EBOR UNIT PARTICIPATION

The formula for calculating tract equity is:

$$\text{Tract Factor} = .5 \times \frac{\text{Accumulated individual well production}}{\text{Total field accumulated production}}$$

$$\text{Plus:} \quad .5 \times \frac{\text{Current individual well prod. Sept. 1/62 - Aug. 31/63}}{\text{Total current production Sept. 1/62 - Aug. 31/63}}$$

NOTE: Production figures as outlined on the attached schedule will be applied in calculating equity.

E B O R U N I T

OPERATIONAL REPORT NO. 1

COVERING JULY 1 to NOVEMBER 30, 1964

AND

ANNUAL REVIEW OF UNIT OPERATIONS

COVERING JULY 1, 1964 to NOVEMBER 30, 1964

December 1964

SUN OIL COMPANY

CALGARY, ALBERTA

EBOR UNIT OPERATION REPORT

JULY 1 - November 30, 1964

The following is a summary of the Ebor Unit Operations for the period July 1 to November 30, 1964.

The Ebor Unit became effective July 1, 1964. It consists of nine wells. There are four producing wells: 12-26, 6-26, 2-26, & 14-23; four injection wells 5-26, 11-26, 3-26, & 7-26, and one source well 4-26.

SUMMARY OF WORK DONE IN THE UNIT

Ditching and Laying of Flowlines and Injection Lines

One quarter mile of 3" line pipe was recovered for consolidation purposes from the abandoned well 13-23 to the producing well 14-23. This line was found in excellent condition. This pipe, together with 3" line pipe from Sun Stock, was strung from the 14-23 well to 2-26 and from 6-26 to 7-26. The 2 3/8" tubing recovered from the injection wells 3-26 and 5-26 was used as an injection line from the plant site to the 7-26 injection well.

The original flowlines, 3" LP to 3-26 and 12-26 and the 2" LP to 11-26, were tied into the injection plant for injection purposes after they were pressure tested.

All ditching, welding, back filling, and levelling has been completed.

Plant Construction

The plant site was chosen some 200' south and east of the treater at 5-26.

An oilwell, 50HP, B323 triplex injection pump powered by a Witte 19 HP gas engine running on propane was set on a common concrete base. The pump has 1 3/4" plungers and is capable of some 800 barrels per day at 250 r.p.m.'s and 1600 p.s.i.

Water coming from the source well is gathered in a 210 barrel accumulator tank. The water is gravity fed to the injection pump from the accumulator tank. The tank is equipped with a float-operated inlet dump valve which will close on high tank level. This will pressurize the flowline to the source well where a Grove Flex-flo back pressure valve will relieve the pressure down the source well annulus. The accumulator tank is also equipped with a low level pressure type switch to shut down the injection pump on low tank level.

The injection header piping is one inch in diameter. One inch Neptune meters are used to meter the injection water to each injector, and one inch trottling valves will be used for flow control.

The accumulator tank inlet and outlet piping and header equipment are housed in an insulated building.

All plant construction including painting has been completed.

Source Well 4-26

Producing well 4-26 was converted to a source well by setting a bridge plug above the producing perforations and perforating the Jurassic sand 2400' to 2420'. A string of 5 1/2" casing with a Porous Products sand screen and a pump seating nipple was set at 527.86'. An Oilmaster three-tube 3 3/4" x 18' BHP and 1" rods were run. Consideration producing problems were encountered trying to produce water from these perforations. Fine sand kept sanding off the BHP resulting in numerous pump jobs and hole clean outs. On October 15, 1964, the interval 1956 - 76'was perforated. The pump and casing was set at 716' and has pumped satisfactorily since.

Unit Production	Oil	Water	Gas
July 1964	587	90	59
August	635	94	110
September	568	53	--
October	544	64	53
November	521	84	52

Pilot Flood Performance

In October, 1962, the well, Sun MacDougall 11-26-9-29 W1, was converted to an injection well in order to test the feasability of injecting water into the Lodgepole formation of the Ebor Field. To date, there has been no positive indication of flood response in offsetting producing wells. However, the pilot flood has indicated that water can be injected into the formation at rates which would be required for a successful full-scale waterflood.

The lack of flood response to date is attributed to the fact that insufficient water has been injected (56,664 bbls.) to sufficiently replace reservoir voidage in the pilot area. The total voidage created by cumulative production from the injection well 11-26, and its offsetting wells (5-26, 6-26, 7-26, and 12-26), is 125,000 reservoir barrels. If the offsetting wells are considered as delineating the edge of a flood pattern centered on 11-26, then the voidage created within the pattern area would be 80,000 reservoir barrels. There has been considerable pilot flood downtime. Also, this is not an "enclosed" pilot scheme. Thus, it is probable that oil rate response (or water breakthrough) might not be noted in any adjacent producing wells until at least another 20,000 bbls. of water would be injected.

The pilot has indicated that injection well rates of about 100 BW/D at pressures less than 1,500 psig may be attained for the enlarged project. The lack of premature response or water breakthrough is encouraging.

Expanded Flood Performance

A brief outline of the early performance of injection wells in the expanded waterflood project is outlined below:

Date	Hours	Well 3-26 BW/D	Well 5-26 BW/D	Well 7-26 BW/D	Well 11-26 BW/D	Total [illegible]	Pressure psig
Oct. 23/64	19	61	21	356	52	490	350
Oct. 24/64	9	91	4	115	18	228	300
Oct. 25/64	8	68	3	92	21	184	300
Oct. 26/64	13	74	5	188	46	313	340
Nov. 4/64	18	114	5	172	12	303	425
Nov. 9/64	12	64	6	107	17	194	450
Nov. 10/64	18	54	4	67	0	125	450
Nov. 11/64	16	76	0	126	14	216	450
Nov. 12/64	11	155	8	74	6	243	450
Nov. 13/64	9	61	5	132	23	221	450

Generally, minor maintenance problems were experienced at the source well. Early in 1965 the bridle and the engine clutch required repairs. In April and May 1965, downhole pump trouble was experienced. Rods were pulled and it was necessary to pull the 5½" casing to retreive the pump which was recovered with about 1 foot of sand around it. The equipment was rerun. In September 1965 it was again necessary to pull the pump and hay was removed from around it.

In November 1965, operation of the injection system was discontinued for reasons discussed elsewhere in this report, and early in 1966, the source well equipment was removed.

B. Injection System

Operation Report No. 1 detailed the mechanical installation of the system. During the first half of 1964 immediately prior to unitization the pilot well 11-26 (which was converted in October, 1962) was capable of sustaining injection rates of about 120 BWPD at a wellhead pressure of about 1380 psig. During mid-1965 injection rates of 50 to 100 BWPD at pressures of about 200 psi were noted in this well and in September 1965, it became evident that a downhole leak existed. It is uncertain whether this was a leak which suddenly occurred or an existing leak which suddenly became worse. As a result, there is some doubt about the actual amount of the reported water which actually entered the reservoir in well 11-26.

During the first quarter of 1965, the injection lines to 5-26 and 12-26 were frozen off. Injection was recommenced into these wells in May 1965. Also in October 1966, the injection line to well 3-26 experienced a flow line leak (at a collar) which was repaired.

C. Production System

The Unit was produced during the winter of 1965 - 1966. Some reduction in producing rates occurred due to extremely cold weather conditions which resulted in problems such as frozen gas lines, etc.

In November 1965 the producing well 12-26 was shut-in due to pump problems and repaired the following spring. Production was suspended from the end of Dec. 1965 to April 1966.

In June 1966, bottomhole pressure surveys were run in the suspended injectors 5-26 and 7-26, which indicated reservoir pressures of 692 and 1017 psig, respectively.

In September 1966, the battery drainline to the pit was replaced due to corrosion and the treater water leg salted up and had to be cleaned. Also one tank developed several small holes due to corrosion and these were patched. No other significant problems were noted.

III. FLOOD PERFORMANCE

Pilot flood performance was summarized in Operations Report No. 1. It should be noted that the volume of water injected to the reservoir in 11-26 may be lower than quoted due to the suspected casing leak. Also, completion and production history, and the relatively high bottomhole pressure in 7-26 indicates that there is a possibility of communication to the underlying Bakken zone in this well.

Within the limits of accurate testing etc. there has been no indicated oil rate response in this Unit. However, in 1966, production from 4 producing wells was equal to production from 7 to 8 wells in mid-1964. Also, water/oil ratios reported in 1964 in wells such as 3-26 and 6-26 showed increased, but in terms of volume, were insignificant. In terms of total produced water reported, (see field performance graph) the amount of produced water has declined from 150 to 200 BWPM in mid-1963, to 50 BWPM in mid-1965 to nil in 1966.

Varied injective capacities were indicated in the injection wells. In the early life of the expanded flood when the manifold pressure was in the range of 400 to 650 psig, well 3-26 yielded rates of 50 to 75 BWPD. Similarly, 5-26 indicated rates of only 10 BWPD or less. Well 7-26 accepted water at rates upto 140 BWPD and 11-26 handled 70 to 110 BWPD.

In general, in 1965, voidage was being created by production at a rate of about 20 res. bbls/day while water was being injected at upto 200 BWPD.

Pattern voidage replacement was varied and is complicated by the fact that the patterns are not enclosed. The attached map indicates the status of the Unit as of October 31, 1966.

In pattern 11-26, cumulative production has created 53,020 bbls. voidage. This has been replaced by a maximum of 69,917 bbls water which represents over-injection of 16,897 bbls.

In pattern 5-26, 35,717 res. bbls of voidage created by cumulative production has been partially replaced by 1,441 bbls. water.

In pattern 3-26, cumulative production has created 124,533 res. bbls. of voidage which has been partially replaced by 13,208 bbls. water.

In pattern 7-26, 53,916 res. bbls of voidage has been partially replaced by upto 39,500 bbls. water.

On a pool wide basis, cumulative production has been equivalent to about 270,000 res. bbls of voidage. Cumulative water injected into the reservoir is reported to be 124,014 bbls.

CONCLUSIONS AND OBSERVATIONS

1. No significant oil rate response has been noted to date.
2. Continuation of the flood program would involve considerable expense for the following items:

(a) Increasing the source well capacity by lowering the downhole pump and increasing the size of the pump unit.
(b) Checking and repairing casing leak in 11-26.
(c) Cement squeezing and recompleting 7-26.
(d) Consideration of WO's in wells such as 5-26 and 11-26 to perforate and complete additional reservoir sections.

3. Continued operation also involves the risk of further costs resulting from corrosion in surface facilities, flowlines, casing, etc. and the general maintenance of relatively old equipment on the Unit, such as prime movers, bottomhole pumps, etc.

