.250	3100.00	66.52	10203.05	6572.94	139.09	3756.30
98.500	3122.42	66.52	10218.34	6605.34	139.78	3097.64
99.000	3141.82	54.43	10210.56	6670.60	141.04	3622.21
99.500	3156.36	66.32	10206.34	6736.20	142.30	3873.30
100.000	3151.51	66.19	10206.95	6801.91	143.68	4045.44
101.000	3149.09	54.00	10202.01	6933.17	146.18	4290.79
102.000	3129.69	65.87	10227.61	7063.98	148.68	4458.81
102.583	3130.28	68.00	10224.64	7140.01	150.31	4542.23
103.000	3246.90	70.59	10223.30	7195.41	151.51	4588.11
104.000	3166.01	65.23	10220.71	7329.02	154.34	4689.25
105.000	3199.84	65.11	10218.74	7461.64	157.06	4812.17
106.000	3170.84	65.04	10217.44	7594.36	159.77	4885.84
107.000	3175.68	64.92	10215.81	7726.58	162.47	4965.80
108.000	3166.01	64.92	10214.70	7858.70	165.18	5027.28
109.000	3173.26	64.74	10213.49	7990.77	167.88	5087.11
110.000	3175.68	64.68	10213.07	8123.04	170.58	5139.66
111.000	3139.42	64.92	10214.02	8254.60	173.28	5191.88
112.000	3047.58	70.12	10213.30	8383.50	176.09	5241.20
113.000	3129.76	70.12	10212.58	8512.19	179.01	5276.41
114.000	2953.33	98.38	10208.14	8638.92	182.52	5285.90
115.000	2984.75	94.33	10208.04	8762.63	186.54	5331.21
116.000	2960.58	53.12	10206.93	8886.49	189.61	5316.88
117.000	2513.47	65.11	10206.75	9000.54	192.07	5331.30
118.000	2984.75	65.78	10206.22	9115.08	194.80	5341.74
119.000	3033.08	67.08	10205.42	9240.45	197.57	5222.51
120.000	3124.92	65.55	10205.28	9368.75	200.33	5303.26
121.000	3141.84	66.95	10204.83	9499.30	203.09	5363.72
122.000	3110.42	65.23	10204.61	9629.56	205.84	5434.85
123.000	3151.51	65.29	10203.90	9760.02	208.56	5492.14
124.000	3166.01	65.04	10205.01	9891.63	211.28	5529.02
125.000	3150.00	64.80	10204.30	10023.21	213.98	5576.12

HOURS	BBLS/DAY	MCF/DAY	P(psi)	SUM BBLS	SUM MCF	SUM(e,t)
126.000	3117.67	64.80	10204.48	10153.79	216.68	5620.09
127.000	3168.42	59.55	10205.01	10284.75	219.27	5653.38
128.000	3045.17	65.67	10206.92	10414.20	221.88	5675.45
129.000	3103.17	65.55	10217.43	10542.29	224.62	5715.19
130.000	3182.93	65.36	10220.26	10673.25	227.34	5711.70
131.000	3170.84	64.86	10219.55	10805.62	230.06	5738.14
132.000	3187.76	64.68	10219.11	10938.09	232.76	5785.72
133.000	3187.76	64.56	10218.56	11070.92	235.45	5818.74
134.000	3214.34	64.50	10218.64	11204.29	238.14	5853.66
135.000	3168.42	59.04	10219.85	11337.27	240.71	5884.35
136.000	3245.76	59.04	10219.45	11470.90	243.17	5920.63
137.000	3383.52	52.87	10219.25	11609.01	245.50	5938.10
138.000	2975.08	59.83	10219.14	11741.48	247.85	5981.94
139.000	3180.51	58.34	10219.14	11869.72	250.31	6058.16
140.000	3158.76	57.86	10219.45	12001.79	252.73	5990.19
141.000	3192.59	59.10	10218.87	12134.11	255.17	6025.61
142.000	3187.76	53.27	10218.74	12267.03	257.51	6044.13
143.000	3185.34	54.67	10221.35	12399.80	259.76	6072.72
144.000	3190.18	48.51	10221.57	12532.63	261.91	6095.48
145.000	3158.76	57.08	10221.77	12664.90	264.11	6116.21
146.000	3173.26	59.43	10223.69	12796.81	266.54	6137.81
