OILFIELD RESEARCH LABORATORIES

536 NORTH HIGHLAND - CHANUTE, KANSAS - PHONE HE1-2650

Chanute, Kansas

November 29, 1965

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. 9, Bourbon County, Kansas, and submitted to our laboratory on November 20, 1965.

Your business is greatly appreciated.

Very truly yours,

OILFIELD RESEARCH LABORATORIES

Carl L. Pate

CLP:rf

4 c. - Wellington, Kansas
2 c. - Muskogee, Oklahoma
1 c. - Roy Wood

Oilfield Research Laboratories

GENERAL INFORMATION & SUMMARY

Company CRA, Inc. Lease Woodward Well No. 9

Location 1000' SNL & 990' WEL, NW¼

Section 13 Twp. 25S Rge. 21E County Bourbon State Kansas

Name of Sand	Bartlesville
Top of Core	638.0
Bottom of Core	682.0
Top of Pay Sand	660.5
Bottom of Pay Sand	673.0
Total Feet of Permeable Sand	30.5
Total Feet of Floodable Pay Sand	10.5

Distribution of Permeable Sand:

Permeability Range Millidarcys	Feet	Cum. Ft.
0 - 5	10.5	10.5
5 - 25	5.1	15.6
25 - 50	4.9	20.5
50 - 100	3.0	23.5
100 - 150	4.5	28.0
150 & above	2.5	30.5

Average Permeability Millidarcys	49.9
Average Percent Porosity	19.3
Average Percent Oil Saturation	31.5
Average Percent Water Saturation	37.7
Average Oil Content, Bbls./A. Ft.	483.
Total Oil Content, Bbls./Acre	16,770.
Average Percent Oil Recovery by Laboratory Flooding Tests	16.0
Average Oil Recovery by Laboratory Flooding Tests, Bbls./A. Ft.	261.
Total Oil Recovery by Laboratory Flooding Tests, Bbls./Acre	2,480.
Total Calculated Oil Recovery, Bbls./Acre (Primary & Secondary)	4,065.
Packer Setting, Feet	
Viscosity, Centipoises @	
A. P. I. Gravity, degrees @ 60 °F	
Elevation, Feet	

A water base mud was used as a circulating fluid in the coring of the sand in this well. This well was drilled in a virgin area. The core was sampled by an employee of Oilfield Research Laboratories.

FORMATION CORED

The detailed log of the formation cored is as follows:

Depth Interval, Feet	Description
638.0 - 641.7	Sandy shale.
641.7 - 660.0	Grayish light brown, shaly sandstone.
660.0 - 673.0	Brown, slightly laminated, slightly shaly sandstone.
673.0 - 678.4	Dark, carbonaceous, slightly shaly sandstone.
678.4 - 682.0	Laminated sandy shale.

Coring was started at a depth of 638.0 feet in grayish light brown, shaly sandstone and completed at 682.0 feet in laminated sandy shale. This core shows a total of 36.7 feet of sandstone. For the most part, the pay is made up of brown, slightly laminated, 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 30.4, 104.6 and 5.5 millidarcys respectively; the overall average being 49.9 (See Table III). By observing the data given on the coregraph, it is noticeable that the sand has a very irregular permeability profile. The permeability of the sand varies from 0.24 to a maximum of 407. millidarcys.

PERCENT SATURATION & OIL CONTENT

The sand in this core shows a fair weighted average percent oil

saturation, namely, 31.5. The weighted average percent oil saturation of the upper, middle and lower sections is 21.5, 39.3 and 43.2 respectively. The weighted average percent water saturation of the upper, middle and lower sections is 49.0, 27.2 and 25.1 respectively; the overall average being 37.7 (See Table III). This gives an overall weighted average total fluid saturation of 69.2 percent. This low total fluid saturation indicates considerable fluid was lost during coring which was probably oil.

The weighted average oil content of the upper, middle and lower sections is 300, 624 and 700 barrels per acre foot respectively; the overall average being 483. The total oil content, as shown by this core, is 16,770 barrels per acre of which 8,110 barrels are in the pay sand section (See Table III).

LABORATORY FLOODING TESTS

Part of the sand in this core responded very well to laboratory flooding tests, as a total recovery of 2,480 barrels of oil per acre was obtained from 9.5 feet of sand. The weighted average percent oil saturation was reduced from 43.4 to 27.4, or represents an average recovery of 16.0 percent. The weighted average effective permeability of the samples is 2.29 millidarcys, while the average initial fluid production pressure is 27.0 pounds per square inch (See Table V).

By observing the data given in Table IV, you will note that of the 34 samples tested, 22 produced water and 10 oil. This indicates that approximately 29 percent of the sand represented by these samples is floodable pay sand. The tests also indicate that the pay sand section extends from a depth of 660.3 to 673.0 feet.