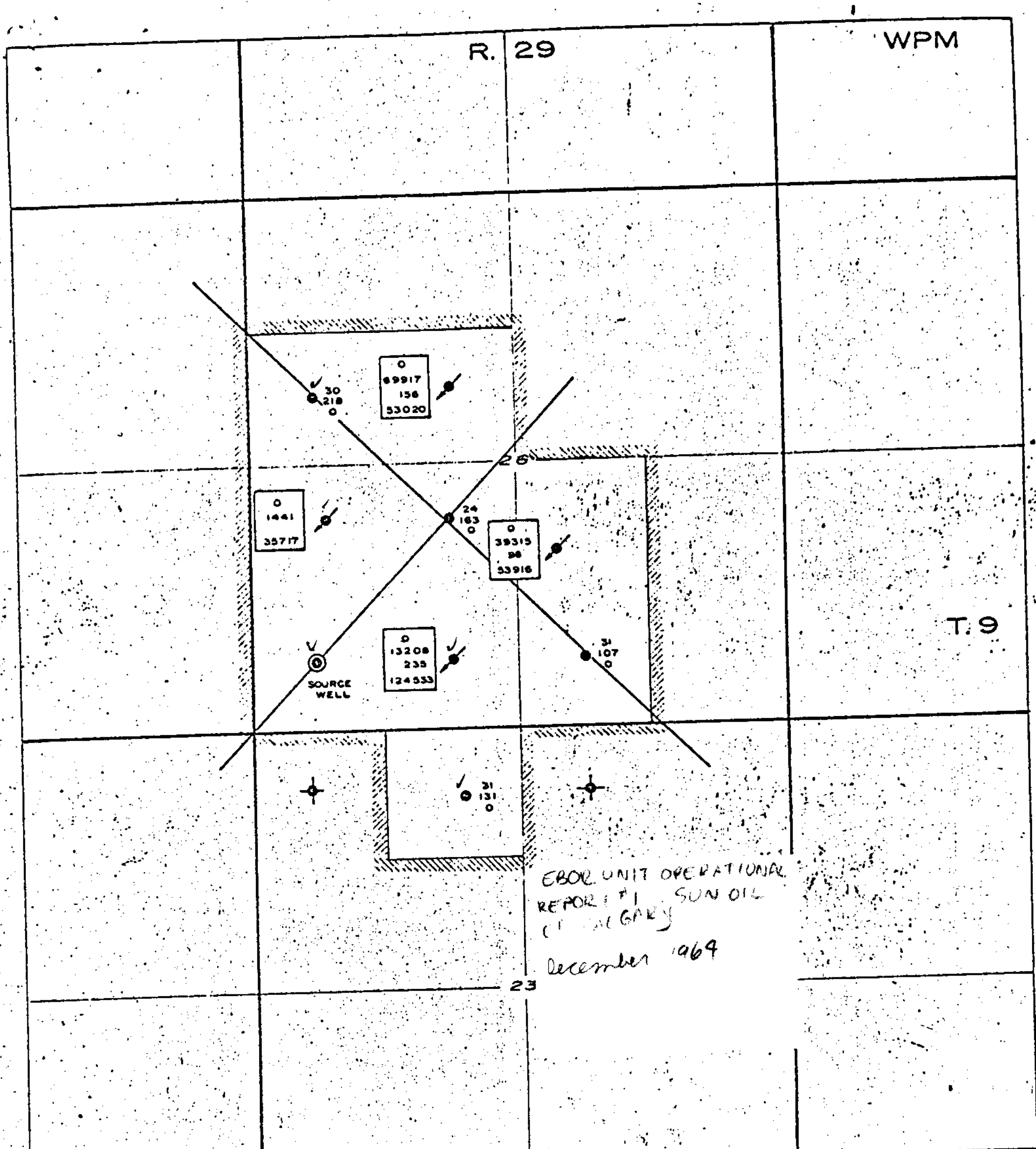
TABLE I

EBOR UNIT PRODUCTION, INJECTION & VOIDAGE HISTORY

MONTH	OIL BBLS.	WATER BBLS.	W.O.R. (BBLS/BBL)	RESERVOIR WITHDRAWALS (RES. BBLS/MO.)	CUMULATIVE WITHDRAWALS (RES. BBLS.)	WATER INJECTED (BBLS.)	CUM. WATER INJECTED (BBLS.)	MANIFOLD PRESS. (PSIG)
July/64	587	90	.15 Form't effective	741	253,161	-	55,323	-
Aug.	635	94	.15	845	254,006	-	55,323	-
Sept.	568	53	.09	718	254,724	307	55,630	-
Oct.	544	64	.12 Start WF	635	255,359	2,470	58,100	-
Nov.	521	86	.17	632	255,991	6,053	64,153	425
Dec.	330	76	.23	423	256,414	5,657	69,810	650
Jan/65	387	53	.14	457	256,871	6,021	75,831	400
Feb.	297	43	.14	355	257,226	5,502	81,333	380
Mar.	340	43	.13	390	257,616	5,558	86,891	380
Apr.	507	44	.09	571	258,187	3,427	90,318	380
May	540	59	.11	626	258,813	4,203	94,521	230
June	499	41	.08	565	259,378	6,079	100,600	230
July	504	57	.11	586	259,974	6,293	106,893	150
Aug.	497 2398	52	.10	574	260,548	6,325	113,218	120
Sept.	447 Ave: 478	36	.08	505	261,053	4,153	117,371	120
Oct.	447 BOPM	36	.08	505	261,558	6,132	123,503	300
Nov.	268	13	.05	294	261,852	511	124,014	300
Dec.	350	17	.05	369	262,221	-	124,014	-
Jan/66	-	-	-	-	262,221	-	124,014	-
Feb.	-	-	-	-	262,221	-	124,014	-
Mar.	-	-	-	-	262,221	-	124,014	-
Apr.	40	-	-	42	262,263	-	124,014	-
May	802	-	-	862	263,125	-	124,014	-
June	516	-	-	552	263,677	-	124,014	-
July	557	-	-	596	264,273	-	124,014	-
Aug.	591 2830	-	-	631	264,904	-	124,014	-
Sept.	547 Ave 566	-	-	570	265,474	-	124,014	-
Oct.	619 BOPM	-	-	647	266,121	-	124,014	-

Cumulative oil produced from Unit area to Nov. 30/66; 195,654 bbls.
Cumulative water injected from Unit area to Nov. 30/66 124,014 bbls.

NOTE: The above cumulative water injection figures include 56,000 bbls water injected into 11-26 prior to July 1/64.
The above cumulative withdrawal figures includes approximately 252,000 res. bbls voidage created by production prior to July 1/64.



SUN OIL CO.

4" = 1 MILE

EBOR UNIT

PROVINCE OF MANITOBA

PRODUCTION, VOIDAGE & INJECTION DATA

OCTOBER/1966

0	MONTHLY INJECTION - bbls.
69917	CUMULATIVE WATER INJECTED - bbls.
156	PATTERN VOIDAGE - RES. bbls./Mo.
53020	CUMULATIVE VOIDAGE BY PRODUCTION - bbls.

- 30 – DAYS PRODUCED
- 218 – Bbls. OIL
- 0 – Bbls. WATER

- ● OIL WELL
- ABANDOND WELL
- INJECTION WELL
- ◎ WATER SOURCE WELL

EBOR UNIT OPERATIONS REPORT NO. 4

APRIL 1/66 TO DEC 1/66

I. SUMMARY

The Ebor Unit became effective July 1/64 and consists of 9 40 acre spaced wells. The current status is 1 suspended water source well which was converted from the producing well 4-26-9-29; 4 suspended injection wells, 3-26, 5-26, 7-26 and 11-26-9-29; and the 4 producing wells 14-23, 2-26, 6-26 and 12-26-9-29. The well 11-26 was converted to a pilot injection well in October 1962, and pattern water flooding was initiated in September 1964.

The injection system has been shut-in since December 1965, after 124,014 bbls water had been injected, this total includes 56,000 bbls water injected into the pilot injector 11-26 prior to unitization. Injection system shut-in resulted from inadequate source water supply, flow line leaks and freezing, appearance of a casing leak in 11-26, and lack of flood response.

Production operations were also suspended for the winter months (Jan, Feb, Mar and April 1966) but were resumed in April 30, 1966.

The following Table I and discussion, and the attached performance graphs and pattern map will summarize Unit operations to date.

II. OPERATING HIGHLIGHTS

A. Water Source System

Water injection into the expanded waterflood was begun in September/64 and from the end of October/64 to the end of November/65 a total of 65,914 bbls. water were injected at rates upto 210 BWPD and manifold pressures ranging from 120 to 650 psig. (See Table I and Ebor Unit "Total Injection History" graph. The average Unit injection rate during this time was 166 BWPD at an average manifold pressure of approximately 350 psig. The limiting factor in injection rates was the availability of source water.

The former producing well 4-26 was converted for use as a water source well for the original pilot project. This well was chosen as it was cased with 7" casing and had exhibited relatively poor producing characteristics. The well was originally recompleted in a Jurassic Sand (2400 - 20) however, sand problems resulted in the abandonment of this zone and recompletion in a shallower sand (1956 - 76 KB). The well was recompleted using 5½" casing with Porous Products sand screen, oilmaster 3 tube, 3 3/4" x 18 bottomhole pump landed at approximately 700' KB, 1" rods, and API 40 pump jack.

Source well capacity was limited to about 200 BWPD and increased rates would have required lowering the pump in the well. This in turn would require the expense of a larger size pump jack. In addition there would have been some risk of sand problems in the well from the higher drawdown pressures that would have resulted with increased rates.

E B O R F I E L D S T U D Y

EBOR FIELD

MANITOBA

Engineering Department
Sun Oil Company
March 1964

INDEX

I SUMMARY

Ebor Field consists of a small pool in the Lodgepole formation containing 11 wells drilled on 40 acre spacing. Currently, two wells have been abandoned, one is suspended and one has been converted to a pilot injection well. Another has been converted to a Jurassic sand water source well with the Lodgepole zone suspended.

Development of the pool commenced in 1955. It is currently virtually depleted by primary means and to January 1, 1964 had produced 189,295 bbls. of 34.0° API oil and 41,697 bbls. of water at GOR's of about 100 scf/bbl.

In 1962, it was noted that abandonment of the field was imminent. In view of its low recovery factor, it was decided that the feasibility of waterflooding should be investigated. In October, 1962, injection commenced in 11-26-9-29 W1 using water from the Jurassic sand found in 4-26-9-29 W1. To date approximately 50,000 bbls. of water have been injected and flood response appears just about to occur.

Production is obtained from several thin porous bands in limestone to dolomitic limestone over about a 100 foot interval of the Lodgepole formation. The bands of pay are interspersed with dense bands of anhydrite and anhydritic limestone, and dolomite. In net pay, porosity averages about 12.1%, permeability about 8.6 md. and pay thickness about 13.8 feet. It has not been possible to correlate discrete porosity bands from well to well with any degree of assurance.

If all the net pay in the reservoir is considered, the original oil in place is about 2.95 million barrels. Thus a primary recovery factor of about 6½% OOIP is indicated. This is not unreasonable as the primary recovery mechanism is weak expansion drive with a very weak solution gas drive, and all bands of potential pay with a very weak solution gas drive, and all bands of potential pay may not be currently effective. The original reservoir pressure was 970 psi and is currently estimated to be about 300 psi. The bubble point is about 400 psi and the gas in solution is about 100 scf/bbl.

The pilot flood has indicated that there is sufficient injectivity capacity in the reservoir and an adequate supply of source water to maintain an expanded flood. Flood expansion should involve the conversion of the wells 3-26, 5-26, and 7-26 from producing to water injection wells. Unitization should precede this step.

II CONCLUSIONS

1. There were approximately 2.95 million barrels of oil originally in place (OOIP) in Ebor Field.

2. Primary recovery by weak expansion drive and very weak solution gas drive will be about 6½% OOIP or about 195,000 barrels.