146.250	4040.89	95.49	10037.78	12834.39	267.34	6131.23
146.500	4562.92	88.94	10026.10	12879.20	268.30	5615.88
147.000	4610.94	91.22	10024.51	12974.76	270.18	5883.25
147.500	4596.75	91.05	10040.93	13070.67	272.08	6227.87
148.000	4669.26	93.36	10039.58	13167.19	274.00	6474.41
149.000	4681.34	90.87	10033.94	13362.00	277.84	6786.01
150.000	4751.43	78.62	10031.54	13558.51	281.37	7023.74
151.000	4724.84	86.92	10032.49	13755.94	284.82	7207.30
152.000	4828.77	86.92	10033.66	13954.97	288.44	7377.11
153.000	4761.10	86.92	10031.09	14154.76	292.06	7507.53
154.000	4823.93	86.92	10029.43	14354.45	295.68	7652.93
155.000	4823.93	90.95	10029.10	14555.44	299.39	7752.37
156.000	4819.10	90.78	10028.83	14756.34	303.17	7864.01
157.000	4741.76	94.14	10028.12	14955.52	307.03	7960.45
158.000	4604.36	100.85	10027.81	15150.24	311.09	8045.80
159.000	4751.43	109.99	10028.72	15345.15	315.48	8101.24
160.000	4809.43	112.80	10033.72	15544.33	320.12	8119.41
161.000	4736.93	118.59	10043.72	15743.21	324.94	8198.29
162.000	4814.27	115.73	10058.46	15942.20	329.83	8281.43
163.000	4800.00	118.49	10057.62	16142.50	334.70	8329.71
164.000	4861.21	115.42	10066.55	16343.77	339.58	8403.57
165.000	4765.93	125.91	10067.17	16544.34	344.61	8462.60
166.000	4807.02	115.73	10066.85	16743.77	349.64	8536.43
167.000	4359.91	126.13	10066.78	16934.75	354.68	8570.93
168.000	4662.01	127.13	10066.13	17122.71	359.95	8624.07
169.000	4761.10	132.21	10066.44	17319.02	365.36	8538.48
170.000	4749.01	131.27	10066.55	17517.15	370.85	8597.28
171.000	4652.34	136.59	10065.90	17713.01	376.43	8669.14
172.000	4744.18	139.26	10066.25	17908.77	382.17	8720.43
173.000	4838.43	139.39	10066.05	18108.41	387.98	8737.05
174.000	4596.75	141.77	10065.79	18304.97	393.84	8790.02
175.000	4746.60	141.77	10065.74	18499.63	399.74	8862.52
176.000	4739.34	150.14	10065.45	18697.25	405.83	8846.73
177.000	4780.43	149.48	10065.36	18895.58	412.07	8899.13
178.000	4770.76	153.82	10077.59	19094.56	418.39	8938.69

Table A-1 continued

HOURS	BBLS/DAY	MCF/DAY	P(psi)	SUM BBLS	SUM MCF	SUM(a,t)
179.000	4775.60	160.11	10073.99	19293.45	424.93	8987.63
180.000	4756.26	157.35	10072.38	19492.03	431.54	9026.71
181.000	4763.51	159.41	10072.68	19690.35	438.14	9065.04
182.000	4751.43	168.68	10072.62	19888.58	444.97	9095.23
183.000	4768.35	167.40	10072.53	20086.91	451.98	9128.41
184.000	4722.43	169.34	10072.71	20284.64	458.99	9156.77
185.000	4836.02	176.88	10072.52	20483.77	466.20	9190.85
186.000	4785.26	178.72	10072.58	20684.21	473.61	9208.83
187.000	4698.26	183.13	10072.51	20881.79	481.15	9265.50
188.000	4722.43	179.82	10072.64	21078.05	488.71	9294.14
189.000	4703.09	184.93	10073.58	21274.42	496.31	9297.65
190.000	4727.26	190.20	10073.21	21470.88	504.13	9318.86
191.000	4642.67	192.26	10072.84	21666.09	512.10	9335.04
192.000	4705.51	189.40	10073.61	21860.84	520.05	9361.48
193.000	4683.76	193.95	10073.35	22056.45	528.03	9360.68
194.000	4683.76	197.45	10073.11	22251.61	536.19	9388.75
