

The indications are that the critical gas saturation is low for the high permeability, oölitic limestone of the Rockwell Field, and that at 2800 psia the gas-oil ratios would begin to rise and cause a lower recovery efficiency.

11. **Maximum Efficient Rate (MER).** Many studies indicate that the recovery from true solution gas-drive reservoirs by primary depletion is essentially independent of both individual well rates and total or reservoir production rates. Kelly, Tracy, and Roe<sup>22</sup> have shown that this is true even for reservoirs with severe permeability stratification where the strata are separated by impermeable barriers and are hydraulically connected only at the wells. The Gloyd-Mitchell zone of the Rodessa Field (see Chapter 3, Sec. 7) is an example of a solution gas-drive reservoir which is essentially not *rate sensitive*, i.e., the recovery is unrelated to the rate at which the reservoir is produced. The recovery from very permeable, uniform reservoirs under very active water drives may also be essentially independent of the rates at which they are produced.

*Applied*

PETROLEUM RESERVOIR  
ENGINEERING

B. C. CRAFT

*and*

M. F. HAWKINS

*Petroleum Engineering Department  
Louisiana State University*

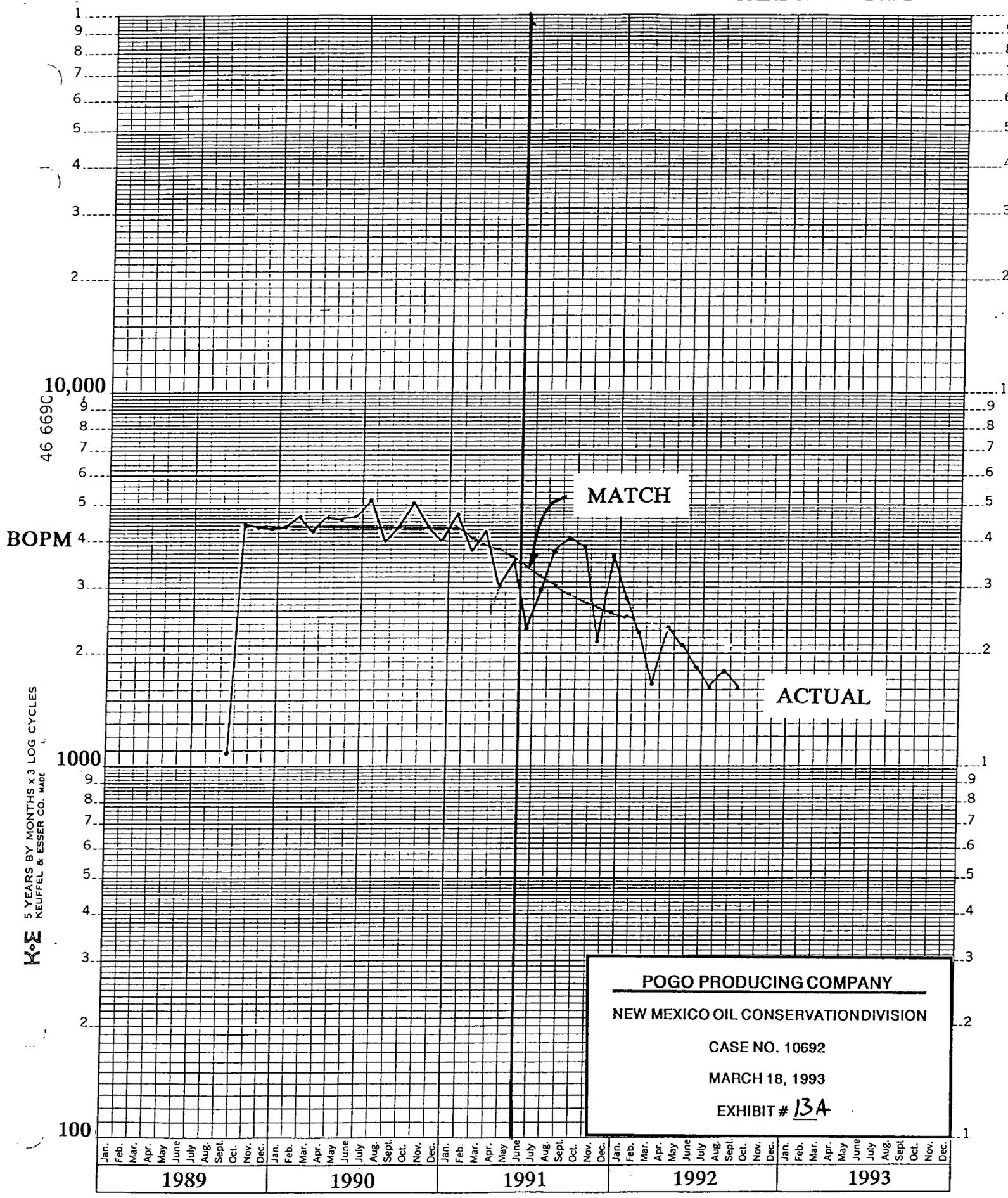
POGO PRODUCING COMPANY

NEW MEXICO OIL CONSERVATION DIVISION

CASE NO. 10692

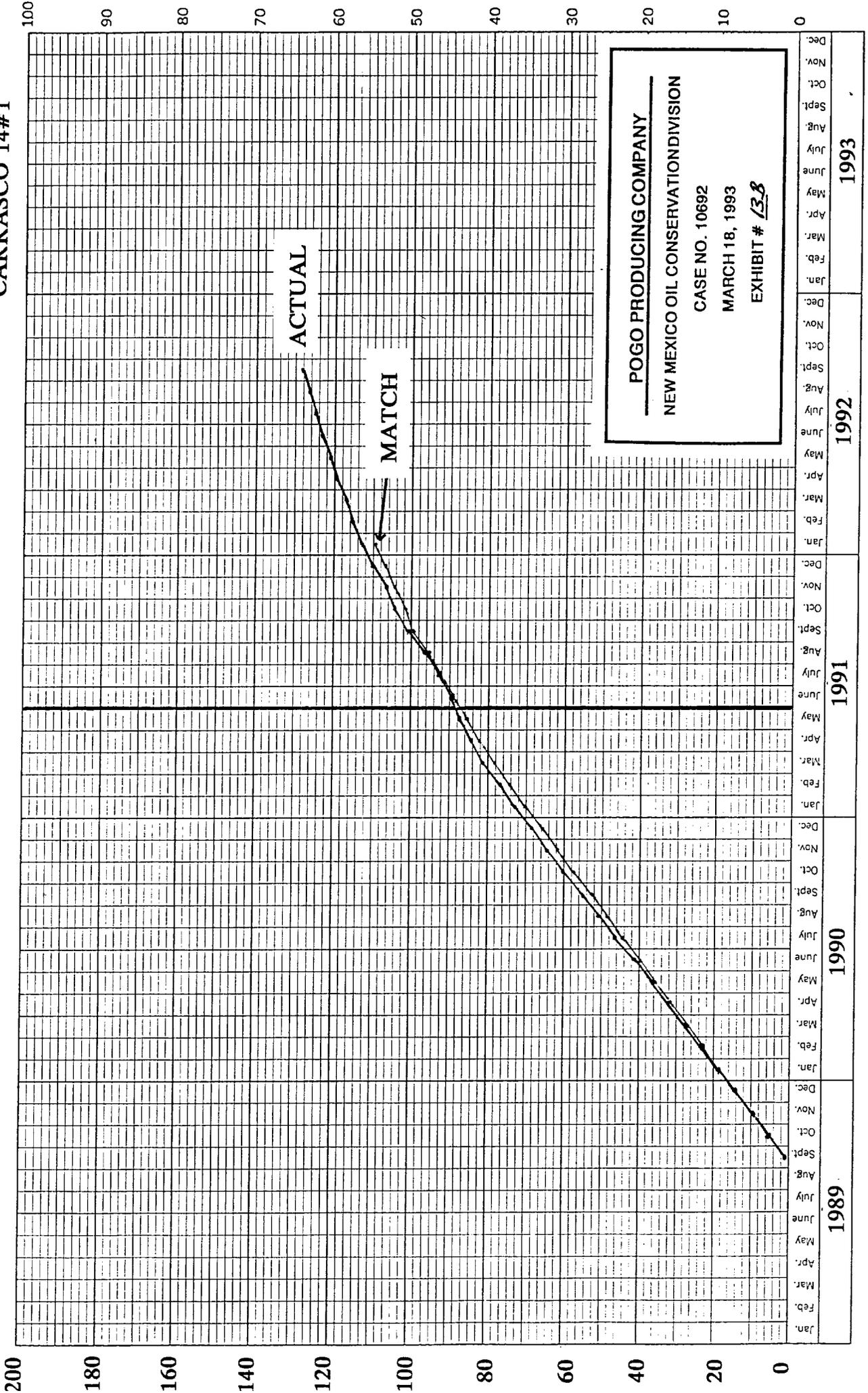
MARCH 18, 1993

EXHIBIT # 12



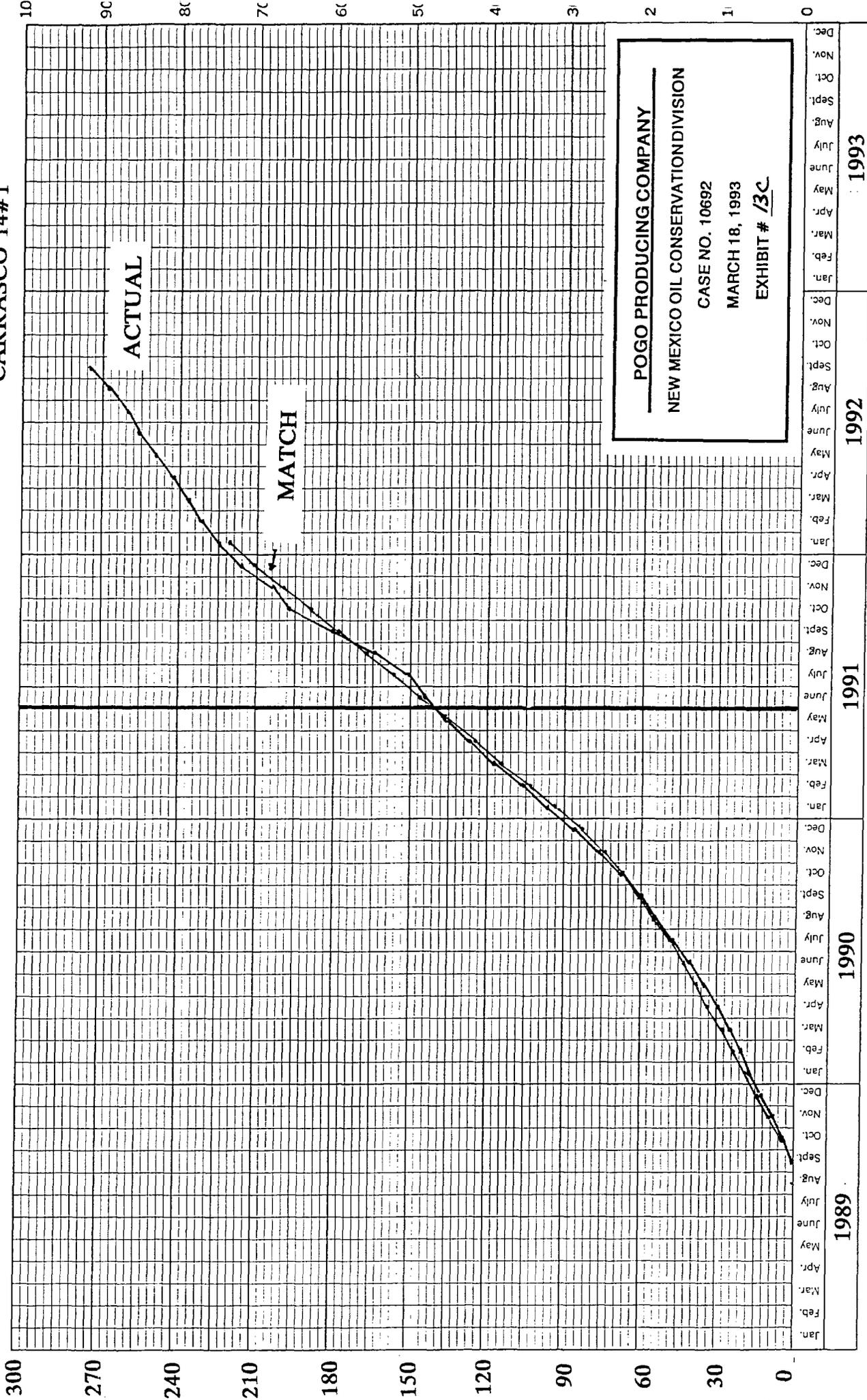
CUMULATIVE OIL, MBBLS

CARRASCO 14#1



CUMULATIVE GAS, MMCF

CARRASCO 14#1

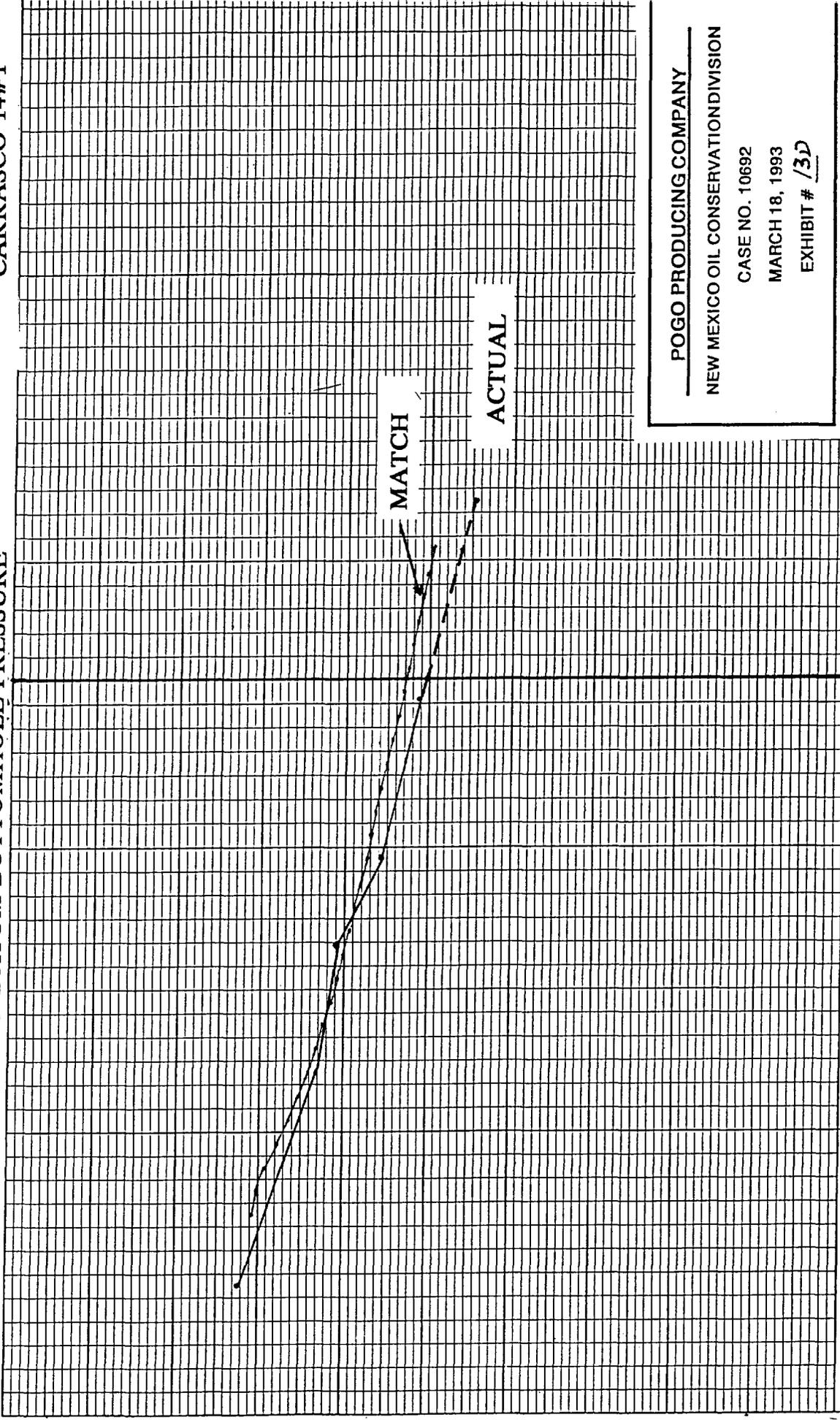


POGO PRODUCING COMPANY  
NEW MEXICO OIL CONSERVATION DIVISION  
CASE NO. 10692  
MARCH 18, 1993  
EXHIBIT # 13C

-3100' DATUM BOTTOMHOLE PRESSURE

CARRASCO 14#1

4000  
3600  
3200  
2800  
2400  
BHP  
2000  
1600  
1200  
800  
400  
0



POGO PRODUCING COMPANY

NEW MEXICO OIL CONSERVATION DIVISION

CASE NO. 10692

MARCH 18, 1993

EXHIBIT # /3D

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EAST LOVING DELAWARE GORS (10-11/92)