3. The reservoir has been virtually depleted by primary means.

4. The pilot flood program has indicated to date, that there is sufficient injectivity and an adequate water source to support a full scale water flood of the field. The response occurring in the producing wells offsetting the pilot injection well should confirm the degree of floodability of the reservoir.

5. There is potential pay in some of the wells, which may not be in communication with the wellbore. Also, some wells may not be completed in correlating zones in the reservoir.

6. The most desirable flooding pattern for the field would result in water injection through 3-26, 5-26, 7-26, and 11-26-9-29 W1.

7. If the flood is expanded, successful flooding would indicate the occurrence of general flood response within one year of the expansion.

8. A moderately successful waterflood could recover as much as an additional 200,000 bbls. of oil.

III RECOMMENDATIONS

1. Waterflood facilities should be installed and the wells 3-26, + 11-26-9-29
   5-26, and 7-26-9-29 W1 should be converted to injection wells.

2. Prior to initiating the enlarged flood, wells should have all significant net pay sections perforated and stimulated so as to adequately drain (and pressure up) the reservoir and so maximum communication can be achieved between injectors and producers.

3. When flood expansion occurs, well 4-26-9-29 W1 should be converted from a suspended Lodgepole producer and Jurassic sand water source to a dual oil producer-water source.

4. To facilitate economic operations and to protect the various interests' rights, Ebor Field should be unitized.

IV HISTORY OF EBOR FIELD

A. DEVELOPMENT:

The Ebor Field is located about 2 miles off the southwest flank of Daly Field. It was discovered in August 1954 with the completion of Dome Harris Cox 14-23-9-29 W1 some 3½ years after the discovery of Daly Field. The development of the pool was completed in August 1955 with the completion of Sun T. McDougall 11-23-9-29 W1. At this time, eleven wells had been drilled on 40 acre spacing.

On March 4, 1960 the well Dome Canadian Superior Ebor 13-23-9-29 was abandoned due to uneconomic productivity after producing 1229 bbls. oil and 385 bbls. water. Subsequently, the well Cal Standard Ebor 15-23-9-29 was abandoned after producing 7446 bbls. oil and 124 bbls. water. In addition to this, it has been operating practise to seasonally suspend the production of some marginal producing wells.

In 1962 it was ascertained that the wells in Ebor Field were producing at or near their economic limits. It was concluded that there would be little prospect of improving production by well workovers and that the only alternative to imminent abandonment of the pool would be the successful use of some form of secondary recovery. In order to consider some aspects of flood recovery feasibility, Sun Oil Company performed a preliminary engineering study of the Ebor Field.

The engineering review concluded that a successful waterflood could recover considerable additional reserves. However, the success of any waterflood in this pool would depend initially on the presence of an adequate water source and the presence of adequate injectivity into the producing formation. Thus, Sun Oil Company forwarded a submission to the Dept. of Mines and Natural Resources, Province of Manitoba, requesting approval to conduct a pilot waterflood in Ebor Field. Approval of the proposed pilot waterflood was granted by Board Order PM-2 on October 9, 1962.

The pilot waterflood plan was immediately put into effect. The well Sun T. McDougall 4-26 was converted to a water source well by plugging back to below the Jurassic formation with a bridge plug perforating in the Jurassic sands. The well T. McDougall 11-26 was used as a pilot injection well. Operation of the pilot commenced late in October 1962 and has continued during 1963. The source has to date exhibited sufficient capacity to cause producing rate response within a reasonable period of time and to balance predicted offsetting production when flood response develops.

B. PRODUCTION HISTORY:

This pool has experienced a very rapid decline in production rate, particularly during the early life of the pool. Figure 13 (Log Average Daily Oil Rate versus Cumulative Oil Produced) indicates that the pool has generally approximated a harmonic type of production rate decline, ie. the nominal decline rate has been proportional to the production rate. Thus, during the pool's first year of production the average rate was 116 BOPD (Figure 12 to 23 respectively summarize the production history for Ebor Field). In 1961, the average rate had declined to 39 BOPD.

In general, the water rate has declined at a faster rate than has the oil rate. Figure 12 shows this trend. It should be noted however that the sharp increase in pool WOR in 1961 resulted from a well workover on Dome 7-26. The decline in WOR's may result from the relatively rapid drop in reservoir pressure that would result from producing from undersaturated reservoir of this type. This would result in a reduction in the flowing pressure gradients in the reservoir. Thus, original flowing conditions may have been such that capillary forces were originally exceeded in some sections of the reservoir. Subsequently, the flowing gradient may have been reduced to the extent that capillary forces, particulary in tighter sections, may have been sufficient to retard the flow of connate water to the well bore.

Various stimulations have been used during the life of the field. Original completions usually employed small acid stimulations (up to 1000 gals.) with moderately sized sand fracs (up to 10,000 lbs. sand). The few subsequent workover stimulations attempted have met with notable lack of success. At the present time, it is believed that nothing can be economically gained by further stimulation of existing perforations due to the low remaining energy in the reservoir.

To December 31, 1963 the cumulative production from the Ebor Feild has been 189,295 bbls. of oil and 41,697 bbls. of water. The producing gas/oil ratio during the life of the field has generally been in the range of 95 to 150 scf/bbl. It is estimated that the primary economically recoverable oil from the field would be about 195,000 bbls. oil and that the field would be abandoned within 2 years under primary depletion.

V RESERVOIR CONSIDERATIONS

A. GEOLOGY OF EBOR FIELD:

The producing section in the Ebor Field lies above the "Transitional Zone" in the Daly Field and is partly correlatable with Stanton's Upper Whitewater member. Production is obtained from several thin porous bands over about a 100 foot interval. The producing section consists primarily of a limestone to dolomitic limestone to dolomite partically plugged with secondary anhydrite.

The porosity appears to be poor to fair, intercrystalline with some pinpoint to small vugs and is very banded. The better porosity falls within the more dolomotized sections.

Figures 1 and 2 (Contours on Top Porosity and Top of the Mississippian Unconformity) are very similar indicating a relatively uniform cap overlying the porosity. In most cases, the wells were not drilled deep enough to obtain a persistent mappable horizon. Thus it is difficult to ascertain if the fall-off in the north and east direction is structural or merely erosional. However, it is generally believed that accumulation is probably controlled by a local porosity development combined with some degree of structure.

B. RESERVOIR FLUID DATA:

There is little data available concerning the fluid properties of oil found in the Ebor pool. However, some data is known and other data can be estimated with a reasonable degree of accuracy.

The basic producing mechanism for the pool has been expansion drive with a very weak solution gas drive. The original reservoir pressure was 970 psig. It is estimated that the bubble-point for the crude is about 350 to 400 psig and that the current reservoir pressure is about 300 psig or less.

The pool produces 34° API oil from an average depth of 2610 feet. From production data, it is estimated that the gas-in-solution at bubble-point is about 90 to 100 scf/bbl. With this data standard correlations indicate that the formation volume factor is 1.05 to 1.08 bbls./bbl.

C. NET PAY DATA:

Determination of effective net pays in Ebor Field is difficult. Five of the eleven wells have been cored and analyzed. The well logs run are not conducive to accurate determination of pay intervals in reservoirs of this type. Again core analysis cut-offs for effective net pays must be arbitrarily assigned.

If we include all pay in core analyses having porosity and permeability equal to, or more than, 9% and 0.8 md., then data from 14-23, 3-26, 4-26, and 12-26 would indicate that the average Ebor well should have 13.8 net feet, at an average permeability and porosity of 8.6 md. and 12.1%.

If should be noted that the cut-offs used have a great effect on the net pays deduced from core analyses. As an example, with 12-26, if cut-offs of 1.0 md. and 10% are used, 19.5 feet at 13.6% and 10.4 md. would be found. At 0.8 md. and 9% cut offs, 24.8 net feet at 12.7% and 8.6 md. would result. At 0.5 md. and 5% cut offs, 48.6 net feet at 10.2% and 5.4 md. would be indicated.

The vertical and lateral distribution of net pay (effective reservoir) in the pool is of great interest. It is not possible to correlate discrete porous bands from well to well with any degree of assurance. The reservoir is composed of stratified bands and layers of dolomite, limestone, anhydrite and combinations of these rocks. The bands range from less than 0.5 to 3 feet in thickness. The bands of net pay are usually distributed over large intervals. As an example, in 12-26, core analysis indicates that net pay intervals are spread over about 78 feet. (See figure 23.)

It should be noted that in some wells a significant amount of potential pay, as indicated by core analysis, may not be in communication with the well bore. As an example, 12-26 is perforated 2644 - '53 (C.A.). Potential pay is indicated as high as 2609 C.A. If it is assumed that vertical communication behind pipe is not effective beyond 10 or 20 feet, then about 198%-ft. of the net pay (314.8%-ft.) indicated by the core analysis, using cut-offs of 0.3 md. and 9%, is not drained directly to the wellbore. Thus, any scheme to promote additional future recovery should include consideration of exposing all potential pay to the wellbore.

D. ESTIMATE OF ORIGINAL-OIL IN-PLACE (O.O.I.P.):

The amount of oil originally-in-place in Ebor pool is difficult to estimate. It is of interest to note that previously published estimates of O.O.I.P. for the pool range from 6.4 MMSTB's (1956) to 1.4 MMSTB's (1961). Apart from defining net pay, the effective area of the pool must be chosen. Thus, if we accept the previously stated average net pay figures of 13.8 net feet at 12.1% porosity; if the connate water saturation is taken as 40%, of the area of the pool is taken as 10 x 40 acres, then the O.O.I.P. is 2.95 MMSTB's

E. RECOVERABLE OIL:

(1) Primary Recovery

The primary recovery from the pool is relatively low. Figure 13 indicates that about 195,000 bbls. would be produced by the expansion drive and weak solution gas drive. Relating this to the previously estimated OOIP of 2.95 MMSTB's, this would indicate a primary recovery factor of about 6½%.

(2) Waterflood Recovery

Any flood recovery prediction made for Ebor Field at this time would be purely speculative. However, the stakes involved in undertaking a waterflood can be outlined within broad limits. A moderately successful flood should recover an additional 200,000 bbls. This cannot be realistically estimated until pilot results are known.

VI WATERFLOOD CONSIDERATIONS

A. FEASABILITY OF FLOODING:

Only concrete results from pilot flood studies will provide reliable data concerning the floodability of the Ebor reservoir. However, some of the reservoir factors influencing the success of failure of flooding in Ebor Field will be discussed below.

To date, it has been shown that Ebor reservoir has sufficient injectivity for successful flooding and an adequate supply of source water to maintain an expanded flood. This has been confirmed by the operation of the pilot system.

There must be adequate net pay and oil saturation to provide a basis for economic feasability. Ebor reservoir has this, however, there are other considerations regarding net pay which should be indicated after pilot flood response. To achieve maximum floodability all significant bands of effective pay should be in communication with the wellbores and the bands should be continuous from well to well. As yet, there is no definite indication of the degree of reservoir continuity and in some cases it is probable that potential pay is not open to the wellbore.

Initially, for a short time most of the wells showed good productivity (70 - 100 BOPD). Thus, if the reservoir energy can be restored and there is reasonable reservoir continuity, pool producing rates of up to 200 to 300 BFPD may be realized while employing four injection wells. However, it should be realized that flood conformance in this pool may be poor so that early high produced water rates may be experienced.