195.000	4678.92	272.49	9903.69	22446.67	545.98	9406.37
195.500	6119.34	271.80	9897.45	22559.15	551.65	9417.31
196.000	6104.84	271.57	9897.09	22686.48	557.31	8991.94
197.000	5923.58	273.51	9892.51	22937.07	568.66	9697.48
198.000	6194.26	273.74	9889.05	23189.53	580.06	10031.82
199.000	6051.67	283.87	9887.74	23444.65	591.68	10204.69
200.000	6158.01	292.32	9886.44	23699.02	603.68	10429.30
201.000	6003.33	290.26	9885.50	23952.38	615.82	10555.21
202.000	6003.33	296.51	9885.21	24202.52	628.05	10701.39
203.000	5969.50	293.57	9886.97	24451.96	640.34	10775.76
204.000	5773.74	296.46	9890.57	24696.61	652.63	10854.24
205.000	5592.48	299.95	9890.92	24933.40	665.06	10919.58
206.000	5938.08	299.95	9891.47	25173.62	677.56	10926.20
207.000	6097.59	301.61	9890.53	25424.37	690.09	10900.51
208.000	6232.93	299.95	9890.46	25681.25	702.62	11008.86
209.000	5652.90	301.25	9892.93	25928.87	715.15	11134.18
210.000	5993.66	305.65	9893.89	26171.51	727.79	11268.72
211.000	6112.09	315.02	9893.59	26423.71	740.72	11197.23
212.000	6124.17	318.40	9893.82	26678.63	753.92	11285.15
213.000	6143.51	313.88	9897.55	26934.21	767.09	11386.03
214.000	5875.24	299.69	9899.85	27184.60	779.87	11467.68
215.000	5829.32	317.01	9900.16	27428.45	792.72	11543.10
216.000	6148.34	314.12	9898.53	27677.98	805.87	11528.33
217.000	6147.00	304.21	9899.54	27934.13	818.75	11527.44
218.000	6147.00	319.30	9899.88	28190.26	831.74	11637.88
219.500	6146.19	319.30	9898.89	28574.42	851.70	11747.84
220.000	5955.00	319.30	9899.33	28700.48	858.35	11779.02
221.000	6000.00	318.02	9900.30	28949.54	871.62	11835.72
222.000	6116.92	317.32	9901.71	29201.97	884.86	11830.51
223.000	6138.67	332.10	9903.25	29457.30	898.39	11859.49
224.000	6153.17	309.06	9904.47	29713.38	911.75	11925.29
225.000	6145.92	338.57	9904.07	29969.61	925.24	11984.01
226.000	6129.00	327.51	9902.71	30225.34	939.12	12038.77
227.000	6131.42	313.56	9904.74	30480.76	952.47	12085.17
228.000	6145.92	339.84	9905.42	30736.54	966.09	12123.79
229.000	6017.83	337.55	9905.61	30989.95	980.20	12163.10
230.000	6017.83	342.60	9962.05	31240.69	994.37	12205.63
231.000	6020.25	342.29	10035.27	31491.49	1008.64	12206.69
232.000	6017.83	332.85	10108.49	31742.28	1022.70	12222.02
233.000	6022.67	344.15	10181.71	31993.13	1036.81	12243.30

HOURS	BBLS/DAY	MCF/DAY	P(psi)	SUM BBLS	SUM MCF	SUM(a,t)
233.010	0.00	0.00		31994.38	1036.88	12233.84
235.000	0.00	0.00		31994.38	1036.88	10491.82
240.000	0.00	0.00		31994.38	1036.88	7335.39
245.000	0.00	0.00	10750.43	31994.38	1036.88	6050.42
250.000	0.00	0.00	10758.69	31994.38	1036.88	5259.22
255.000	0.00	0.00	10764.22	31994.38	1036.88	4698.90
260.000	0.00	0.00	10769.44	31994.38	1036.88	4271.78
265.000	0.00	0.00	10773.14	31994.38	1036.88	3930.85
270.000	0.00	0.00	10776.51	31994.38	1036.88	3649.92
275.000	0.00	0.00	10779.57	31994.38	1036.88	3412.97
280.000	0.00	0.00	10782.10	31994.38	1036.88	3209.51
285.000	0.00	0.00	10784.29	31994.38	1036.88	3032.29