CONCLUSION

From a study of the above data, we estimate that approximately 4,065 barrels of oil per acre or an average of 387 barrels per acre foot can be recovered from the area, represented by this core, by efficient primary and water-flood operations. The following data and assumptions were used in calculating the above oil recovery value:

Original formation volume factor	1.05
Irreducible water saturation, percent	18.0
Past primary recovery, percent	None
Present oil saturation, percent	79.6
Average porosity, percent	19.5
Oil saturation after flooding, percent	27.4
Performance factor	0.50
Net floodable pay sand, feet	10.5

This core shows a rather clean pay sand section (660.5 - 673.0 feet) having a good oil saturation, a comparatively low water saturation and a rather wide variation in permeability. Apparently, the zone extending from 641.7 to 673.0 feet is, more or less, gas sand; while that extending from a depth of 673.0 to 678.4 is not floodable. There is a low permeability layer separating the oil and gas sand sections.

Oilfield Research Laboratories

RESULTS OF SATURATION & PERMEABILITY TESTS

TABLE 1-B

Company CRA, Inc. Lease Woodward Well No. 9

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	642.2	17.9	19	45	64	264	1.6	1.0	1.0	264	1.60
2	643.2	18.5	18	38	56	258	11.	1.1	2.1	284	1.21
3	644.4	17.9	14	46	60	195	2.1	1.2	3.3	234	2.52
4	645.6	14.5	28	64	92	316	2.5	0.9	4.2	285	2.25
5	646.2	18.3	11	52	63	157	39.	1.1	5.3	173	42.90
6	648.2	18.8	11	50	61	161	71.	1.0	6.3	161	71.00
7	649.8	15.5	26	52	78	313	1.2	1.0	7.3	313	1.20
8	651.5	17.4	15	69	84	203	135.	1.0	8.3	203	135.00
9	652.5	22.9	17	39	56	302	25.	1.0	9.3	302	25.00
10	653.5	20.4	18	42	60	285	31.	1.0	10.3	285	31.00
F-11	654.4	16.8	19	-	-	248	-	0.5	10.8	124	-
11	654.6	17.9	19	45	64	264	109.	0.5	11.3	132	54.50
12	655.5	21.1	22	39	61	361	65.	1.0	12.3	361	65.00
13	656.4	20.2	30	36	66	471	36.	0.5	12.8	235	18.00
F-13	656.6	18.0	27	-	-	377	-	0.5	13.3	188	-
14	657.5	18.5	30	40	70	431	12.	1.0	14.3	431	12.00
15	658.5	15.7	31	56	87	378	0.71	1.0	15.3	378	0.71
16	659.5	16.7	27	48	75	350	0.62	1.0	16.3	350	0.62
17	660.4	18.3	25	34	59	355	1.5	0.5	16.8	177	0.75
F-17	660.6	18.6	34	-	-	490	-	1.2	18.0	588	-
18	662.5	18.3	33	42	75	469	28.	1.3	19.3	610	36.40
19	663.5	20.7	39	29	68	626	20.	1.0	20.3	626	20.00
20	664.5	19.8	44	29	73	676	102.	1.0	21.3	676	102.00
F-21	665.4	19.2	42	-	-	625	-	0.5	21.8	312	-

Oilfield Research Laboratories

RESULTS OF SATURATION & PERMEABILITY TESTS

TABLE 1-B

Company CRA, Inc. Lease Woodward Well No. 9

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.		
21	665.6	18.7	29	39	68	421	55.	0.5	22.3	210	27.50
F-22	666.4	18.7	30	-	-	435	-	0.5	22.8	218	-
22	666.6	20.9	24	41	65	390	71.	0.5	23.3	195	35.50
23	667.5	23.7	51	21	72	940	115.	1.0	24.3	940	115.00
24	668.5	19.0	55	29	84	812	170.	1.0	25.3	812	170.00
F-25	669.4	20.1	41	-	-	639	-	0.5	25.8	319	-
25	669.6	19.8	33	31	64	508	7.6	0.5	26.3	254	3.80
F-26	670.4	19.3	41	-	-	614	-	0.5	26.8	307	-
26	670.6	22.1	39	15	54	669	407.	0.5	27.3	334	203.50
27	671.5	21.2	49	23	72	809	210.	1.0	28.3	809	210.00
28	672.5	23.6	49	18	67	900	101.	1.0	29.3	900	101.00
29	673.5	19.4	35	30	65	529	11.	1.0	30.3	529	11.00
30	674.5	20.3	44	26	70	695	13.	1.0	31.3	695	13.00
31	675.5	21.1	49	20	69	804	2.7	1.0	32.3	804	2.70
32	686.5	21.9	48	20	68	816	1.6	1.0	33.3	816	1.60
33	677.5	22.1	46	20	66	789	1.9	0.8	34.1	631	1.52
34	678.2	19.2	34	39	73	508	0.24	0.6	34.7	305	0.14
								Total--------		16,770	