B. PILOT WATERFLOOD:

In 1962 it was ascertained that this pool was virtually depleted to the economic limit. Due to low remaining reservoir energy, it was highly unlikely that any workovers would be successful enough to stave off abandonment of the pool within a year or so. As an alternative to abandonment, it was decided to investigate the feasibility of waterflooding. A preliminary study was made and in September 1962, a submission was made to the Manitoba Dept. of Mines and Minerals.

The submission requested approval to convert Sun McDougall 11-26 to an injection well and to investigate the Jurassic Sands as a water source through the well Sun McDougall 4-26. The proposal was approved by Board Order #PM2, (Manitoba Regulation 87/62).

On November 2, 1962, a Lane Wells C.I. bridge plug was run in 4-26 and set at 2550 KB. Five sax of cement were dropped on top of the plug by dump bailer. The casing was perforated from 2400 - 2420 in the Jurassic Sand, with 2 JSPF.

The following day, the fluid level was found at 700' with sand up to 1100'. Sand was circulated out to T. D. and the well was swabbed. A considerable amount of very fine sand was seen to be suspended in the water. A pump was run to about 1000' and the well was placed on production on November 6, 1962. Within a day, sand had ceased to appear in the water. On November 10, clean water was being produced with the fluid level at 100' from surface. By November 15, the source well was capable of 110 to 115 BWPD. No trouble has been experienced with the source well since that time. (Refer to Fig.24) The well has since been capable of producing up to 130 BWPD with little affect on the water level in the annulus.

On November 18, 1962, pump and rods were pulled from 11-26. A water injection pump was installed and injection commenced on November 2, 1962. Since that time, the well has taken water at rates of from 105 to 120 BWPD. With reference to Fig. 24, it can be seen that the wellhead pressure increased to 1400 psi by May 1963, at which time about 16,000 bbls. of water had been injected. The wellhead pressure has remained relatively constant (at about 1395 to 1425 psig) since that time.

It is estimated that the fracturing pressure for the formation is about 2600 psi at the formation face. When the wellhead injection pressure is 1400 psi and the hydraulic head of water in the well above the perfs. is 0.44 (2580) equals 1130 psi, then the sand face pressure is 2530 psi. Thus, it is probable that the water is being injected at or near the parting pressure for the formation. The above data assumes a Unit fracturing gradient of about 1.0 psi per ft. for the Virden Area.

C. WATER SOURCE:

It was thought that the presence of an adequate source of water for flooding might be doubtful. For the pilot programs it was decided that the Jurassic Sands would be the best water source to test. (For a limited time California Standard used this formation as a water source at Daly 2-1-10-28 in the Daly Field, producing at rates up to 1,000 BWPD.)

For the pilot study, it was decided to use Sun McDougall 4-26 as a water source well. This was done as this well was completed with 7" casing. This would mechanically enable the well to be converted to a dual oil producer-water source well if pilot results indicate flood feasibility.

The well was plugged back with a bridge plug below the Jurassic Sand and then was perforated 2400 - 2420. During the first two or three days sand problems were encountered, however, the well was soon producing up to 120 barrels of clean water per day. The fluid level in the annulus of the well remains about 300' from the surface. Quality of the water is good (See Fig. 25). This source of water should be adequate for an expanded flood.

D. PILOT FLOOD RESPONSE:

The timing of response in wells offsetting the pilot injection well is of interest. It has been predicted that response should be noted after 45,000 to 55,000 barrels of water have been injected into 11-26. This is an approximate made by treating the injection well and all its offsets as a partial nine-spot pattern, calculating the voidage created by production from the partial pattern, then multiplying this by about 75%. (It should be noted that the first symptoms of response may now be appearing with about 49,000 barrels water injected.

E. PROPOSED WATERFLOOD PLAN:

The choice of an injection pattern will be an important factor in the success of any expanded flood in the Ebor Field. The choices available are limited by the location of the pilot injection well in 11-26. It is recommended that a five-spot pattern be established in the Pool. Thus, in addition to the injection well 11-26, the wells 3-26, 5-26, and 7-26 would be converted to injection wells.

The above choice was made for several reasons. This pattern adapts well to the presence of the injection well 11-26. It appears to provide the best areal sweep efficiency of available (3 or 4 well) injection pattern. It also should be beneficial to have injection wells within one location of producers if there tends to be relatively poor continuity of pay sections across the pool. To achieve adequate response in a reasonable period of time, it is believed that the injectivity of the four wells will be required.

We may reasonably assume that each of the above injection wells will be capable of handling about 100 BWPD. Up to December 31, 1963, 189,295 bbls. of oil and 41,697 bbls. of water had been produced. This is equivalent to about 1.06 (189,295) + 41,697 = 243,000 reservoir barrels of voidage. At that time about 39,000 bbls. of water had been injected through 11-26. The reservoir is currently being over-injected at about 80 reservoir bbls./day. Thus, at this time (March 31, 1963), voidage would be about 200,000 barrels. If injection were to start immediately and response is assumed to occur at about 3/4 x fillup, then full response should be noted within 0.75 (200,000)/400 = 375 days, after injection start. This is an order of magnitude number only. It should be noted that wells off-setting the pilot injector should be showing response at the present time.

It is recommended that upon expansion of the flood, the well 4-26 be dually completed to provide a Lodgepole withdrawal point as well as a water source well.

TABLE #1

PRODUCTION HISTORY

EBOR FIELD

Year	Cumulative Oil Dec. 31/Bbls.	Yearly Production Bbls.	Daily Production/Bbls.
1954	2,485	2,485	-
1955	46,027	43,542	116
1956	82,522	36,495	100
1957	106,107	23,585	65
1958	127,217	21,110	57
1959	144,132	16,915	46
1960	159,713	15,581	43
1961	173,820	14,107	39
1962	183,482	4,469	12
1963	189,295	5,813	16

TABLE #2

SUMMARY OF COMPLETION PRACTICES

EBOR FIELD

Well	KB	To	Top Miss. (Lodgepole)	Casing Size - Depth	Perforations	Treatment
13-23	1749	2769	2614	7" @ 2632	2632 - 94 (OH)	Frac. 10,000# 220 B. Crude
14-23	1742	2710	2597	5½ @ 2686	2686 - 2711 (OH) 2616 - 34	Frac. 10,000# Frac. 10,000#
15-23	1723	2741	2585	7" @ 2680	2598 - 2604 2626 - 2632	Frac.
2-26	1708	2668	2561	5½ @ 2638	2594 - 2614	Frac.
3-26	1733.5	2659	2594	5½ @ 2660	2610 - 25	Frac.
4-26	1747	2783	2595	7" @ 2728'	2604 - 10 2616 - 24 2642 - 48 2400 - 20 (Jurassic Sand)	Acid - 2 Bbls. & Frac.
5-26	1734	2680	2587	5½ @ 2672 Re. Perfs.	2667 - 74 2593 - 97 2599 - 2606	Frac. 9,000# - 144 Bbls. Crude WO squeezed perf. Acid 4 Bbls. Frac. Sanded off.
6-26	1714	2659	2560	5½ @ 2647	2612 - 2628 2648 - 2659 (OH)	Acidized - 2 Bbls. Frac. 10,500# WO Acidized 1,000 gals. XFMW Frac. 9,100#
7-26	1696	2939	2570	5½ @ 2720	2600 - 14	Frac. 10,000# - 250# Adomite
11-26	1683	2628	2546	5½ @ 2628	2584 - 94	Frac. 9,000# - 124 Bbls. Oil
12-26	1716	2662	2577	5½ @ 2652	2641 - 2649	Frac. 10,000# - 100Bbls. Oil

FIGURES

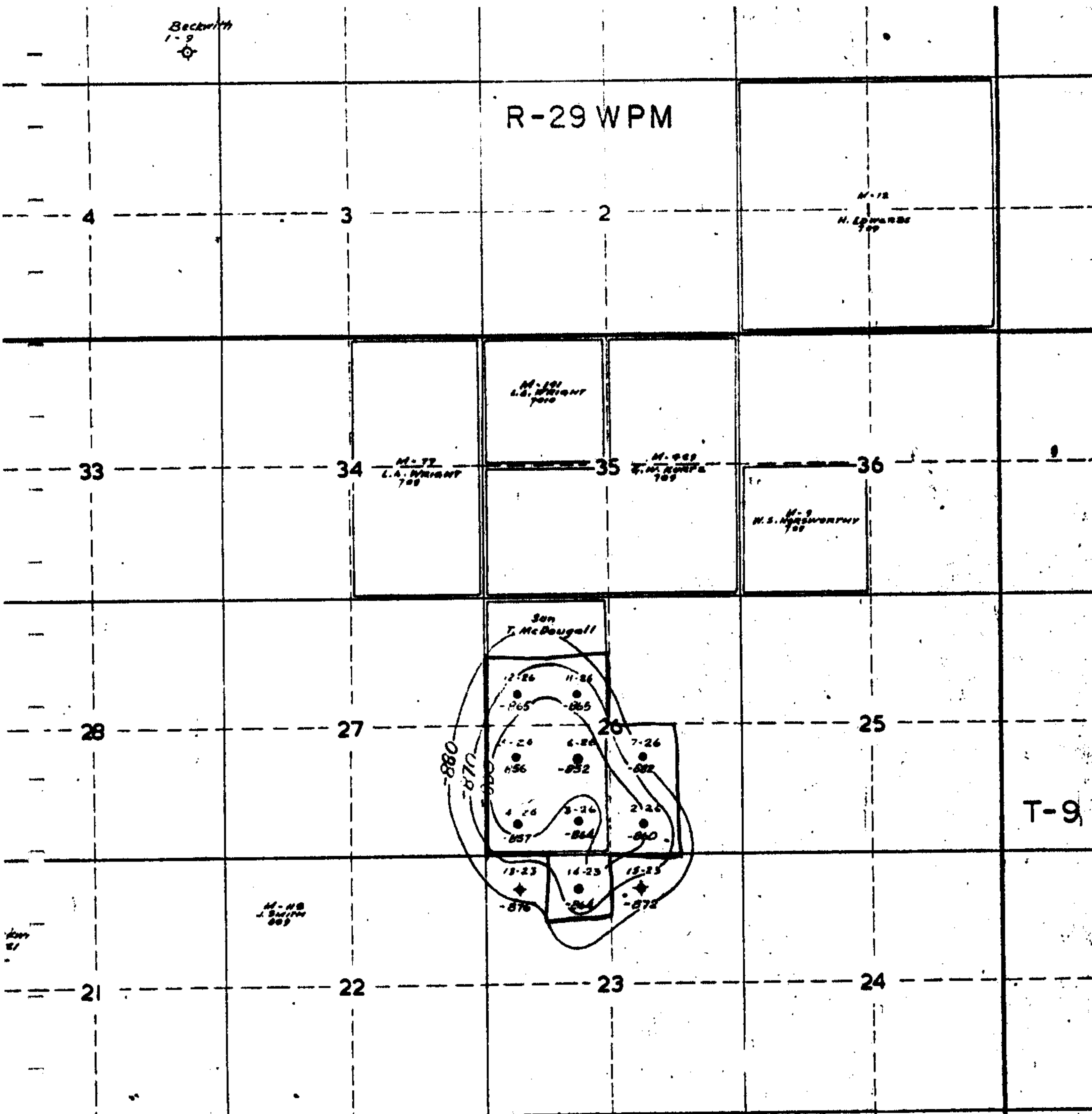


FIG. 1

WELL REFERENCE

- ABANDONED WELL
- OIL WELL
- LOC. OR DRILLING
- GAS WELL
- SUN LEASES

SUN OIL COMPANY

EBOR FIELD

MANITOBA

CONTOURED ON: TOP POROSITY

CONTOUR INTERVAL: 10 FEET

DATE: SEPT. 5, 1962 GEOLOGY BY G. P. W.

