OILFIELD RESEARCH LABORATORIES
536 NORTH HIGHLAND - CHANUTE, KANSAS - PHONE HE1-2650

March 3, 1966

CRA, Incorporated
Box 445
Wellington, Kansas

Gentlemen:

Enclosed herewith is the report of the analysis of the Rotary core taken from the Woodward Lease, Well No. 23, Bourbon County, Kansas, and submitted to our laboratory on February 25, 1966.

Your business is greatly appreciated.

Very truly yours,

OILFIELD RESEARCH LABORATORIES

Benjamin R Pearman

Benjamin R. Pearman

BRP:rf

3 c. - Wellington, Kansas
1 c. - Muskogee, Oklahoma
1 c. - Independence, Kansas

Oilfield Research Laboratories

GENERAL INFORMATION & SUMMARY

Company CRA, Incorporated Lease Woodward Well No. 23

Location 2045' EWL & 1280' NSL, SW¼

Section 12 Twp. 25S Rge. 21E County Bourbon State Kansas

Name of Sand	Bartlesville
Top of Core	614.0
Bottom of Core	665.0
Top of Sand (Analyzed)	614.0
Bottom of Sand (Analyzed)	660.0
Total Feet of Permeable Sand	43.7
Total Feet of Floodable Sand	20.8

Distribution of Permeable Sand:

Permeability Range Millidarcys	Feet	Cum. Ft.
0 - 10	5.3	5.3
10 - 50	17.0	22.3
50 - 100	8.0	30.3
100 - 200	7.8	38.1
200 & above	5.6	43.7

Average Permeability Millidarcys	83.0
Average Percent Porosity	20.6
Average Percent Oil Saturation	30.3
Average Percent Water Saturation	46.6
Average Oil Content, Bbls./A. Ft.	471.
Total Oil Content, Bbls./Acre	20,593.
Average Percent Oil Recovery by Laboratory Flooding Tests	11.5
Average Oil Recovery by Laboratory Flooding Tests, Bbls./A. Ft.	186.
Total Oil Recovery by Laboratory Flooding Tests, Bbls./Acre	3,863.
Total Calculated Oil Recovery, Bbls./Acre (Primary & Secondary)	7,050.
Packer Setting, Feet	
Viscosity, Centipoises @	
A. P. I. Gravity, degrees @ 60 °F	
Elevation, Feet	1041.1

Fresh water mud was used as the circulating fluid while taking this core. The core was sampled and the samples sealed in cans by a representative of Oilfield Research Laboratories. The well was drilled in virgin territory.

FORMATION CORED

The detailed log of the formation cored is as follows:

Depth Interval, Feet	Description
614.0 - 628.6	Light brown, shaly sandstone.
628.6 - 629.7	Sandy shale.
629.7 - 630.6	Laminated sandstone and shale.
630.6 - 639.5	Brown shaly sandstone.
639.5 - 640.1	Laminated sandy shale.
640.1 - 648.2	Brown, slightly shaly sandstone.
648.2 - 648.8	Shale.
648.8 - 651.6	Brown, slightly shaly sandstone.
651.6 - 660.0	Brown, laminated, shaly sandstone.
660.0 - 665.0	Laminated sandy shale.

Coring was started at a depth of 614.0 feet in shaly sandstone and completed at 665.0 feet in sandy shale. This core shows a total of 43.7 feet of sandstone. For the most part, the pay is made up of brown, slightly shaly sandstone.

PERMEABILITY

For the sake of distribution, the core was divided into three sections. The weighted average permeability of the upper, middle and lower sections is 125.7, 77.1 and 17.8 millidarcys respectively; the overall average being 83.0 (See Table III). By observing the data given on the

coregraph, it is noticeable that the sand has an irregular permeability profile. The permeability of the sand varies from 0.25 to a maximum of 364. millidarcys.