Oilfield Research Laboratories

SUMMARY OF PERMEABILITY & SATURATION TESTS

TABLE III

Company CRA, Inc. Lease Woodward Well No. 9

Depth Interval, Feet	Feet of Core Analyzed	Average Permeability, Millidarcys	Permeability Capacity Ft. x Md.
641.7 - 660.5	15.3	30.4	465.26
661.7 - 673.0	9.8	104.6	1,025.45
673.0 - 678.4	5.4	5.5	29.96
641.7 - 678.4	30.5	49.9	1,520.67

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
641.7 - 660.5	16.3	18.7	21.5	49.0	300	4,880
660.5 - 673.0	13.0	19.5	39.3	27.2	624	8,110
673.0 - 678.4	5.4	20.7	43.2	25.1	700	3,780
641.7 - 678.4	34.7	19.3	31.5	37.7	483	16,770

Oilfield Research Laboratories

RESULTS OF LABORATORY FLOODING TESTS

TABLE IV

Company CRA, Inc. Lease Woodward Well No. 9

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	642.2	17.4	15	202	0	0	15	65	202	0	Imp.	-
2	643.2	18.1	16	225	0	0	16	63	225	30	0.800	35
3	644.4	18.2	12	169	0	0	12	80	169	34	0.777	30
4	645.6	14.1	24	262	0	0	24	72	262	0	Imp.	-
5	646.2	18.8	12	175	0	0	12	80	175	236	8.40	20
6	648.2	19.0	8	118	0	0	8	69	118	41	0.800	30
7	649.8	15.1	23	269	0	0	23	61	269	0	Imp.	-
8	651.5	17.8	16	221	0	0	16	75	221	194	3.70	20
9	652.5	22.6	15	263	0	0	15	74	263	241	16.24	20
10	653.5	20.9	15	243	0	0	15	77	243	233	17.49	20
11	654.4	16.8	19	248	0	0	19	61	248	8	0.200	45
12	655.5	20.9	19	308	0	0	19	73	308	239	12.65	20
13	656.6	18.0	27	377	0	0	27	64	377	7	0.300	40
14	657.5	18.6	26	375	0	0	26	67	375	58	1.70	25
15	658.5	15.3	28	332	0	0	28	64	332	0	Imp.	-
16	659.5	16.2	25	314	0	0	25	55	314	0	Imp.	-
17	660.6	18.6	34	490	8	115	26	64	375	13	0.500	30
18	662.5	17.8	33	456	1	14	32	54	442	3	0.200	50
19	663.5	21.1	39	638	14	229	25	59	409	58	1.40	20
20	664.5	20.2	44	689	18	282	26	67	407	75	2.30	20
21	665.4	19.2	42	625	15	223	27	67	402	29	0.800	20
22	666.4	18.7	30	435	0	0	30	54	435	0	Imp.	-
23	667.5	23.2	51	918	26	468	25	60	450	40	1.70	25
24	668.5	19.4	55	827	28	421	27	66	406	232	10.70	20

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. 9

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	669.4	20.1	41	639	14	218	27	70	421	47	1.40	20
26	670.4	19.3	41	614	0	0	41	47	614	0	Imp.	-
27	671.5	20.8	49	790	18	290	31	60	500	48	1.50	30
28	672.5	23.2	49	882	23	414	26	61	468	70	2.20	20
29	673.5	19.1	33	489	0	0	33	36	489	0	Imp.	-
30	674.5	19.9	41	633	0	0	41	37	633	4	0.200	50
31	675.5	20.9	45	730	0	0	45	28	730	0	Imp.	-
32	676.5	21.6	44	738	0	0	44	27	738	0	Imp.	-
33	677.5	21.7	43	724	0	0	43	29	724	0	Imp.	-
34	678.2	19.6	32	486	0	0	32	45	486	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