SCALE: 2" = 1 Mile DRAFTING BY L.S.L.

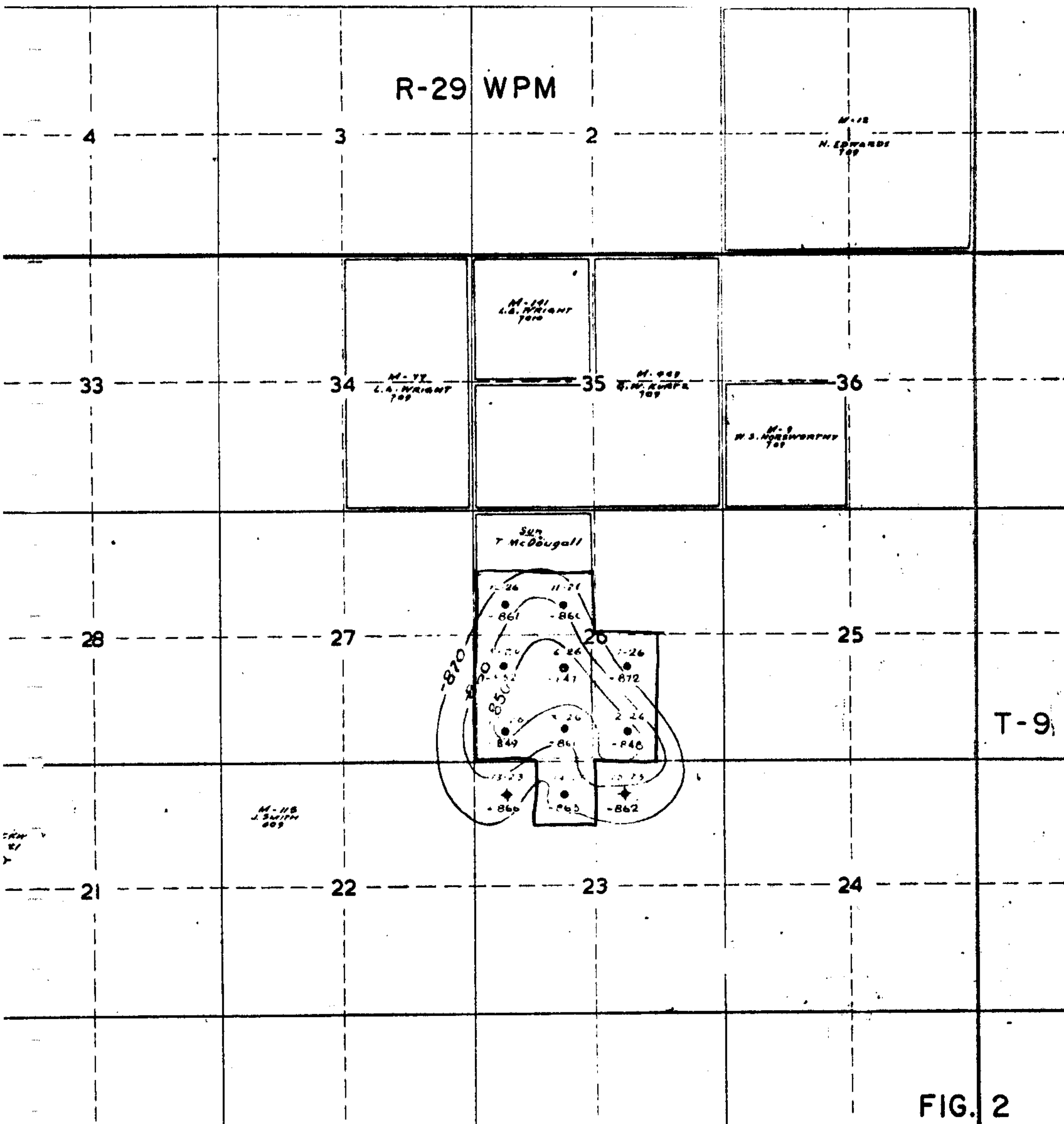


FIG. 2

WELL REFERENCE

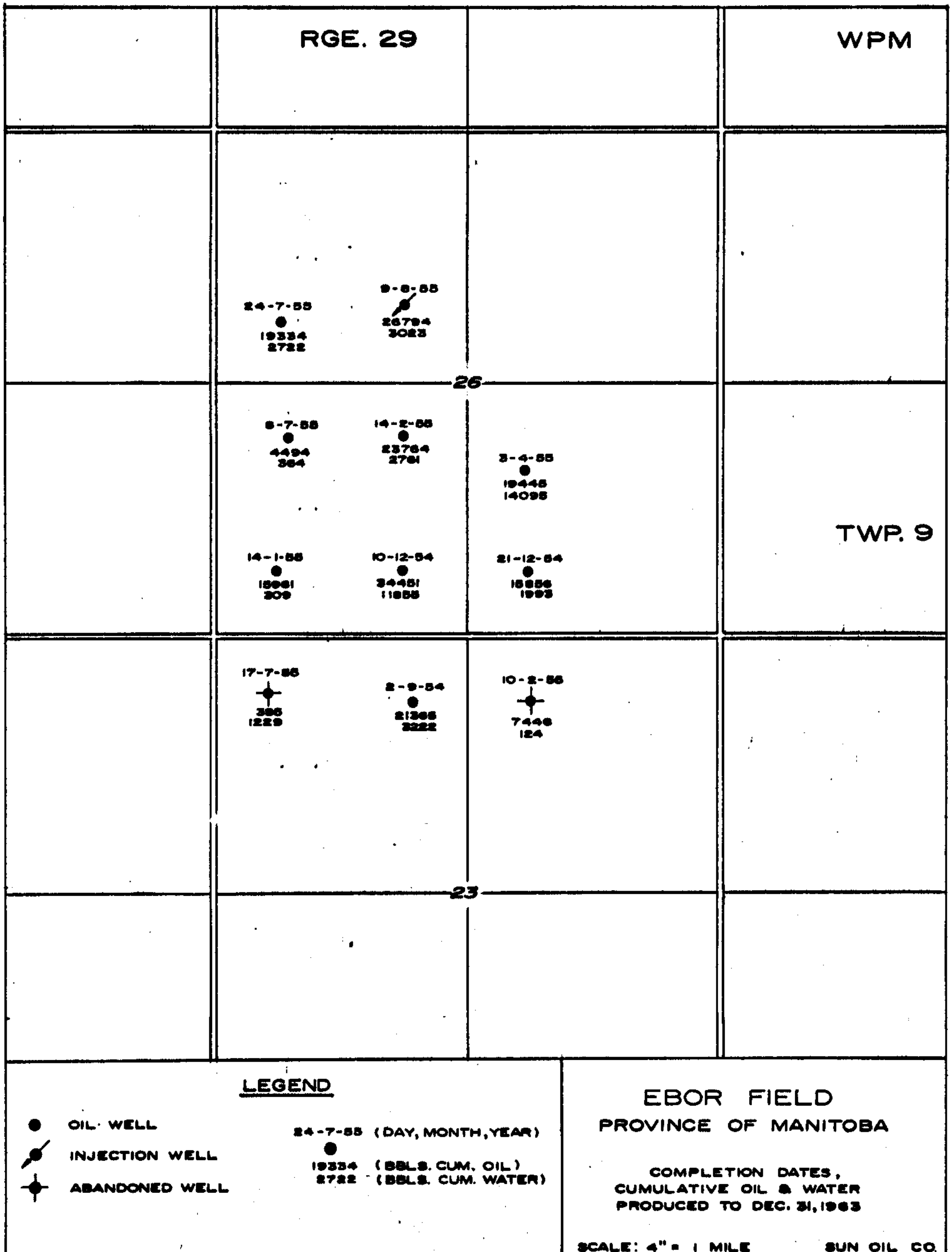
- ABANDONED WELL
- OIL WELL
- LOC. OR DRILLING
- GAS WELL
- SUN LEASES

SUN OIL COMPANY

EBOR FIELD

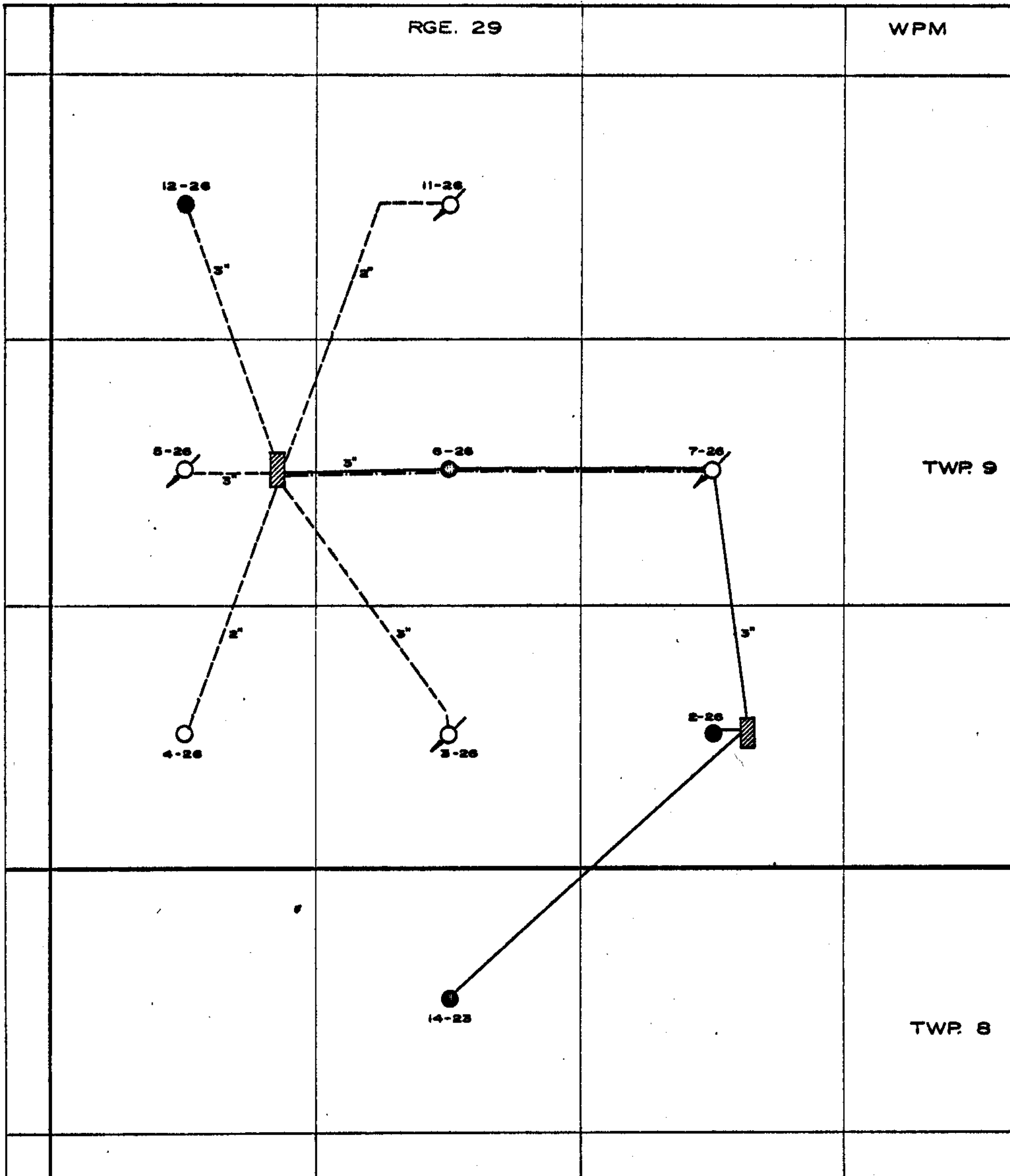
MANITOBA

CONTOURED ON : TOP MISS. UNCONFORMITY
CONTOUR INTERVAL : 10 FEET
DATE : SEPT. 5, 1962 GEOLOGY BY G. P. W.
SCALE : 2" = 1 Mile DRAFTING BY L. S. L.