PERCENT SATURATION & OIL CONTENT

The sand in this core shows a good weighted average percent oil saturation, namely, 30.3. The weighted average percent oil saturation of the upper, middle and lower sections is 9.2, 42.2 and 40.9 respectively. The weighted average percent water saturation of the upper, middle and lower sections is 67.6, 34.2 and 37.2 respectively; the overall average being 46.6 (See Table III). This gives an overall weighted average total fluid saturation of 76.9 percent. This low total fluid saturation indicates considerable fluid was lost during coring most of which was probably oil.

The weighted average oil content of the upper, middle and lower sections is 147, 678 and 585 barrels per acre foot respectively; the overall average being 471. The total oil content, as shown by this core, is 20,593 barrels per acre of which 14,277 barrels are in the pay sand section (See Table III).

LABORATORY FLOODING TESTS

The sand in this core responded to laboratory flooding tests, as a total recovery of 3,863 barrels of oil per acre was obtained from 20.8 feet of sand. The weighted average percent oil saturation was reduced from 43.0 to 31.5, or represents an average recovery of 11.5 percent. The weighted average effective permeability of the samples is 3.66 millidarcys, while the average initial fluid production pressure is 24.5 pounds per square inch (See Table V).

By observing the data given in Table IV, you will note that of the

44 samples tested, 38 produced water and 21 oil. This indicates that approximately 48 percent of the sand represented by these samples is floodable pay sand. The tests also show that the sand has a wide variation in effective permeability to water.

CONCLUSION

The results of the laboratory tests indicate that efficient primary and secondary operations in the vicinity of this well should recover approximately 7,050 barrels of oil per acre or an average of 339 barrels per acre foot from the 20.8 feet of floodable pay sand analyzed in this core. These recovery values were calculated using the following data and assumptions:

Original formation volume factor	1.06
Reservoir water saturation, percent	25.0
Average porosity, percent	20.7
Oil saturation after flooding, percent	30.2
Performance factor, percent	50.0
Net floodable pay sand, feet	20.8

This core shows a pay sand section (630.6 - 651.6) having a good oil saturation, a moderate water saturation and a wide variation in effective permeability to water.

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RESULTS OF SATURATION & PERMEABILITY TESTS

TABLE 1-B

Company CRA, Inc. Lease Woodward Well No. 23

Sample No.	Depth, Feet	Effective Porosity Percent	Percent Saturation			Oil Content Bbls. / A Ft.	Perm., Mill.	Feet of Sand		Total Oil Content	Perm. Capacity Ft. X md.
			Oil	Water	Total			Ft.	Cum. Ft.		
1	614.1	22.6	3	87	90	53	238.	0.6	0.6	32	142.80
2	615.1	23.4	5	85	90	91	204.	1.0	1.6	91	204.00
3	616.1	22.3	9	54	63	156	179.	1.0	2.6	156	179.00
4	617.1	21.2	6	67	73	99	95.	1.0	3.6	99	95.00
5	618.1	24.0	12	52	64	223	202.	1.0	4.6	223	202.00
6	619.1	23.8	5	70	75	92	127.	1.0	5.6	92	127.00
7	620.1	22.3	5	70	75	87	110.	1.0	6.6	87	110.00
8	621.1	22.0	5	68	73	85	48.	1.0	7.6	85	48.00
9	622.1	22.2	11	62	73	189	27.	1.0	8.6	189	27.00
10	623.1	24.2	3	71	75	56	364.	1.0	9.6	56	364.00
11	624.1	21.4	9	66	75	149	238.	1.0	10.6	149	238.00
12	625.1	19.0	15	68	83	221	13.	1.0	11.6	221	13.00
13	626.1	21.6	14	71	85	234	109.	1.0	12.6	234	109.00
14	627.1	22.6	8	68	76	140	33.	1.0	13.6	140	33.00
15	628.1	20.8	12	67	79	193	54.	1.0	14.6	193	54.00
16	630.1	14.0	24	65	89	260	0.25	0.9	15.5	234	0.23
17	631.1	21.0	36	35	71	586	250.	1.0	16.5	586	250.00
18	632.1	21.1	38	33	71	621	95.	1.0	17.5	621	95.00
19	633.1	21.8	39	37	76	659	40.	1.0	18.5	659	40.00
20	634.1	19.1	39	37	76	577	29.	1.0	19.5	577	29.00
21	635.1	17.8	35	48	83	483	5.9	1.0	20.5	483	5.90
22	636.1	19.4	34	48	82	511	53.	1.0	21.5	511	53.00
23	637.1	21.8	37	34	71	625	126.	1.0	22.5	625	126.00
24	638.1	20.8	51	30	81	821	72.	1.0	23.5	821	72.00