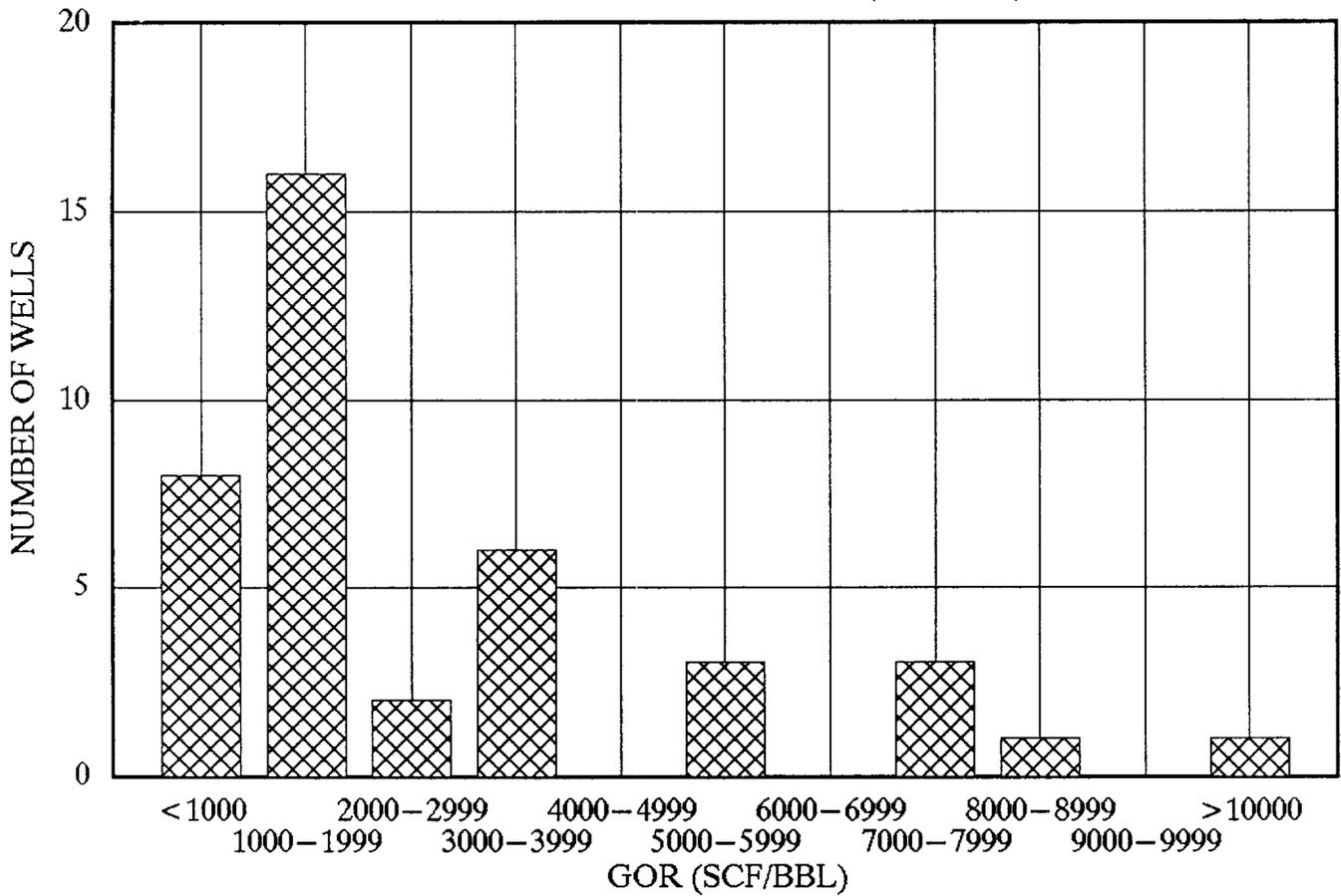
T23S R28E

EDDY COUNTY, NEW MEXICO

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L	K	J	I	L	K	J	I	L	K	J	I	L	K	J	I
M	N	O	P	M	N	O	P	M	N	O	P	M	N	O	P
D	C	B	A <sup>9</sup>	D	C	B	A <sup>10</sup>	D	C	B	A <sup>11</sup>	D	C	B	A <sup>12</sup>
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D	C	B	A <sup>21</sup>	D	C	B	A <sup>22</sup>	D	C	B	A <sup>23</sup>	D	C	B	A <sup>24</sup>
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D	C	B	A <sup>28</sup>	D	C	B	A <sup>27</sup>	D	C	B	A <sup>26</sup>	D	C	B	A <sup>25</sup>
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# FREQUENCY DISTRIBUTION OF GORS

EAST LOVING DELAWARE (7/90-9/90)