RGE. 29
WPM
TWP. 9
26
23
24-7-55
19334
2722
9-8-55
26794
3023
8-7-55
4494
364
14-2-55
23764
2761
3-4-55
19445
14095
14-1-56
15961
309
10-12-54
34451
11855
21-12-54
15856
1993
17-7-56
386
1229
2-9-54
21365
3222
10-2-56
7446
124
LEGEND
OIL WELL
INJECTION WELL
ABANDONED WELL
24-7-55 (DAY, MONTH, YEAR)
19334 (BBLS. CUM. OIL)
2722 (BBLS. CUM. WATER)
EBOR FIELD
PROVINCE OF MANITOBA
COMPLETION DATES, CUMULATIVE OIL & WATER PRODUCED TO DEC. 31, 1963
SCALE: 4" = 1 MILE
SUN OIL CO.

FIGURE 3



LEGEND

INJECTION WELL

OIL WELL

EXISTING INJECTION LINE

NEW INJECTION LINE

NEW OIL GATHERING LINE

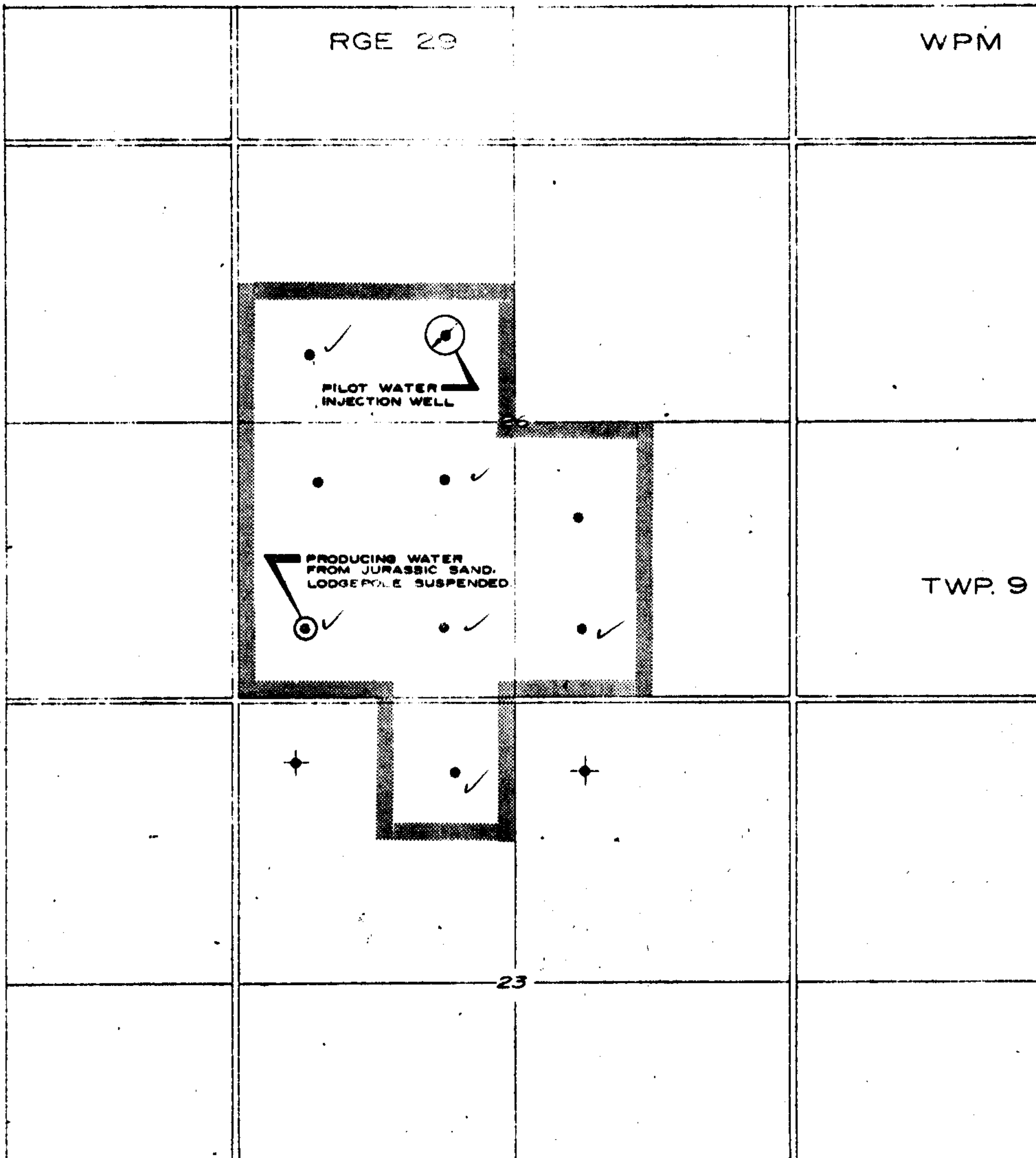
PROPOSED EBOR WATERFLOOD

OPER DEPT. D·A·V·

SUN OIL COMPANY MARCH 30, 1964

NOT TO SCALE

FIGURE 4



LEGEND

- OIL WELL
- INJECTION WELL
- ABANDONED WELL
- PROPOSED UNIT BOUNDARY

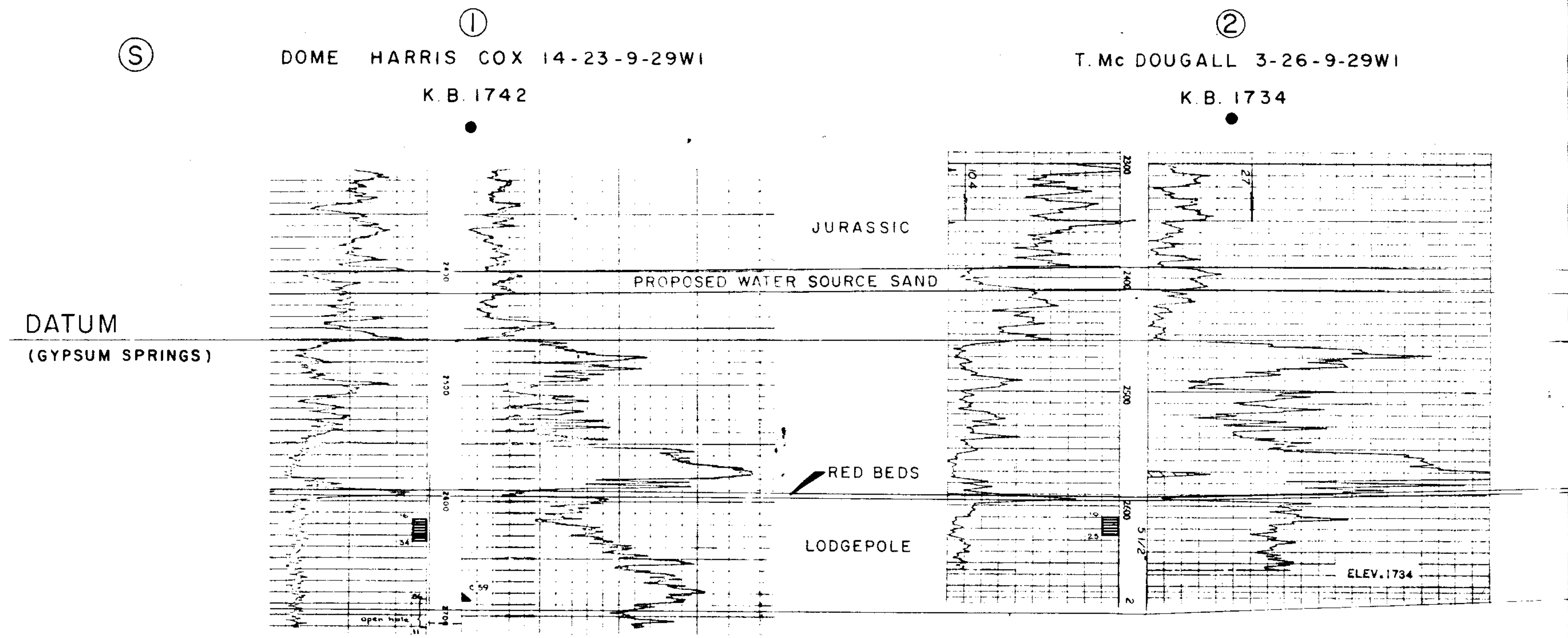
EBOR FIELD