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RESULTS OF SATURATION & PERMEABILITY TESTS

TABLE 1-B

Company CRA, Inc. Lease Woodward Well No. 23

Sample No.	Depth, Feet	Effective Porosity Percent	Percent Saturation			Oil Content Bbls. / A Ft.	Perm., Mill.	Feet of Sand		Total Oil Content	Perm. Capacity Ft. X md.
			Oil	Water	Total			Ft.	Cum. Ft.		
25	639.1	21.4	40	28	68	664	45.	0.9	24.4	596	40.50
26	640.2	16.9	39	43	82	511	17.	0.5	24.9	256	8.50
27	641.1	17.2	37	54	91	493	5.3	1.0	25.9	493	5.30
28	642.1	21.0	44	31	75	716	29.	1.0	26.9	716	29.00
29	643.1	22.0	48	29	77	818	67.	1.0	27.9	818	67.00
30	644.1	21.8	47	34	81	794	23.	1.0	28.9	794	23.00
31	645.1	20.5	55	32	87	874	198.	1.0	29.9	874	198.00
32	646.1	21.0	49	30	79	798	93.	1.0	30.9	798	93.00
33	647.1	21.7	45	22	67	756	37.	1.6	32.5	1,210	59.20
34	649.1	21.8	45	30	75	760	184.	0.8	33.3	608	147.20
35	650.1	21.3	40	28	68	661	116.	1.0	34.3	661	116.00
36	651.1	20.4	44	31	75	696	69.	1.0	35.3	696	69.00
37	652.1	17.7	36	39	75	494	17.	1.0	36.3	494	17.00
38	653.1	18.2	45	38	83	634	7.8	1.0	37.3	634	7.80
39	654.1	14.8	28	55	83	321	15.	1.0	38.3	321	15.00
40	655.1	18.8	50	35	85	729	21.	1.0	39.3	729	21.00
41	656.1	18.7	37	40	77	536	31.	1.0	40.3	536	31.00
42	657.1	20.0	45	30	75	697	35.	1.0	41.3	697	35.00
43	658.1	18.3	43	41	84	610	16.	1.0	42.3	610	16.00
44	659.1	19.5	42	25	67	634	4.9	1.4	43.7	888	6.86
								Total		20,593	

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SUMMARY OF PERMEABILITY & SATURATION TESTS

TABLE III

Company CRA, Inc. Lease Woodward Well No. 23

Depth Interval, Feet	Feet of Core Analyzed	Average Permeability, Millidarcys	Permeability Capacity Ft. x Md.
614.0 - 630.6	15.5	125.7	1,946.03
630.6 - 651.6	19.8	77.1	1,526.60
651.6 - 660.0	8.4	17.8	149.66
614.0 - 660.0	43.7	83.0	3,622.29

Depth Interval, Feet	Feet of Core Analyzed	Average Percent Porosity	Average Percent Oil Saturation	Average Percent Water Saturation	Average Oil Content Bbl./A. Ft.	Total Oil Content Bbls./Acre
614.0 - 630.6	15.5	21.5	9.2	67.6	147	2,281
630.6 - 651.6	19.8	20.6	42.2	34.2	678	13,403
651.6 - 660.0	8.4	18.3	40.9	37.2	585	4,909
614.0 - 660.0	43.7	20.6	30.3	46.6	471	20,593