**POGO PRODUCING COMPANY**

NEW MEXICO OIL CONSERVATION DIVISION

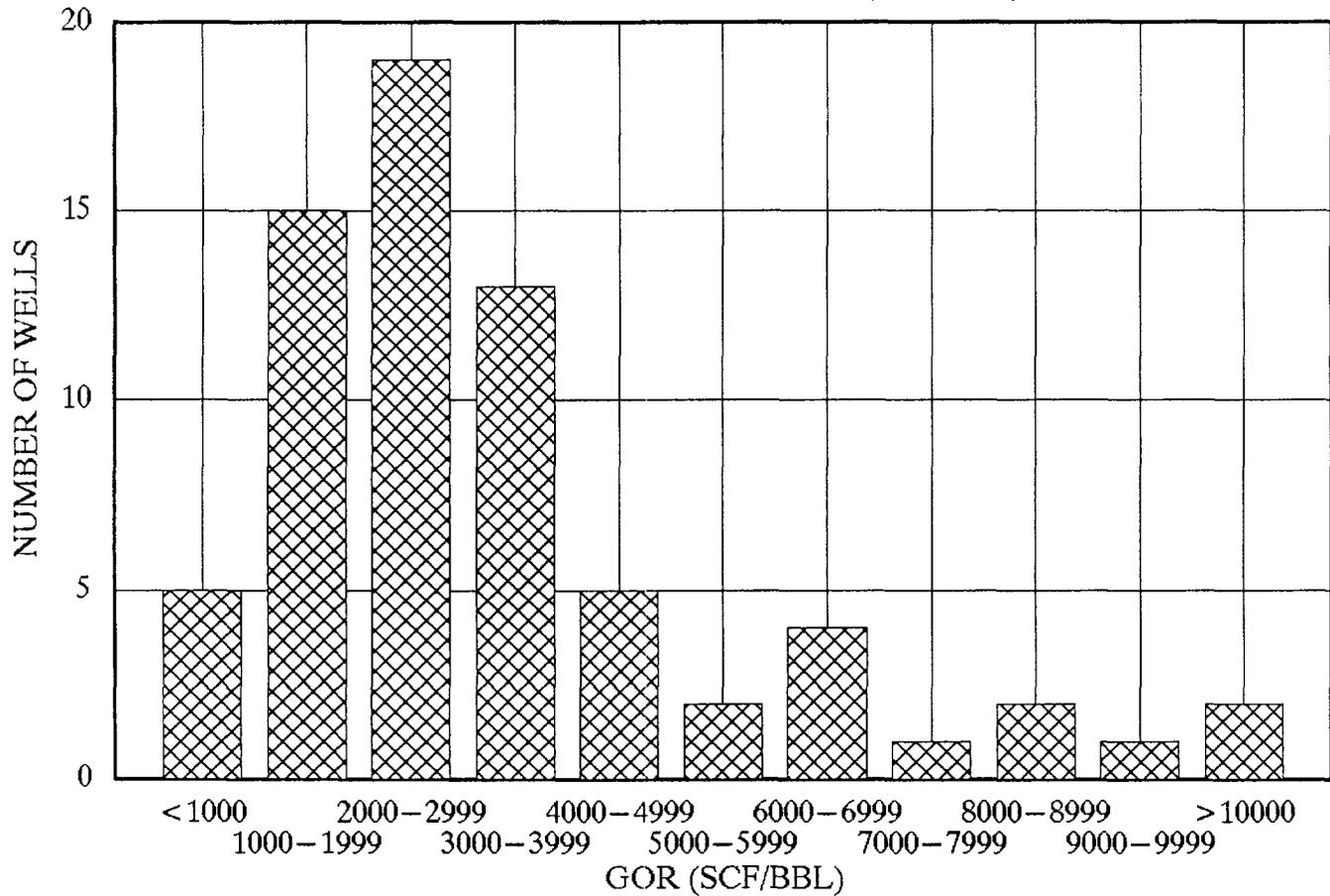
CASE NO. 10692

MARCH 18, 1993

EXHIBIT # 15

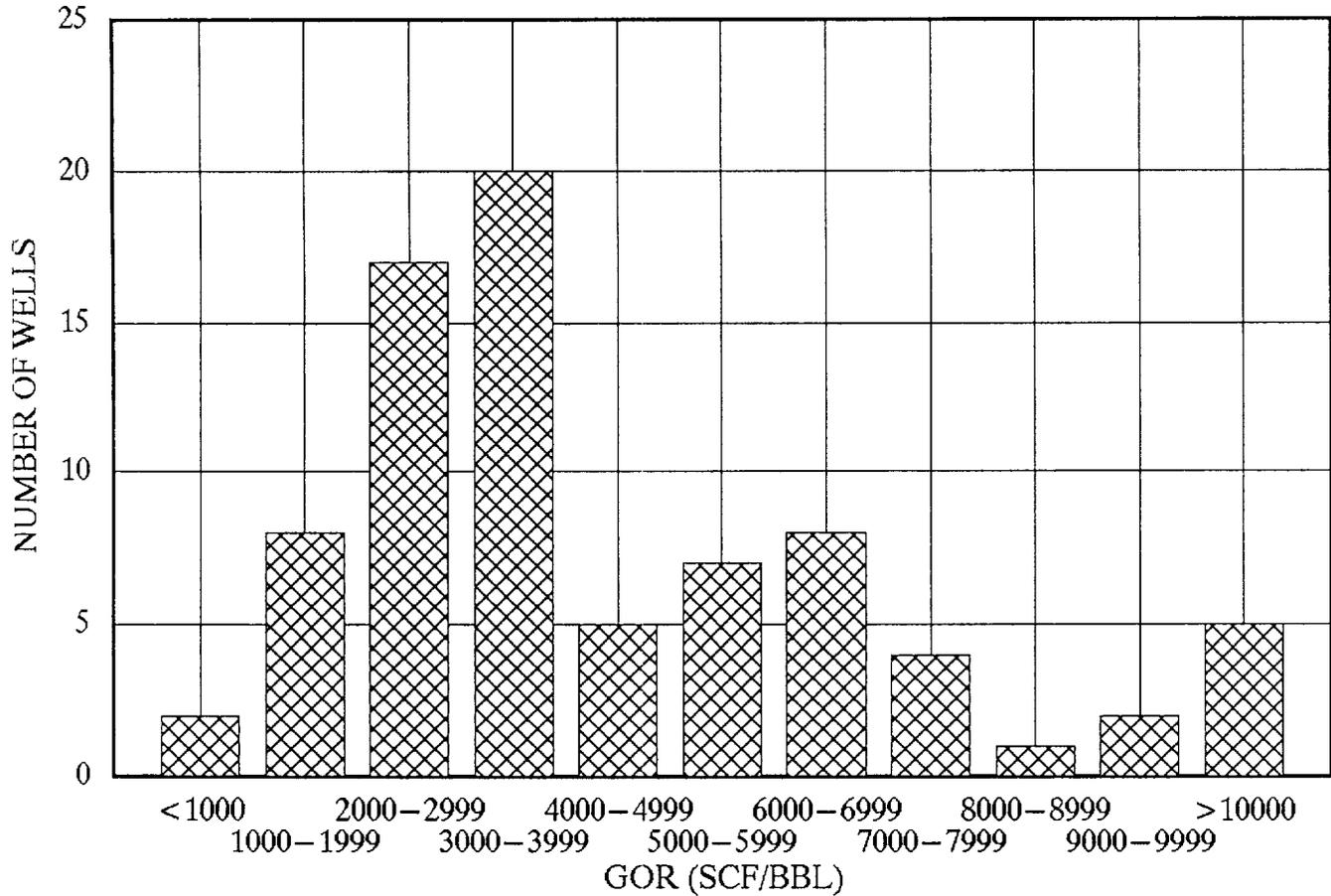
# FREQUENCY DISTRIBUTION OF GORS

EAST LOVING DELAWARE (1/91-3/91)



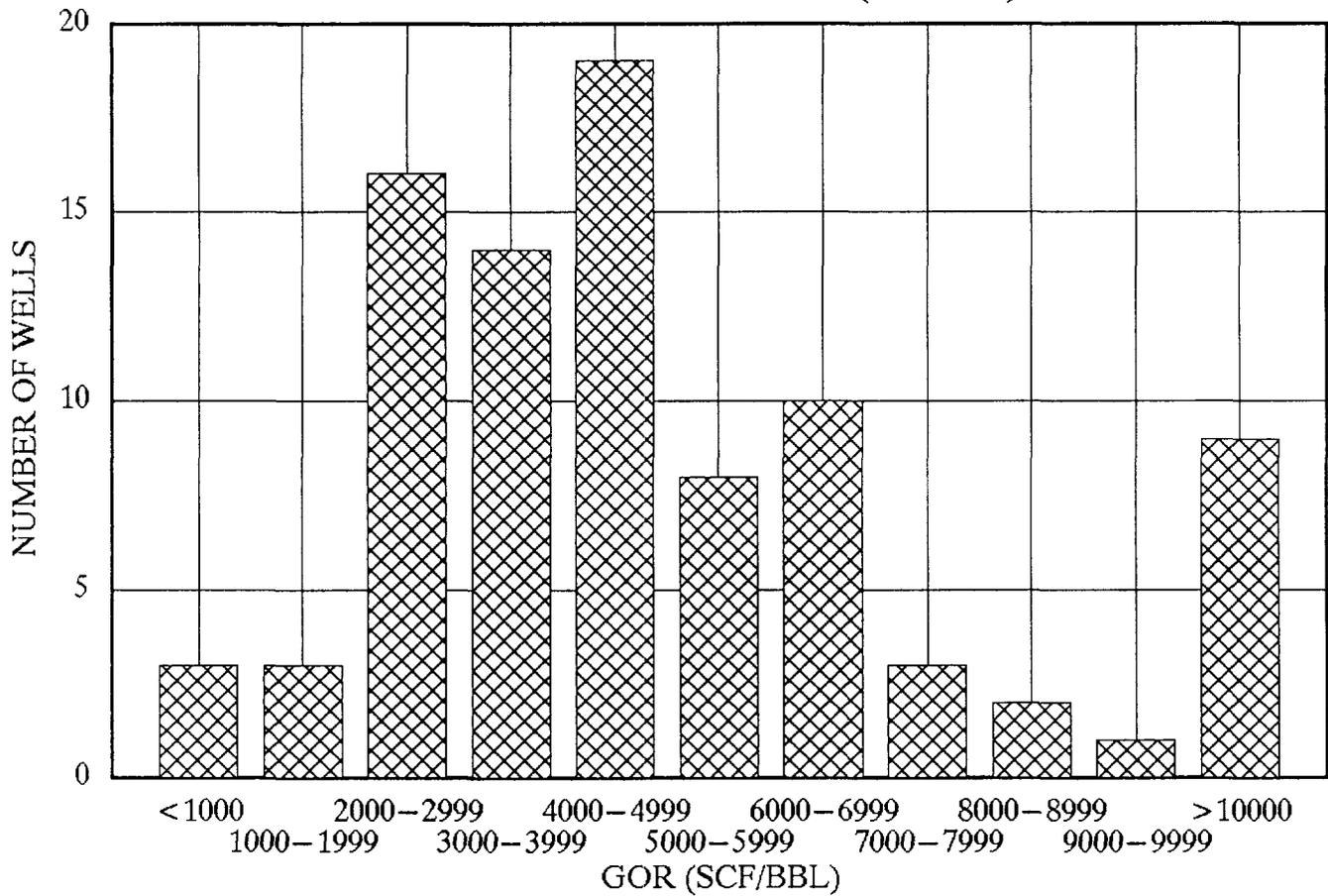
# FREQUENCY DISTRIBUTION OF GORS

EAST LOVING DELAWARE (7/91-9/91)



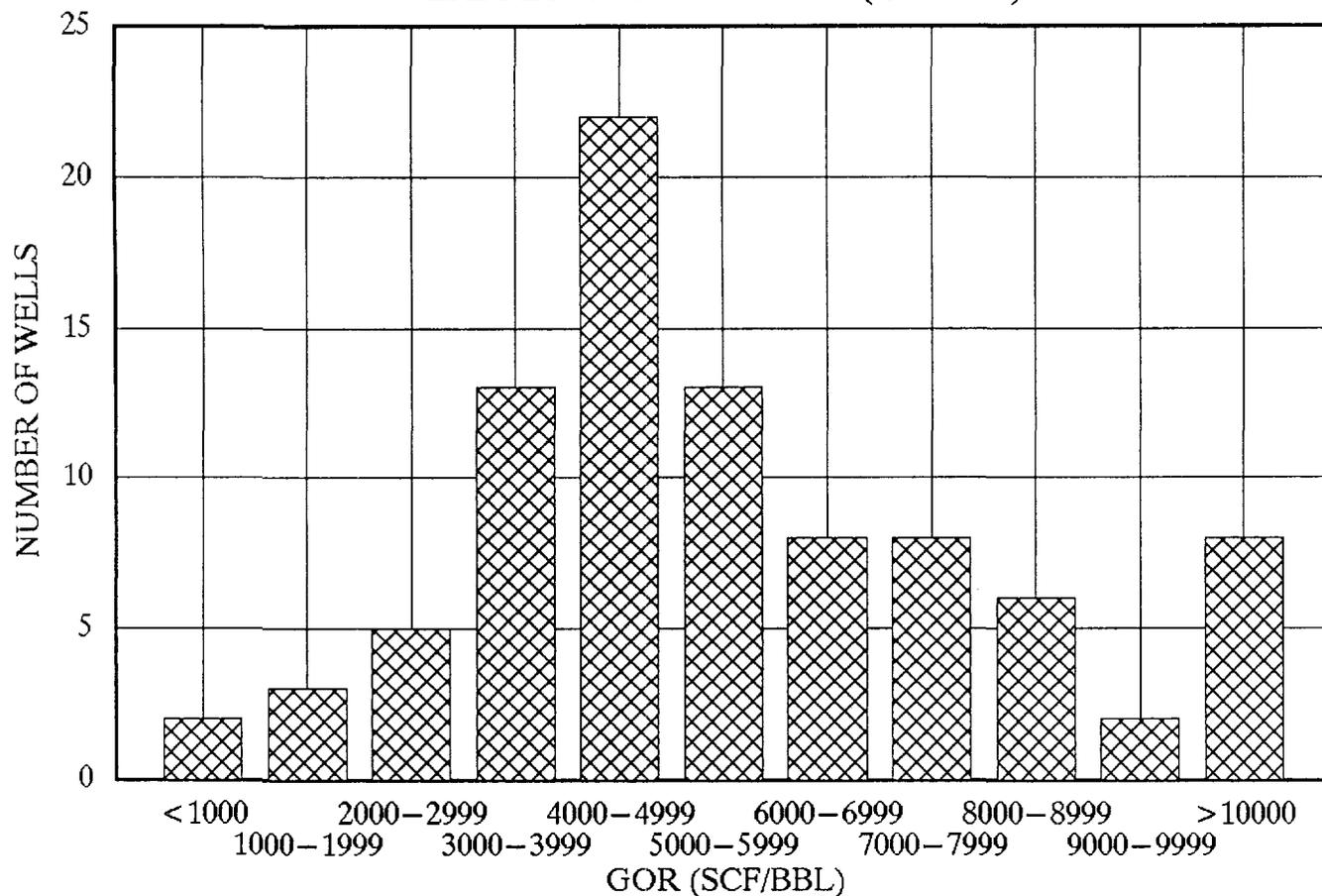
# FREQUENCY DISTRIBUTION OF GORS

EAST LOVING DELAWARE (1/92-3/92)