PROVINCE OF MANITOBA

PROPOSED UNIT BOUNDARY
FOR EBOR UNIT

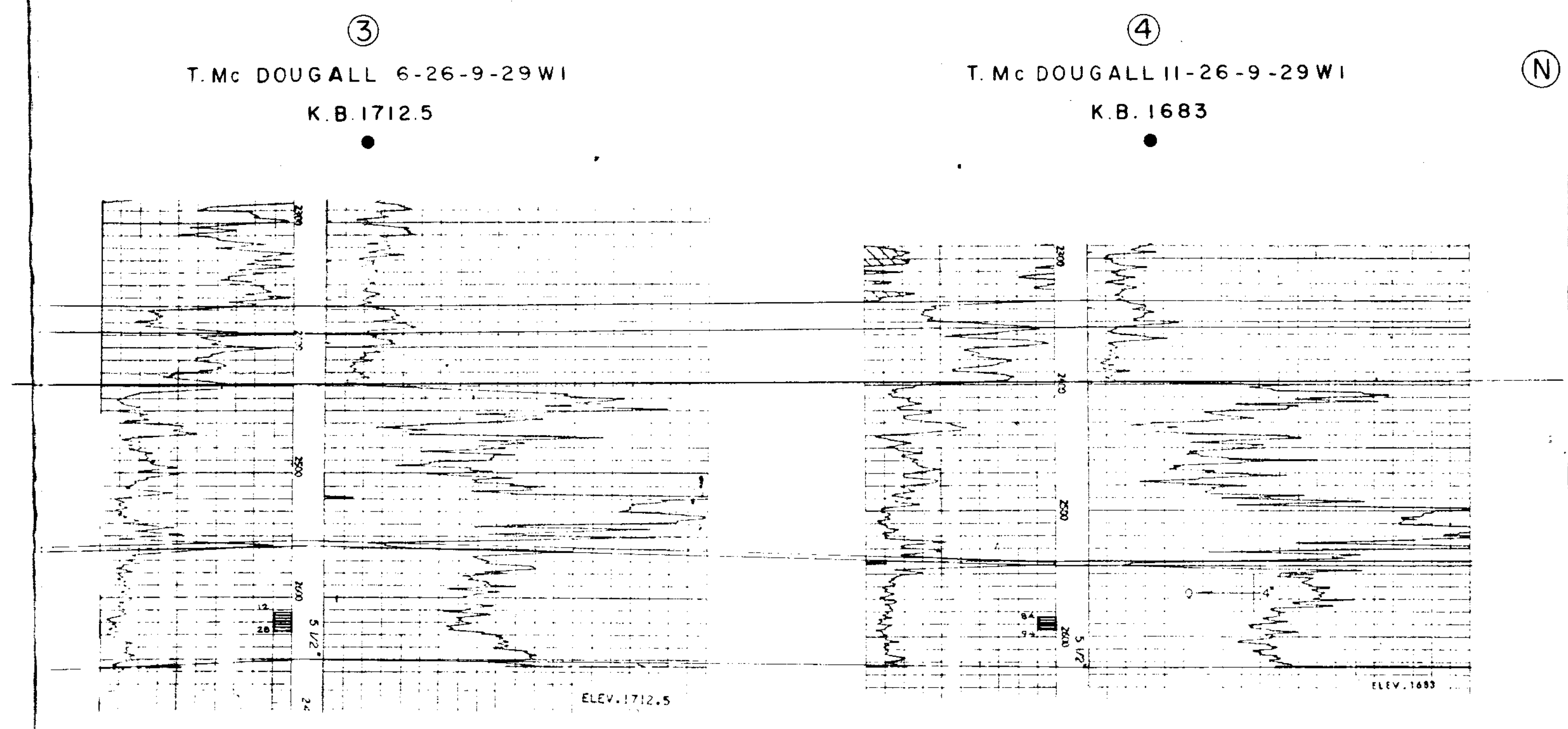
MARCH 1964

SCALE: 4" = 1 MILE   SUN OIL CO

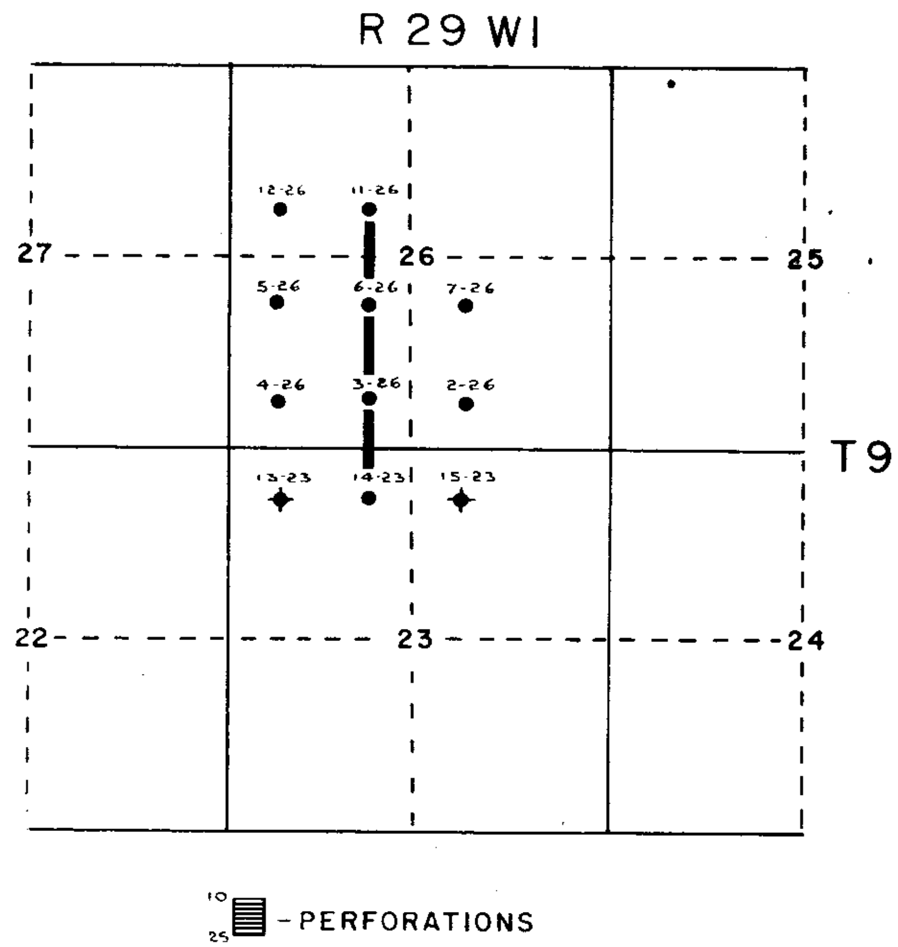
FIGURE 5



S
1
DOME HARRIS COX 14-23-9-29W1
K.B. 1742
2
T. Mc DOUGALL 3-26-9-29W1
K.B. 1734
DATUM
(GYPSUM SPRINGS)
JURASSIC
PROPOSED WATER SOURCE SAND
RED BEDS
LODGEPOLE
ELEV. 1734
5 1/2
open hole



3
T. Mc DOUGALL 6-26-9-29 W1
K.B. 1712.5
4
T. Mc DOUGALL 11-26-9-29 W1
K.B. 1683
N
2300
2500
2600
5 1/2"
ELEV. 1712.5
ELEV. 1683



SUN OIL COMPANY

EBOR FIELD

MANITOBA

CROSS SECTION

SEPTEMBER 1962

FIGURE 6

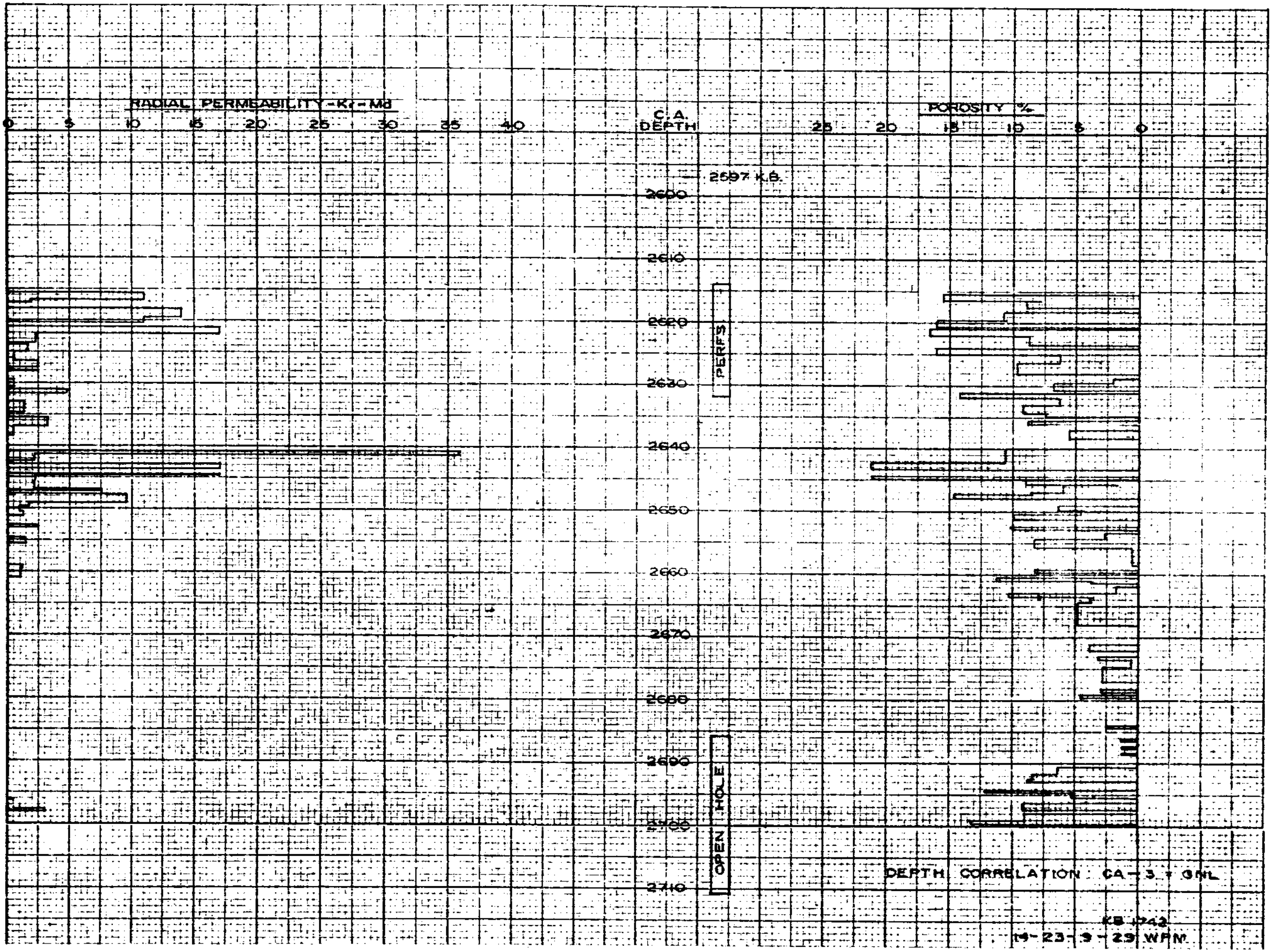

RADIAL PERMEABILITY - Kr - Md
0
5
10
15
20
25
30
35
40
C.A. DEPTH
2597 K.B.
2600
2610
2620
2630
2640
2650
2660
2670
2680
2690
2700
2710
PERFS
OPEN HOLE
POROSITY %
25
20
15
10
5
0
DEPTH CORRELATION: CA-3 + GNL
KB 1742
14-23-9-29 WPM