Oilfield Research Laboratories

RESULTS OF LABORATORY FLOODING TESTS

TABLE IV

Company CRA, Inc. Lease Woodward Well No. 23

Sample No.	Depth, Feet	Effective Porosity Percent	Original Oil Saturation		Oil Recovery		Residual Saturation			Volume of Water Recovered cc*	Effective Permeability Millidarcys**	Initial Fluid Production Pressure Lbs./Sq./In.
			%	Bbls./A. Ft.	%	Bbls./A. Ft.	% Oil	% Water	Bbls./A. Ft.			
1	614.1	22.8	5	88	0	0	5	92	88	270	43.000	10
2	615.1	23.8	4	74	0	0	4	90	74	353	17.330	10
3	616.1	22.3	10	173	0	0	10	81	173	593	48.800	10
4	617.1	21.0	7	114	0	0	7	82	114	388	13.400	10
5	618.1	23.6	12	219	0	0	12	85	219	209	14.710	10
6	619.1	24.0	5	93	0	0	5	90	93	316	17.280	10
7	620.1	22.3	5	87	0	0	5	94	87	368	17.500	10
8	621.1	21.7	7	118	0	0	7	87	118	318	18.500	10
9	622.1	22.2	9	155	0	0	9	90	155	135	2.700	10
10	623.1	24.0	5	93	0	0	5	92	93	160	28.750	10
11	624.1	21.0	10	163	0	0	10	89	163	259	17.230	10
12	625.1	18.6	17	245	0	0	17	80	245	473	9.600	10
13	626.1	22.0	15	256	0	0	15	82	256	190	30.000	10
14	627.1	22.5	7	122	0	0	7	91	122	194	4.400	20
15	628.1	20.8	12	194	0	0	12	83	194	396	8.400	10
16	630.1	13.9	23	248	0	0	23	67	248	0	Imp.	-
17	631.1	21.5	36	599	10	167	26	67	432	218	14.400	20
18	632.1	21.4	38	631	12	200	26	72	431	345	8.800	20
19	633.1	21.4	39	647	9	149	30	64	498	112	2.400	20
20	634.1	18.6	39	562	8	115	31	63	447	53	1.400	30
21	635.1	18.0	35	489	3	42	32	63	447	5	0.300	50
22	636.1	19.7	34	519	6	92	28	59	427	81	1.500	20
23	637.1	22.3	37	640	10	173	27	72	467	257	7.400	20
24	638.1	20.4	51	806	26	411	25	69	395	94	2.900	10

Notes: cc—cubic centimeter.

*—Volume of water recovered at the time of maximum oil recovery.