# FREQUENCY DISTRIBUTION OF GORS

EAST LOVING DELAWARE (7/92-9/92)



**EAST LOVING DELAWARE  
HISTORY AND STATISTICS OF GORS**

DATES	PRODUCTION		PRODUCING GOR	MEDIAN GOR
	GAS MCF	OIL BBL		
7/90 - 9/90	583,791	312,683	1,867	1,584
1/91 - 3/91	1,133,452	442,511	2,561	2,457
7/91 - 9/91	1,314,457	359,141	3,660	3,600
1/92 - 3/92	1,276,299	294,102	4,340	4,243
7/92 - 9/92	1,168,789	225,428	5,185	4,748

POGO PRODUCING COMPANY

NEW MEXICO OIL CONSERVATION DIVISION

CASE NO. 10692

MARCH 18, 1993

EXHIBIT # 16

From:  
**Fundamentals of Reservoir Engineering**  
by John C. Calhoun, Jr.  
Copyright 1953  
University of Tulsa Press

of uncertainty. In the early life of a reservoir, moreover, special care must be taken that reliable average pressures are chosen, and that reliable gas-production figures are available because the differences in terms in Equation 149 are small during the early period when reservoir pressure is near its original value.

### 90. Average Gas-Oil Ratios

For material balance and other calculations, it is necessary to know amounts of gas produced. In the material-balance equation, the produced gas shows up as a cumulative gas-oil ratio rather than as a gas volume. The expression of gas production by gas-oil ratios is more common than by gas cumulative figures. Very often current producing gas-oil ratios are available and it is desirable to convert them to a cumulative gas-oil-ratio basis. The present discussion is concerned with the handling of such gas-measurement quantities.

Producing, or instantaneous, gas-oil ratio signifies a current rate. It is by definition the current rate of gas production divided by the current rate of oil production. It is expressed usually as standard cubic feet of gas per barrel of stock-tank oil. Such ratios are given as a result of a few hours' testing or as a result of several days of testing. The symbol  $R$  will be used to designate current producing gas-oil ratio over whatever testing period may be applicable.

To obtain an average producing gas-oil ratio for several wells or for all wells in a field, one cannot take an arithmetic average value of the ratios. For example, two wells with gas-oil ratios of 2,000 and 8,000 would not necessarily have an average ratio of 5,000. They would only if both wells were producing the same amounts of oil. An average producing gas-oil ratio must be obtained by dividing total current gas production from all wells involved by total current oil production from all wells involved. Thus, if the 2,000-ratio well produced at the rate of 100 bbl. per day and the 8,000 ratio well at the rate of 50 bbl. per day, the average value of  $R$  for the two wells would be:

$$R_{avg} = \frac{2,000 \times 100 + 8,000 \times 50}{150} = 4,000 \text{ cu. ft. per bbl.}$$

**POGO PRODUCING COMPANY**  

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**NEW MEXICO OIL CONSERVATION DIVISION**  
CASE NO. 10692  
MARCH 18, 1993  
EXHIBIT # 17

For a large number of wells the average ratio is figured as:

$$R_{\text{avg}} = \frac{\sum R_i \times Q_{0i}}{\sum Q_{0i}} \quad (154)$$

where  $R_i$  and  $Q_{0i}$  signify the individual ratios and stock-tank oil production rates and the sign  $\sum$  means the addition of such quantities for all the wells in question.

The total gas produced in an interval of time is equal to the producing gas-oil ratio during that period of time multiplied by the oil-production rate during the interval. To find the cumulative gas produced up to a certain time on a reservoir, therefore, one needs the current ratio at various periods and the amount of production during each period.

If  $\Delta N$  represents cumulative stock-tank production, then the production over a short interval of time is its derivative, or  $d(\Delta N)$ . The product of the gas-oil ratio at this interval and the production is equal to the gas produced in the interval, or:

$$\text{Gas produced in interval} = R \times d(\Delta N) \quad (155)$$

The cumulative gas produced from zero time up to a certain time  $t$  is the integral of Equation 155 or:

$$\text{Cumulative gas} = \int_0^t R \times d(\Delta N) \quad (156)$$

Expressed another way, this is the area under the curve of  $R$  plotted against the cumulative production  $\Delta N$ . This is shown in Fig. 142.

The cumulative gas-oil ratio, expressed by the symbol  $R_c$ , is defined as all the gas produced and kept from the reservoir up to a certain time divided by the cumulative oil produced at that same time. Therefore:

$$R_c = \frac{\int_0^t R \times d(\Delta N) - \text{gas reinjected}}{\Delta N} \quad (157)$$

In the case where no gas is reinjected, the cumulative gas-oil ratio is simply the area shown in Fig. 142 divided by  $\Delta N$ .

In averaging individual gas-oil ratios, therefore, at a specific time, the important thing to remember is that they must be weighted according to the production which they represent. In

averaging current producing gas-oil ratios at successive times to get a cumulative ratio, the important thing to remember is that the current ratios cannot be weighted on the basis of the time they represent but on the basis of the cumulative production they represent. In other words a graph of the gas-oil ratio,  $R$ , versus

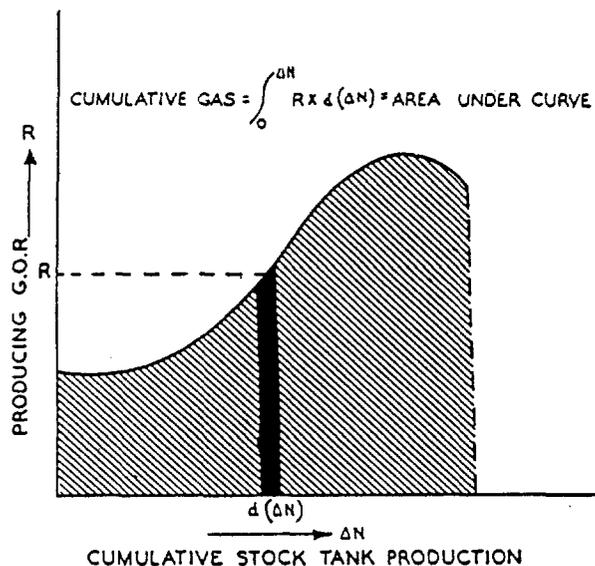
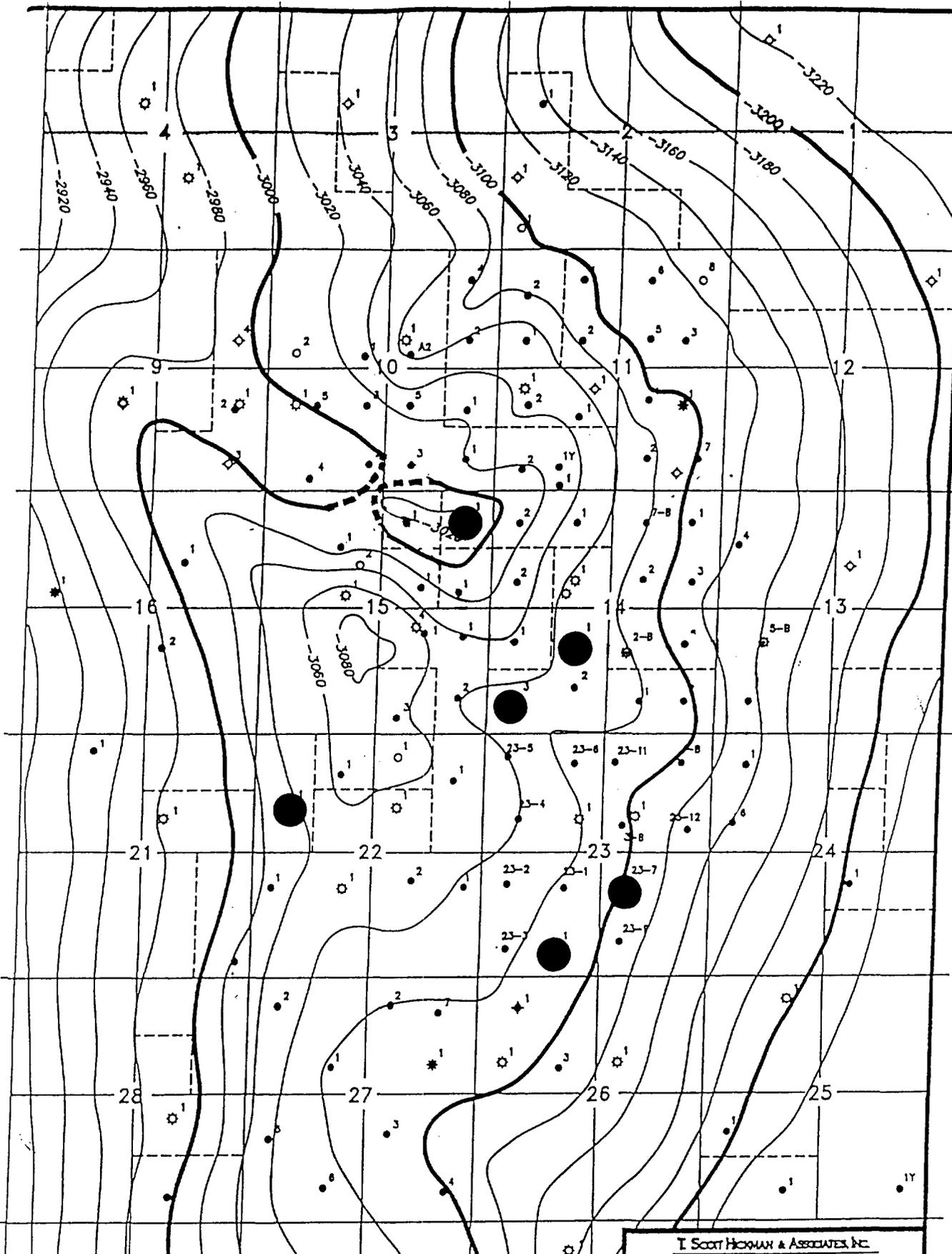