290.000	0.00	0.00	10786.25	31994.38	1036.88	2876.13
295.000	0.00	0.00	10788.06	31994.38	1036.88	2737.19
300.000	0.00	0.00	10789.67	31994.38	1036.88	2612.55
305.000	0.00	0.00	10790.91	31994.38	1036.88	2499.96
310.000	0.00	0.00	10792.16	31994.38	1036.88	2397.62
315.000	0.00	0.00	10793.41	31994.38	1036.88	2304.11
320.000	0.00	0.00	10794.66	31994.38	1036.88	2218.26
325.000	0.00	0.00	10795.91	31994.38	1036.88	2139.10
330.000	0.00	0.00	10797.16	31994.38	1036.88	2065.85
332.490	0.00	0.00	10797.79	31994.38	1036.88	2031.35
332.500	7890.00	30.00	10797.79	31996.02	1036.88	2031.22
333.500	7895.17	82.46	9865.83	32324.88	1039.23	2017.71
333.750	7132.03	183.24	9859.59	32403.15	1040.61	2775.87
334.000	7650.21	182.15	9876.58	32480.14	1042.51	3858.29
334.500	7951.70	198.56	9846.86	32642.66	1046.48	4318.89
335.000	7226.24	181.25	9843.40	32800.76	1050.44	4973.76
335.500	8083.60	197.59	9844.65	32960.24	1054.38	5881.48
336.500	7348.72	239.71	9843.78	33281.75	1063.49	6565.00
337.000	7532.44	257.86	9844.90	33436.76	1068.68	7258.98
337.500	7588.97	278.23	9844.29	33594.27	1074.26	7385.37
338.000	7725.58	300.53	9842.38	33753.80	1080.29	7649.18
339.000	7245.09	299.97	9841.51	34065.69	1092.80	8176.54
340.000	7447.65	335.58	9839.25	34371.79	1106.04	8666.36
341.000	7459.43	339.22	9837.13	34682.35	1120.10	8938.47
342.000	7548.93	353.74	9836.13	34995.03	1134.53	9280.84
343.000	7322.81	371.02	9831.69	35304.85	1149.63	9586.96
344.000	7584.26	369.67	9830.44	35615.42	1165.06	9890.28
345.000	7421.74	377.98	9827.52	35928.04	1180.64	10090.70
346.000	7563.06	377.98	9820.99	36240.23	1196.39	10373.71
347.000	7391.12	384.47	9820.51	36551.77	1212.27	10567.24
348.000	7424.09	369.33	9840.56	36860.42	1227.98	10800.30
349.000	7445.29	401.52	9837.96	37170.20	1244.04	10954.97
350.000	7442.94	392.30	9836.41	37480.37	1260.58	11124.32
351.000	7405.25	391.95	9834.26	37789.71	1276.91	11291.74
352.000	7471.20	377.25	9834.88	38099.64	1292.94	11448.08
353.070	7470.00	390.00	9874.82	38432.70	1310.04	11596.47
353.100	0.00	0.00	10656.77	38437.37	1310.29	11603.17
355.000	0.00	0.00	10736.66	38437.37	1310.29	9797.94
360.000	0.00	0.00	10755.57	38437.37	1310.29	6219.19
365.000	0.00	0.00	10764.73	38437.37	1310.29	4945.71
370.000	0.00	0.00	10772.16	38437.37	1310.29	4226.95
375.000	0.00	0.00	10775.22	38437.37	1310.29	3749.64
380.000	0.00	0.00	10778.29	38437.37	1310.29	3403.13
384.500	0.00	0.00	10781.04	38437.37	1310.29	3160.59

Table A-1 continued

HOURS	BBLS/DAY	MCF/DAY	P(psi)	SUM BBLS	SUM MCF	SUM(a,t)
384.590	8000.00	360.00	9957.08	38452.37	1310.96	3156.25
385.000	8319.89	366.18	9792.31	38591.77	1317.16	38.94
385.250	8233.35	409.42	9777.72	38677.98	1321.20	1488.66
385.500	8430.05	378.43	9769.75	38764.77	1325.31	2741.41
386.000	8678.27	374.84	9758.91	38942.98	1333.15	4235.72
386.500	8528.40	395.27	9750.74	39122.22	1341.18	5289.45
387.000	8528,40	394.08	9752.85	39299.89	1349.40	6257.17