**—Determined by passing water through sample which still contains residual oil.

Oilfield Research Laboratories

RESULTS OF LABORATORY FLOODING TESTS

TABLE IV

Company CRA, Inc. Lease Woodward Well No. 23

Sample No.	Depth, Feet	Effective Porosity Percent	Original Oil Saturation		Oil Recovery		Residual Saturation			Volume of Water Recovered cc*	Effective Permeability Millidarcys**	Initial Fluid Production Pressure Lbs./Sq./In.
			%	Bbls./A. Ft.	%	Bbls./A. Ft.	% Oil	% Water	Bbls./A. Ft.			
25	639.1	21.4	40	664	17	282	23	70	382	215	6.600	10
26	640.2	17.4	39	526	15	202	24	69	324	20	0.500	20
27	641.1	17.0	38	501	0	0	38	55	501	0	Imp.	-
28	642.1	20.8	44	710	16	258	28	70	452	52	1.500	30
29	643.1	21.6	48	804	20	335	28	71	469	87	2.700	20
30	644.1	21.3	47	776	17	280	30	65	496	18	0.600	35
31	645.1	21.0	55	894	24	391	31	68	503	199	5.700	20
32	646.1	21.3	49	809	21	347	28	71	462	269	7.800	20
33	647.1	21.3	45	743	8	132	37	55	611	31	0.800	20
34	649.1	22.3	45	778	10	173	35	60	605	326	10.500	20
35	650.1	20.8	40	646	2	32	38	53	614	69	1.700	20
36	651.1	19.9	44	679	4	62	40	59	617	14	0.500	30
37	652.1	17.9	37	514	0	0	37	40	514	0	Imp.	-
38	653.1	18.1	45	631	0	0	45	38	631	0	Imp.	-
39	654.1	14.8	27	310	0	0	27	57	310	0	Imp.	-
40	655.1	18.4	50	713	2	29	48	51	684	12	0.400	50
41	656.1	18.4	39	556	0	0	39	56	556	11	0.300	40
42	657.1	19.6	45	683	5	76	40	59	607	17	0.400	30
43	658.1	18.0	43	601	0	0	43	53	601	7	0.300	50
44	659.1	19.3	44	658	0	0	44	27	658	0	Imp.	-

Notes: cc—cubic centimeter.

*—Volume of water recovered at the time of maximum oil recovery.