FIG. 142.

time does not give average or cumulative gas-oil ratio. A knowledge of  $R$  versus cumulative production is necessary as indicated by Equation 157.

## 91. Computing Original Oil in Place From Gas Produced

In section 90 it was pointed out that the area under a plot of the producing gas-oil ratio versus cumulative oil produced would be equivalent to the total cumulative gas produced from a reservoir. This is a true statement regardless of the mechanism of production. Furthermore, at the termination of the producing life of a reservoir the total area under the plot will be essentially equivalent to the total amount of gas which was originally avail-



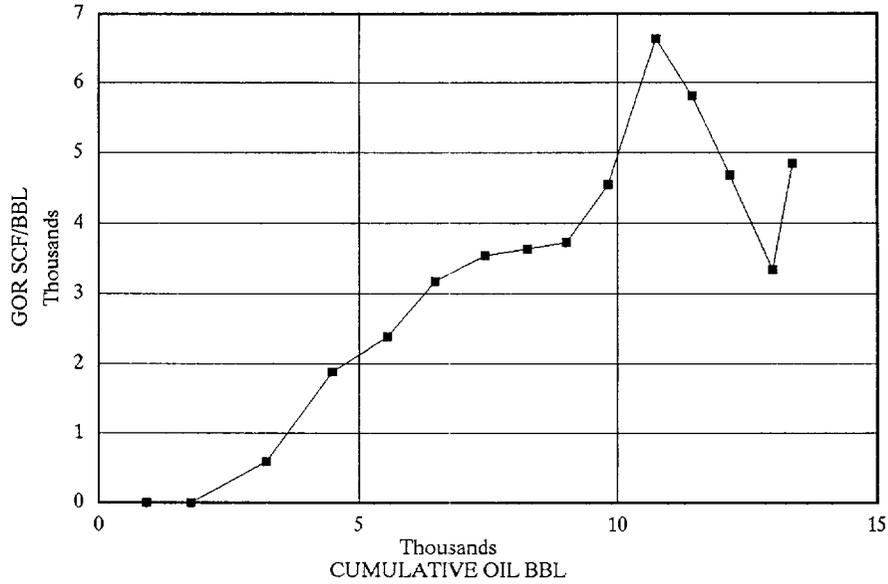
**POGO PRODUCING COMPANY**  
 NEW MEXICO OIL CONSERVATION DIVISION  
 CASE NO. 10692  
 MARCH 18, 1993  
 EXHIBIT # 18

**T. SCOTT HOGMAN & ASSOCIATES, INC.**  
 POGO PRODUCING COMPANY  
 East Lovig (Delaware) Field  
 Township 23S Range 28E  
 Eddy County, New Mexico  
 STRUCTURE MAP  
 Top of  
 BRUSHY CANYON M1 SAND  
 Contour Interval = 20'  
 SCALE 4000'

**EAST LOVING DELAWARE**  
**STRUCTURALLY HIGH WELLS**

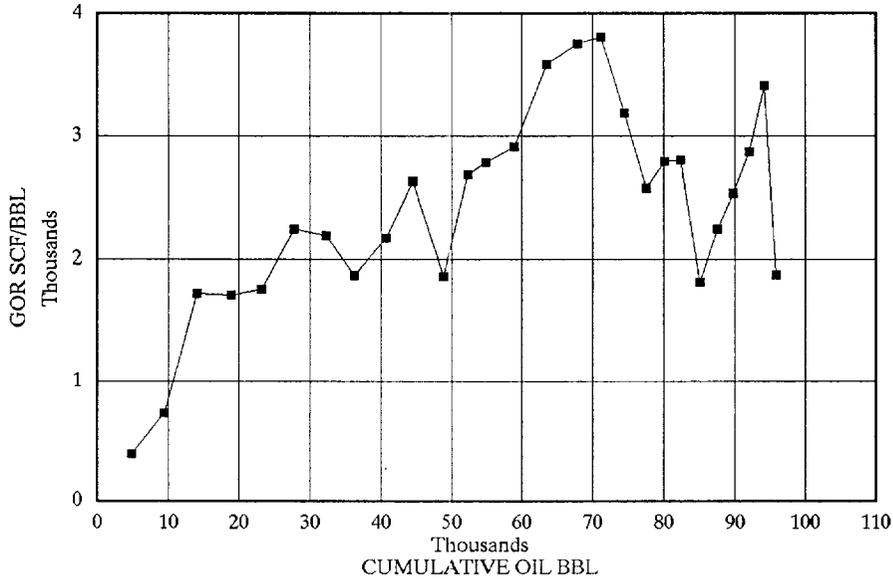
**BURKHAM #1 (22E)**

GOR vs CUMULATIVE



**SIEBERT #1 (15A)**

GOR vs CUMULATIVE



**POGO PRODUCING COMPANY**

NEW MEXICO OIL CONSERVATION DIVISION

CASE NO. 10692

MARCH 18, 1993

EXHIBIT # 19

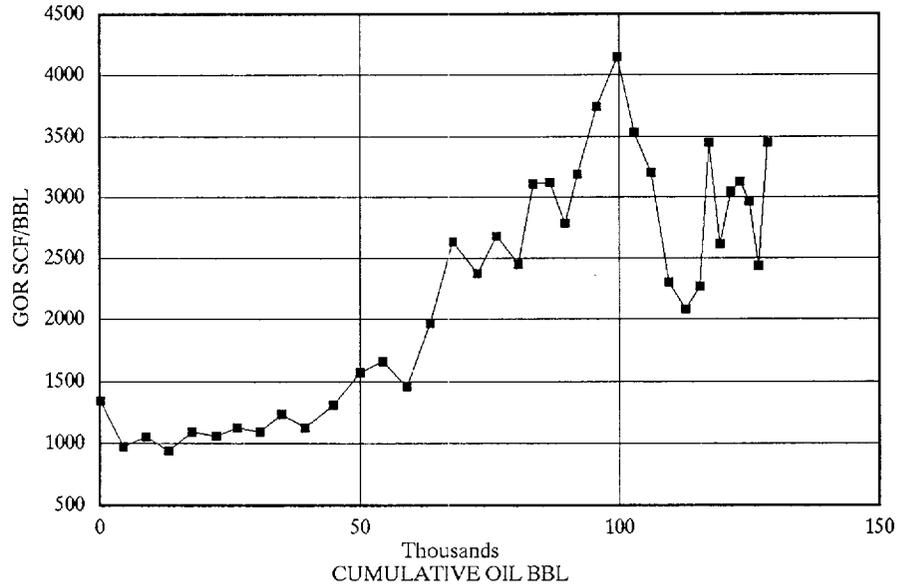
# EAST LOVING DELAWARE

## MID STRUCTURE WELLS

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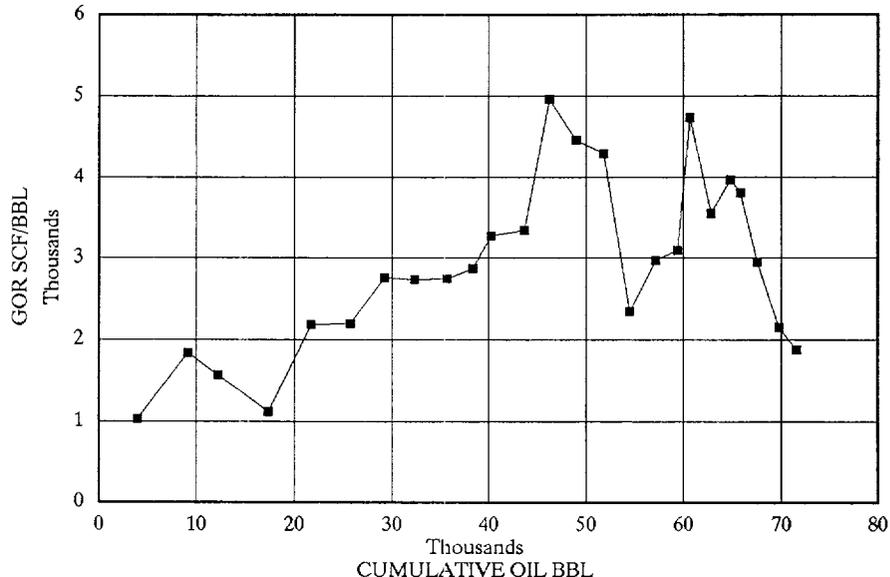
### RGA #1 (14K)