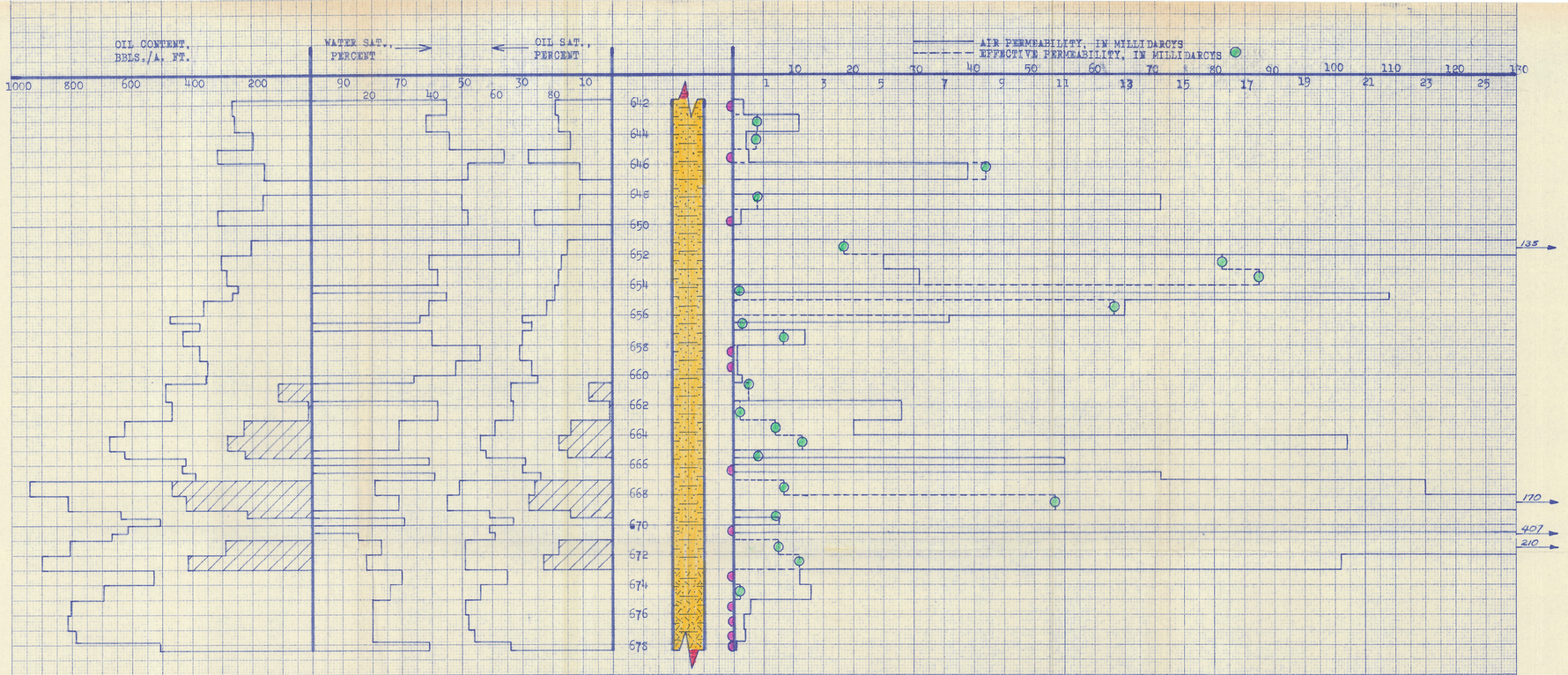
SUMMARY OF LABORATORY FLOODING TESTS

TABLE V

Company CRA, Inc. Lease Woodward Well No. 9

Depth Interval, Feet	660.5 - 673.0
Feet of Core Analyzed	9.5
Average Percent Porosity	20.2
Average Percent Original Oil Saturation	43.4
Average Percent Oil Recovery	16.0
Average Percent Residual Oil Saturation	27.4
Average Percent Residual Water Saturation	62.0
Average Percent Total Residual Fluid Saturation	89.4
Average Original Oil Content, Bbls./A. Ft.	690.
Average Oil Recovery, Bbls./A. Ft.	261.
Average Residual Oil Content, Bbls./A. Ft.	429.
Total Original Oil Content, Bbls./Acre	6,556.
Total Oil Recovery, Bbls./Acre	2,480.
Total Residual Oil Content, Bbls./Acre	4,076.
Average Effective Permeability, Millidarcys	2.29
Average Initial Fluid Production Pressure, p.s.i.	27.0

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



CRA, INC.

WOODWARD LEASE WELL NO. 9
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
641.7 - 660.5	16.3	18.7	21.5	49.0	300	4,880	30.4	
660.5 - 673.0	13.0	19.5	39.3	27.2	624	8,110	104.6	
673.0 - 678.4	5.4	20.7	43.2	25.1	700	3,780	5.5	
641.7 - 678.4	34.7	19.3	31.5	37.7	483	16,770	49.9	4,065 (Primary & Secondary)

OILFIELD RESEARCH LABORATORIES
CHANUTE, KANSAS
NOVEMBER, 1965