**—Determined by passing water through sample which still contains residual oil.

Oilfield Research Laboratories

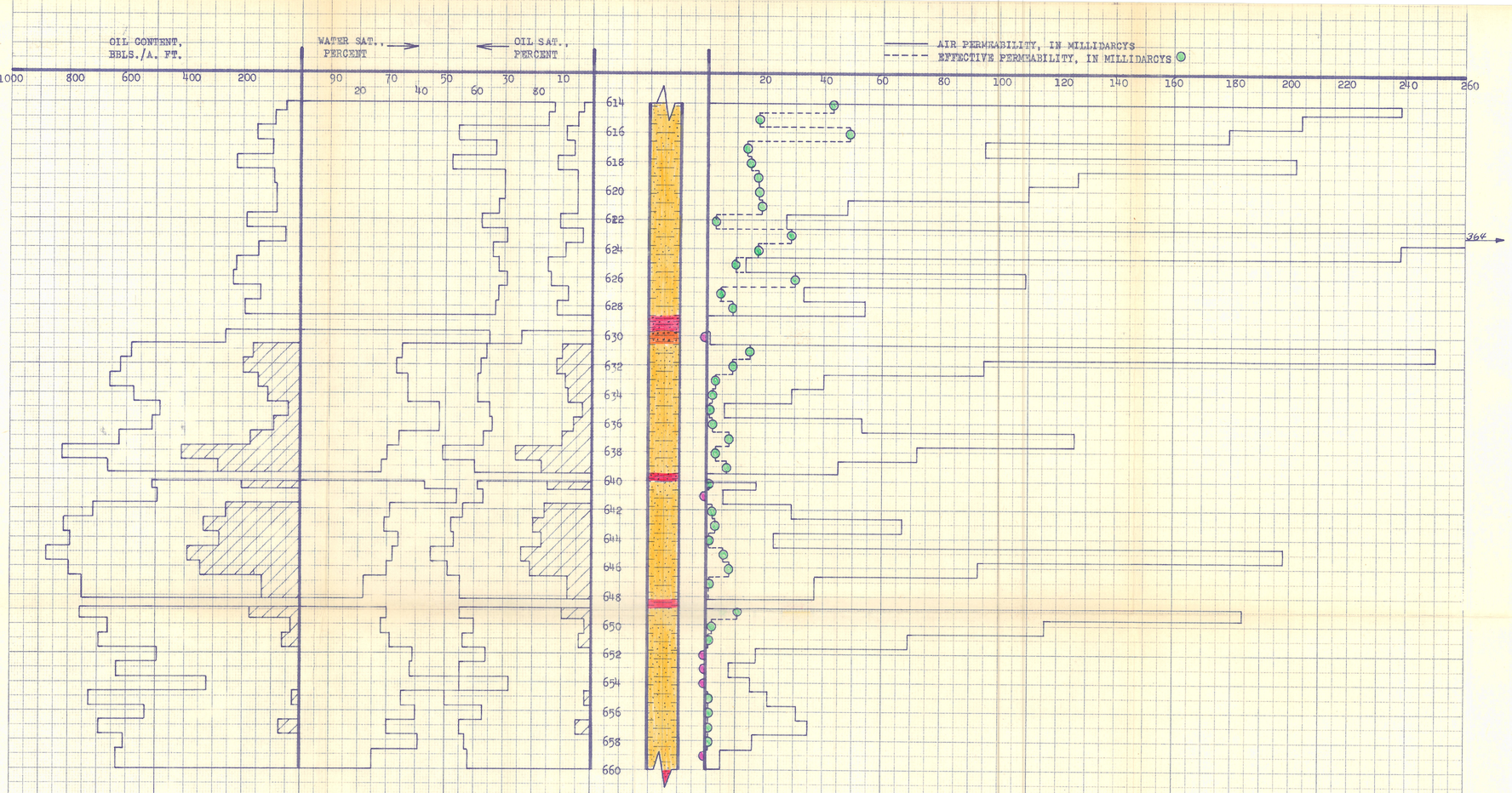
SUMMARY OF LABORATORY FLOODING TESTS

TABLE V

Company CRA, Inc. Lease Woodward Well No. 23

Depth Interval, Feet	630.6 - 651.6	651.6 - 660.0	630.6 - 660.0
Feet of Core Analyzed	18.8	2.0	20.8
Average Percent Porosity	20.7	19.0	20.6
Average Percent Original Oil Saturation	42.5	47.5	43.0
Average Percent Oil Recovery	12.3	3.5	11.5
Average Percent Residual Oil Saturation	30.2	44.0	31.5
Average Percent Residual Water Saturation	64.9	55.0	63.9
Average Percent Total Residual Fluid Saturation	95.1	99.0	95.4
Average Original Oil Content, Bbls./A. Ft.	685.	699.	687.
Average Oil Recovery, Bbls./A. Ft.	200.	53.	186.
Average Residual Oil Content, Bbls./A. Ft.	485.	646.	501.
Total Original Oil Content, Bbls./Acre	12,881.	1,396.	14,277.
Total Oil Recovery, Bbls./Acre	3,758.	105.	3,863.
Total Residual Oil Content, Bbls./Acre	9,123.	1,291.	10,414.
Average Effective Permeability, Millidarcys	4.01	0.400	3.66
Average Initial Fluid Production Pressure, p.s.i.	22.9	40.0	24.5

NOTE: Only those samples which recovered oil were used in calculating the above averages.



CRA, INC.

WOODWARD LEASE WELL NO. 23
BOURBON COUNTY, KANSAS

DEPTH INTERVAL, FEET	FEET OF CORE ANALYZED	AVERAGE POROSITY, PERCENT	AVG. OIL SATURATION PERCENT	AVG. WATER SATURATION PERCENT	AVG. OIL CONTENT BBLS./A.FT.	TOTAL OIL CONTENT BBLS./ACRE	AVG. AIR PERMEABILITY, MILLIDARCYS	CALCULATED OIL RECOVERY, BBLS./ACRE
614.0 - 630.6	15.5	21.5	9.2	67.6	147	2,281	125.7	
630.6 - 651.6	19.8	20.6	42.2	34.2	678	13,403	77.1	
651.6 - 660.0	8.4	18.3	40.9	37.2	585	4,909	17.8	
614.0 - 660.0	43.7	20.6	30.3	46.6	471	20,593	83.0	7,050(Primary & Secondary)

OILFIELD RESEARCH LABORATORIES
CHANUTE, KANSAS
MARCH, 1966