GOR vs CUMULATIVE



### RGA #3 (14M)

GOR vs CUMULATIVE

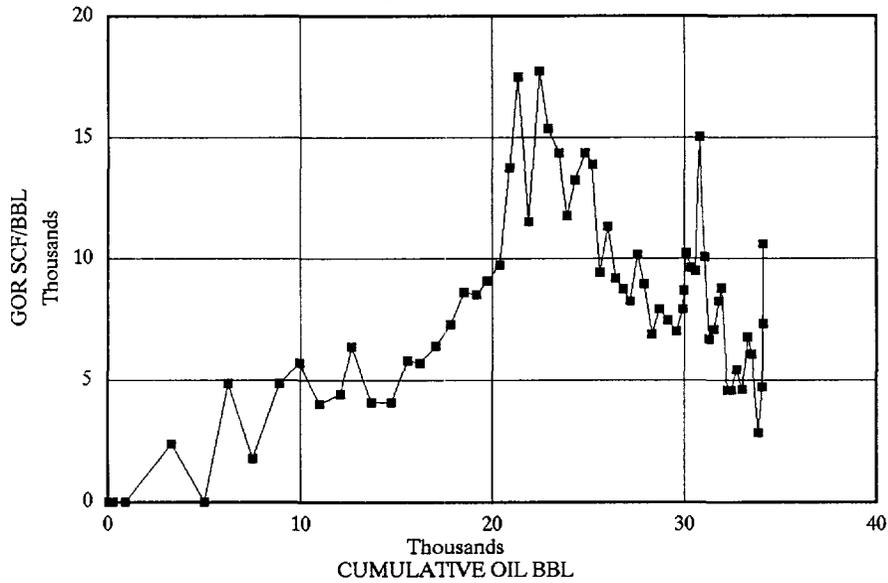


# EAST LOVING DELAWARE

## STRUCTURALLY LOW WELLS

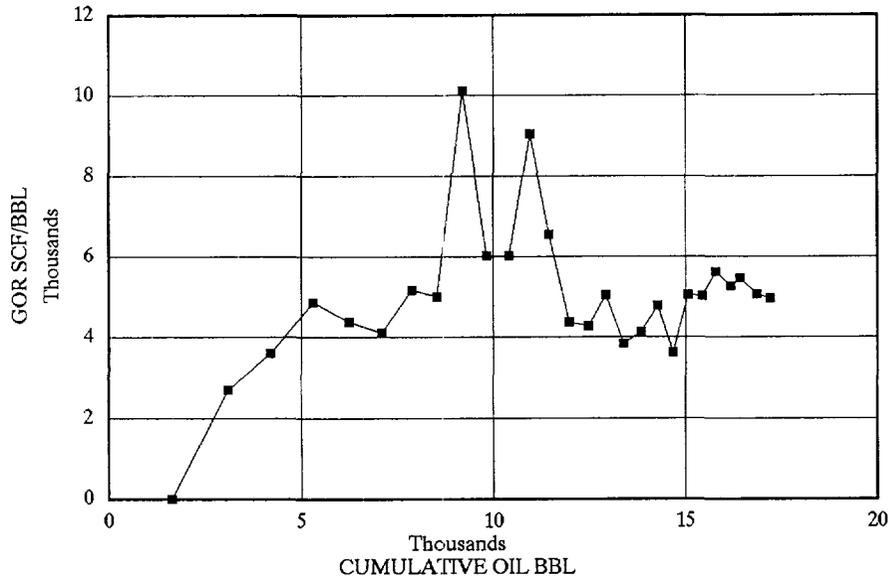
### BRANTLEY COM #1 (23N)

GOR vs CUMULATIVE



### CULEBRA BLUFF 23 (SOUTH) #7 (23J)

GOR vs CUMULATIVE



EAST LOVING (DELAWARE) WELLS  
 8,000-1 GOR  
 (SORTED BY SECTION & UNIT)

POGO PRODUCING COMPANY  
 NEW MEXICO OIL CONSERVATION DIVISION  
 CASE NO. 10692  
 MARCH 18, 1993  
 EXHIBIT # 20

WELL NAME	LOCATION	PRODUCTION			CALCULATIONS:					MONTHLY INCREASE	
		10-11/92			DAILY		ADJUSTED DAILY			MCF	BBL
		MCF	BBL	GOR	MCF BBL	MCF BBL	MCF BBL	GOR	MCF	BBL	
PARDUE - MARTIN #2	02L 23S 28E	3,383	1,160	2,916	55	19	55	19	2,916		
PARDUE - MARTIN #1	02M 23S 28E	5,206	1,002	5,196	85	16	85	16	5,196		
NEL COM. #5	09I 23S 28E	9,671	878	11,015	159	14	159	14	11,015		
PARDUE FARMS #4	10A 23S 28E	0	0		0	0	0	0			
FEDERAL 10 #2	10C 23S 28E	6,365	188	33,856	104	3	104	3	33,856		
FEDERAL 10 #3	10E 23S 28E	6,166	1,799	3,427	101	29	101	29	3,427		
FEDERAL 10 #1	10F 23S 28E	9,194	1,829	5,027	151	30	151	30	5,027		
PECOS IRRIGATION 'A' #2	10G 23S 28E	3,486	783	4,452	57	13	57	13	4,452		
PARDUE FARMS #2	10H 23S 28E	675	1,017	664	11	17	11	17	664		
LEWIS ESTATE #1	10I 23S 28E	2,500	870	2,873	41	14	41	14	2,873		
PARDUE FARMS #5	10J 23S 28E	8,905	4,272	2,085	146	70	146	70	2,085		
URQUIDEZ #3	10K 23S 28E	14,648	2,428	6,033	240	40	240	40	6,033		
URQUIDEZ COMM. #5	10L 23S 28E	17,439	2,657	6,563	286	44	572	87	6,563	8,577	1,307
URQUIDEZ #4	10M 23S 28E	8,105	409	19,817	133	7	133	7	19,817		
URQUIDEZ #2	10N 23S 28E	17,227	1,842	9,352	282	30	565	60	9,352	8,472	906
PARDUE FARMS #3	10O 23S 28E	24,562	1,084	22,658	403	18	805	36	22,658	12,079	533
PARDUE FARMS #1	10P 23S 28E	17,516	1,271	13,781	287	21	574	42	13,781	8,614	625
AMOCO 11 FEDERAL #6	11B 23S 28E	3,553	1,101	3,227	58	18	58	18	3,227		
ONSUREZ #1	11C 23S 28E	3,590	1,035	3,469	59	17	59	17	3,469		
PARDUE D 8808 JV - P #2	11D 23S 28E	14,651	1,511	9,696	240	25	240	25	9,696		
PARDUE D 8808 JV - P #1	11E 23S 28E	11,772	1,231	9,563	193	20	193	20	9,563		
ONSUREZ #2	11F 23S 28E	3,737	1,038	3,600	61	17	61	17	3,600		
AMOCO 11 FEDERAL #5	11G 23S 28E	7,501	1,235	6,074	123	20	123	20	6,074		
AMOCO FEDERAL #3	11H 23S 28E	4,343	1,143	3,800	71	19	71	19	3,800		
AMOCO FEDERAL #1	11I 23S 28E	5,133	819	6,267	84	13	84	13	6,267		
AMOCO 11 FEDERAL #4	11J 23S 28E	5,528	1,461	3,784	91	24	91	24	3,784		
PARDUE B 8808 JVP #1	11K 23S 28E	16,743	4,675	3,581	274	77	458	128	3,581	5,497	1,535
PARDUE B 8808 JVP #2	11L 23S 28E	16,090	2,786	5,775	264	46	528	91	5,775	7,913	1,370
PARDUE C 8808 JVP #2	11M 23S 28E	16,673	3,059	5,450	273	50	547	100	5,450	8,200	1,504
AMOCO 11 FEDERAL #2	11O 23S 28E	13,283	3,837	3,462	218	63	218	63	3,462		
AMOCO 11 FEDERAL #7	11P 23S 28E	12,501	1,778	7,031	205	29	205	29	7,031		