387.500	8495.62	409.55	9752.86	39477.23	1357.77	6935.41
388.000	8504.98	417.83	9750.33	39654.32	1366.39	7516.58
389.000	8512.01	474.21	9749.32	40008.84	1384.97	8421.07
390.000	8423.02	515.06	9750.09	40361.65	1405.58	9140.09
391.000	8399.61	514.60	9748.22	40712.12	1427.03	9733.52
392.000	8430.05	522.52	9756.12	41062.74	1448.64	10209.07
393.000	8394.92	515.23	9753.58	41413.26	1470.26	10621.29
394.000	8425.36	529.79	9750.19	41763.68	1492.03	10998.27
395.000	8561.18	499.46	9745.66	42117.57	1513.47	11323.40
396.000	8364.48	484.22	9742.18	42470.19	1533.97	11629.33
397.000	8469.86	496.76	9743.74	42820.90	1554.40	11947.14
398.000	8385.56	496.76	9746.69	43172.06	1575.10	12165.48
399.000	8444.10	497.65	9744.99	43522.67	1595.82	12413.59
400.000	8248.40	539.97	9753.42	43870.43	1617.44	12612.60
401.000	8364.48	539.97	9754.02	44216.54	1639.93	12822.89
402.000	8341.06	538.03	9750.73	44564.57	1662.39	12957.33
403,000	8343.41	532.27	9751.31	44912.16	1684.69	13138.54
404.000	8446.44	512.25	9749.87	45261.95	1706.45	13297.53
404.800	8446.44	530.00	9748.36	45543.50	1723.82	13410.39
404.900	0.00	0.00	10599.42	45561.10	1724.93	13430.68
405.000	0.00	0.00	10657.60	45561.10	1724.93	21896.78
410.000	0.00	0.00	10733.82	45561.10	1724.93	8220.60
415.000	0.00	0.00	10748.17	45561.10	1724.93	6285.14
420.000	0.00	0.00	10757.49	45561.10	1724.93	5284.92
427.000	0.00	0.00	10731.98	45561.10	1724.93	4443.77
427.900	0.00	0.00	10716.18	45561.10	1724.93	4361.69
427.950	9900.00	360.00	9776.57	45571.41	1725.30	4357.25
428.250	10000.00	370.34	9694.19	45695.78	1729.87	-845.57
428.500	9868.94	441.87	9667.73	45799.27	1734.10	1678.72
428.750	9980.00	403.03	9652.72	45902.65	1738.50	3377.45
429.000	9970.00	391.51	9644.65	46006.55	1742.64	4436.94
429.250	9950.00	435.70	9643.27	46110.30	1746.94	5363.38
429.500	9934.61	434.09	9638.29	46213.87	1751.47	6121.13
430.000	9873.63	437.77	9633.87	46420.20	1760.56	7291.48
431.000	9791.54	555.45	9639.84	46829.90	1781.25	8924.08
432.000	9634.41	615.81	9642.69	47234.60	1805.65	10055.02
433.000	9690.70	652.05	9652.09	47637.21	1832.06	10901.75
434.000	9662.55	643.50	9657.86	48040.40	1859.05	11545.52
435.000	9791.54	643.50	9655.45	48445.70	1885.87	12115.42
436.000	9704.77	620.33	9651.98	48851.87	1912.20	12596.41
437.000	9728.22	568.50	9645.73	49256.72	1936.96	13059.01
438.000	9953.37	568.50	9649.37	49666.76	1960.65	13433.02
439.000	9826.72	580.82	9663.71	50078.84	1984.59	13780.54
440.000	9843.14	612.39	9663.11	50488.63	2009.45	14162.46
441.000	9864.25	648.84	9662.55	50899.20	2035.73	14450.84
442.000	9749.33	525.33	9680.53	51307.82	2060.19	14725.51
443.000	9894.74	611.83	9689.55	51717.07	2083.88	14985.01
444.000	9885.36	611.27	9691.61	52129.15	2109.36	15189.00
445.000	9843.14	578.69	9690.15	52540.16	2134.15	15434.26
446.010	0.00	0.00	9688.79	52747.28	2146.33	15651.88
450.000	0.00	0.00	10712.48	52747.28	2146.33	10436.69
466.300	0.00	0.00	10754.62	52747.28	2146.33	5395.81