EAST LOVING (DELAWARE) WELLS  
 8,000-1 GOR  
 (SORTED BY SECTION & UNIT)

WELL NAME	LOCATION	PRODUCTION			CALCULATIONS:					MONTHLY INCREASE	
		10-11/92			DAILY		ADJUSTED DAILY			MCF	BBL
		MCF	BBL	GOR	MCF BBL	MCF BBL	MCF BBL	GOR			
CULEBRA BL UFF UNIT (SOUTH) #5	13L 23S 28E	1,700	314	5,414	28	5	28	5	5,414		
CANDIE 13 #1	13M 23S 28E	3,245	1,909	1,700	53	31	53	31	1,700		
CULEBRA BL UFF 14 (SOUTH) #1	14A 23S 28E	8,940	1,434	6,234	147	24	147	24	6,234		
CULEBRA BL UFF UNIT (SOUTH) #7	14B 23S 28E	15,603	3,546	4,400	256	58	512	116	4,400	7,674	1,744
TELEDYNE #1	14C 23S 28E	0	0		0	0	0	0			
TELEDYNE #2	14D 23S 28E	21,250	6,943	3,061	348	114	391	128	3,061	1,284	419
TRACHTA #2	14E 23S 28E	17,446	2,909	5,997	286	48	572	95	5,997	8,580	1,431
CARRASCO 14 #1	14F 23S 28E	28,894	5,061	5,709	474	83	730	128	5,709	7,679	1,345
CARRASCO 14 #2	14G 23S 28E	16,933	4,156	4,074	278	68	521	128	4,074	7,293	1,790
CARRASCO 14 #3	14H 23S 28E	6,636	1,460	4,545	109	24	109	24	4,545		
CARRASCO 14 #5	14I 23S 28E	14,007	1,014	13,814	230	17	230	17	13,814		
CULEBRA BL UFF UNIT (SOUTH) #2	14J 23S 28E	16,270	4,249	3,829	267	70	489	128	3,829	6,679	1,744
RGA #1	14K 23S 28E	28,661	4,983	5,752	470	82	735	128	5,752	7,957	1,383
TRACHTA #1	14L 23S 28E	17,164	2,717	6,317	281	45	563	89	6,317	8,441	1,336
RGA #3	14M 23S 28E	13,695	3,442	3,979	225	56	225	56	3,979		
RGA #2	14N 23S 28E	13,669	3,699	3,695	224	61	224	61	3,695		
REID #1	14O 23S 28E	15,251	3,781	4,034	250	62	250	62	4,034		
REID #2	14P 23S 28E	14,653	1,868	7,844	240	31	240	31	7,844		
SIEBERT #1	15A 23S 28E	29,484	5,721	5,154	483	94	659	128	5,154	5,259	1,020
CHAVES #1	15B 23S 28E	4,881	1,013	4,818	80	17	80	17	4,818		
NYMEYER A #1	15C 23S 28E	2,769	646	4,286	45	11	45	11	4,286		
KIDD #1	15G 23S 28E	2,242	554	4,047	37	9	37	9	4,047		
WITT #1	15H 23S 28E	14,789	1,426	10,371	242	23	242	23	10,371		
CAVINESS-PAINE #1	15I 23S 28E	7,024	1,518	4,627	115	25	115	25	4,627		
CAVINESS-PAINE #4	15J 23S 28E	1,343	317	4,237	22	5	22	5	4,237		
CAVINESS-PAYNE #3	15O 23S 28E	1,846	484	3,814	30	8	30	8	3,814		
CAVINESS-PAYNE #2	15P 23S 28E	10,840	1,132	9,576	178	19	178	19	9,576		
LEU-1 #1	21P 23S 28E	6,463	1,101	5,870	106	18	106	18	5,870		
QUEBEN #1	22A 23S 28E	5,800	1,252	4,633	95	21	95	21	4,633		
MARKHAM #1	22C 23S 28E	2,534	1,115	2,273	42	18	42	18	2,273		
BURKHAM #2	22D 23S 28E	6,018	1,218	4,941	99	20	99	20	4,941		

EAST LOVING (DELAWARE) WELLS  
 8,000:1 GOR  
 (SORTED BY SECTION & UNIT)

WELL NAME	LOCATION	PRODUCTION			CALCULATIONS:						MONTHLY INCREASE	
		10-11/92			DAILY		ADJUSTED DAILY		MCF		BBL	
		MCF	BBL	GOR	MCF	BBL	MCF	BBL	GOR	MCF		BBL
BURKHAM #1	22E 23S 28E	5,187	1,437	3,610	85	24	85	24	3,610			
QUEEN #2	22H 23S 28E	12,910	1,645	7,848	212	27	212	27	7,848			
JASSO UNIT #1	22I 23S 28E	9,700	2,065	4,697	159	34	159	34	4,697			
BRANTLEY #2	22J 23S 28E	6,531	1,385	4,716	107	23	107	23	4,716			
MCCLEARY #1	22L 23S 28E	798	434	1,839	13	7	13	7	1,839			
CULEBRA BL UFF UNIT (SOUTH) #4	23A 23S 28E	6,322	1,180	5,358	104	19	104	19	5,358			
CULEBRA BL UFF 23 (SOUTH) #11	23B 23S 28E	14,474	2,507	5,773	237	41	237	41	5,773			
CULEBRA BL UFF 23 (SOUTH) #6	23C 23S 28E	15,064	1,870	8,056	247	31	247	31	8,056			
CULEBRA BL UFF 23 (SOUTH) #5	23D 23S 28E	13,496	2,024	6,668	221	33	221	33	6,668			
CULEBRA BL UFF 23 (SOUTH) #4	23E 23S 28E	7,060	1,127	6,264	116	18	116	18	6,264			
DONALDSON COM A #1	23F 23S 28E	11,067	1,946	5,687	181	32	181	32	5,687			
CULEBRA BL UFF UNIT (SOUTH) #3	23G 23S 28E	6,537	1,608	4,065	107	26	107	26	4,065			
CULEBRA BL UFF 23 (SOUTH) #12	23H 23S 28E	1,421	478	2,973	23	8	23	8	2,973			
CULEBRA BL UFF 23 (SOUTH) #7	23J 23S 28E	2,108	440	4,791	35	7	35	7	4,791			
CULEBRA BL UFF 23 (SOUTH) #1	23K 23S 28E	8,707	1,734	5,021	143	28	143	28	5,021			
CULEBRA BL UFF 23 (SOUTH) #2	23L 23S 28E	7,259	1,114	6,516	119	18	119	18	6,516			
CULEBRA BL UFF 23 (SOUTH) #3	23M 23S 28E	6,974	1,403	4,971	114	23	114	23	4,971			
BRANTLEY COM #1	23N 23S 28E	297	207	1,435	5	3	5	3	1,435			
CULEBRA BL UFF 23 (SOUTH) #9	23O 23S 28E	3,189	751	4,246	52	12	52	12	4,246			
CANDELARIO #1	24D 23S 28E	2,798	330	8,479	46	5	46	5	8,479			
CULEBRA BL UFF UNIT (SOUTH) #6	24E 23S 28E	5,147	835	6,164	84	14	84	14	6,164			
PARDUUE FARMS 26 BATTERY 2 #2	26D 23S 28E	10,313	1,345	7,668	169	22	169	22	7,668			
PARDUUE FARMS 26 BATTERY 3 #3	26F 23S 28E	4,409	604	7,300	72	10	72	10	7,300			
PARDUUE FARM 27 #7	27A 23S 28E	9,889	785	12,597	162	13	162	13	12,597			
PARDUUE FARMS 27 BATTERY 2 #2	27B 23S 28E	4,948	573	8,635	81	9	81	9	8,635			
PARDUUE FARMS 27 BTRY 1 #1	27H 23S 28E	1,270	558	2,276	21	9	21	9	2,276			
PARDUUE FARMS 27 BTRY 1 #3	27I 23S 28E	8,291	904	9,171	136	15	136	15	9,171			
PARDUUE FARMS 27 BATTERY 6 #6	27N 23S 28E	5,057	636	7,951	83	10	83	10	7,951			
PARDUUE FARMS 27 BTRY 1 #4	27P 23S 28E	2,547	606	4,203	42	10	42	10	4,203			
TOTAL S		833,965	153,711	5,426			17,678	3,186	5,548	120,198	19,994	



STATE OF NEW MEXICO  
ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT  
OIL CONSERVATION DIVISION



BRUCE KING  
GOVERNOR

ANITA LOCKWOOD  
CABINET SECRETARY

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July 9, 1993

HINKLE, COX, EATON,  
COFFIELD & HENSLEY  
Attorneys at Law  
P. O. Box 2068  
Santa Fe, New Mexico 87501

RE: CASE NO. 10692  
ORDER NO. R-9501-B

Dear Sir:

Enclosed herewith are two copies of the above-referenced Division order recently entered in the subject case.

Sincerely,

*Sally Leichtle*  
Sally E. Leichtle  
Administrative Secretary

cc: BLM - Carlsbad  
Donna McDonald - OCD  
Alvin Tapia - OCD  
George Geran  
Tim Goudeau