FIGURE 7

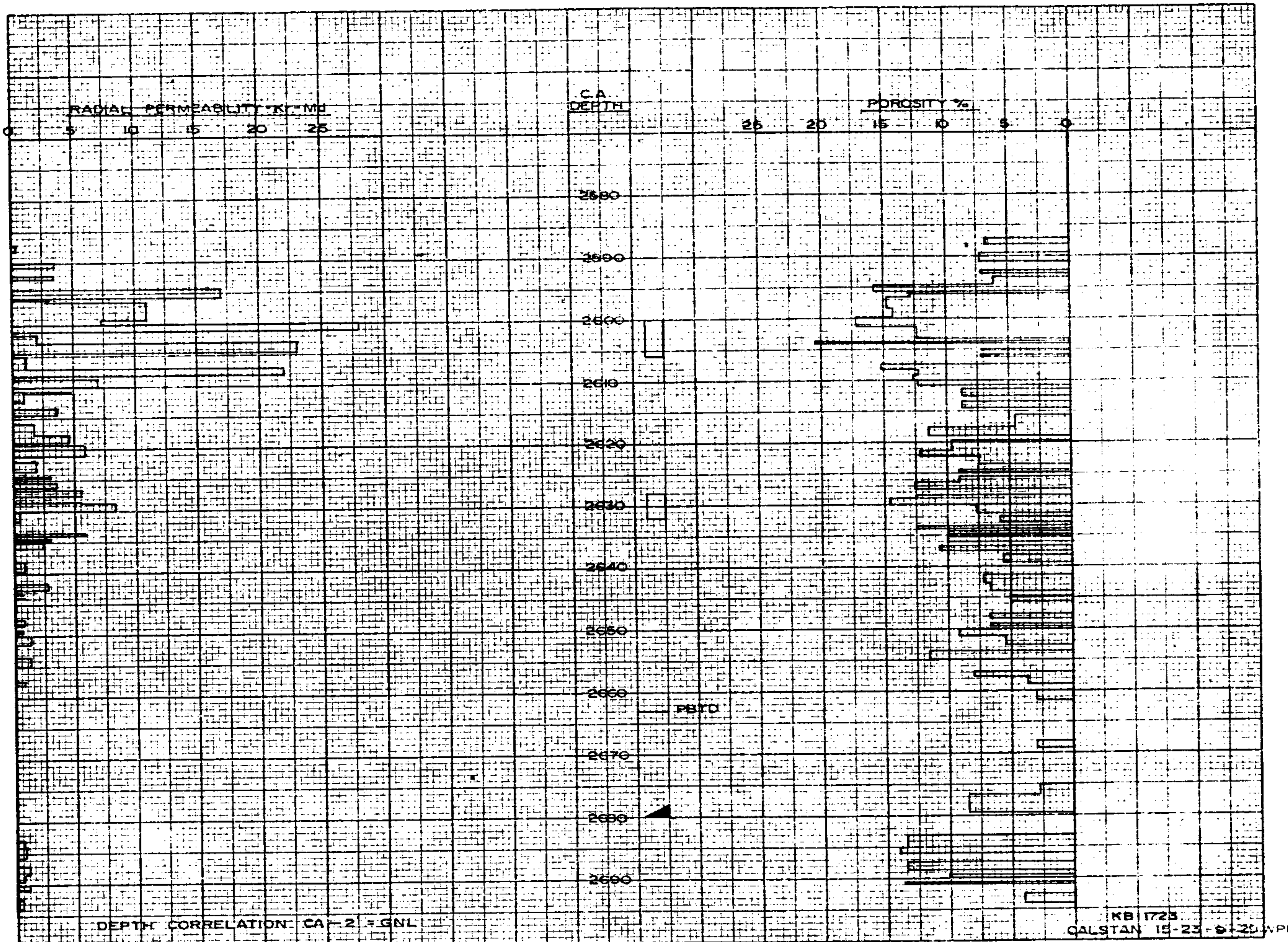

RADIAL PERMEABILITY K - MD
0
5
10
15
20
25
C.A. DEPTH
POROSITY %
25
20
15
10
5
0
2580
2590
2600
2610
2620
2630
2640
2650
2660
2670
2680
2690
PBTD
DEPTH CORRELATION CA-2 = GNL
KB 1723
CALSTAN 15-23-9-20 WPM

FIGURE 8

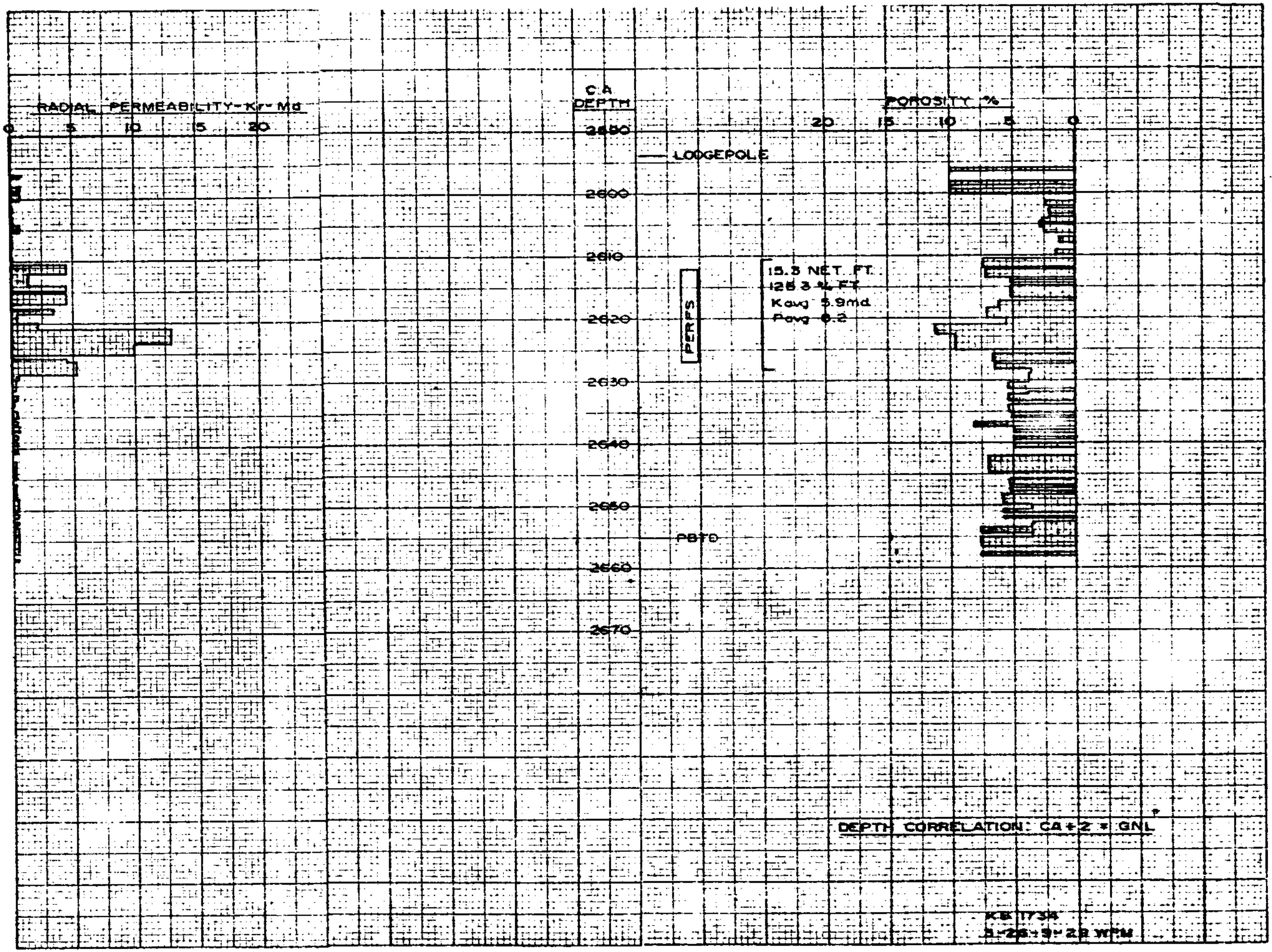

RADIAL PERMEABILITY - Kr - Md
0
5
10
15
20
C.A
DEPTH
2590
2600
2610
2620
2630
2640
2650
2660
2670
LODGEPOLE
PERFS
PBTD
15.3 NET FT.
128.3 % FT.
Kavg 5.9md
POROSITY %
20
15
10
5
0
DEPTH CORRELATION: CA + 2 = GNL
KB 1734
1-26-9-28 WPM

FIGURE 9

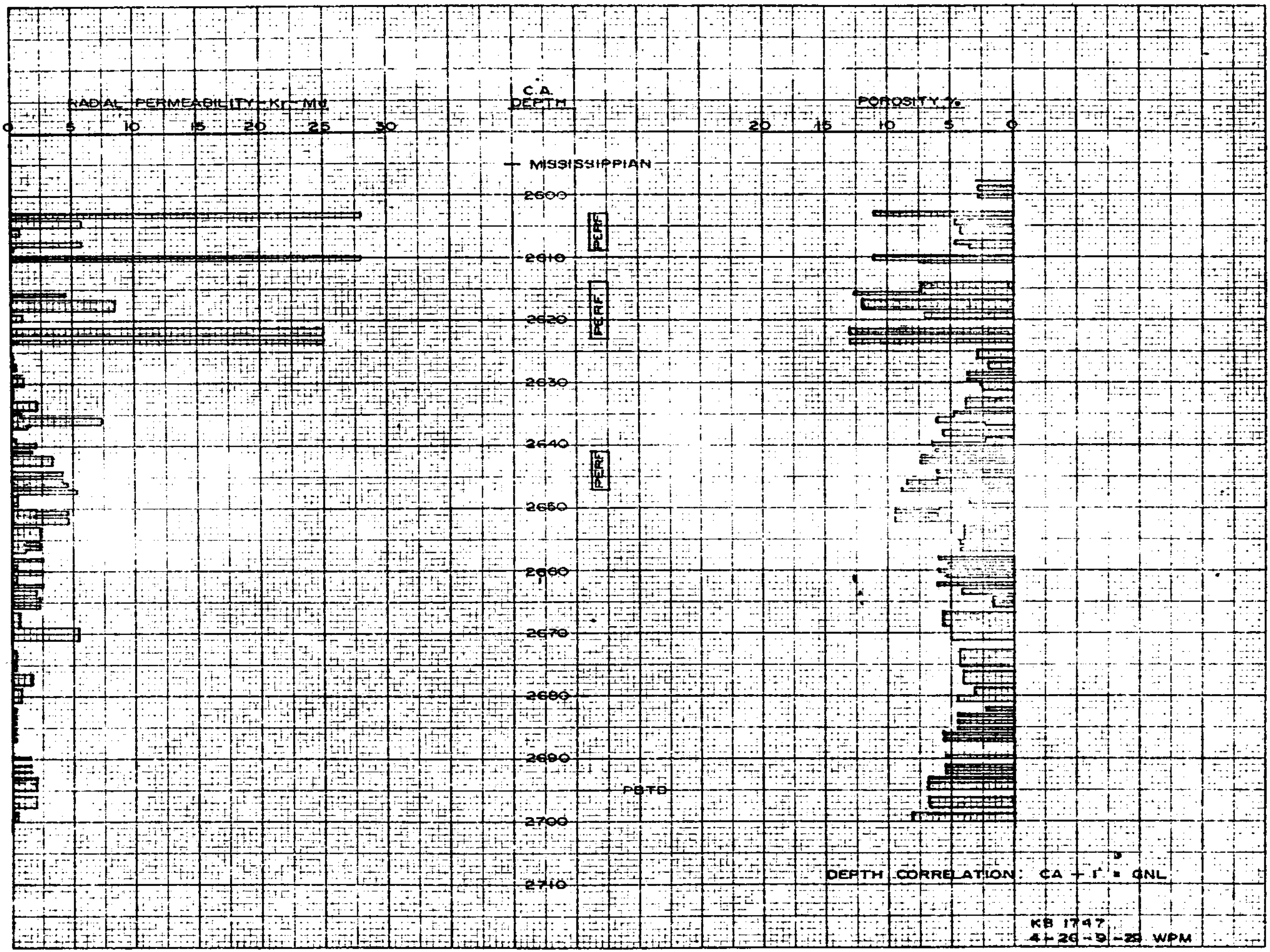
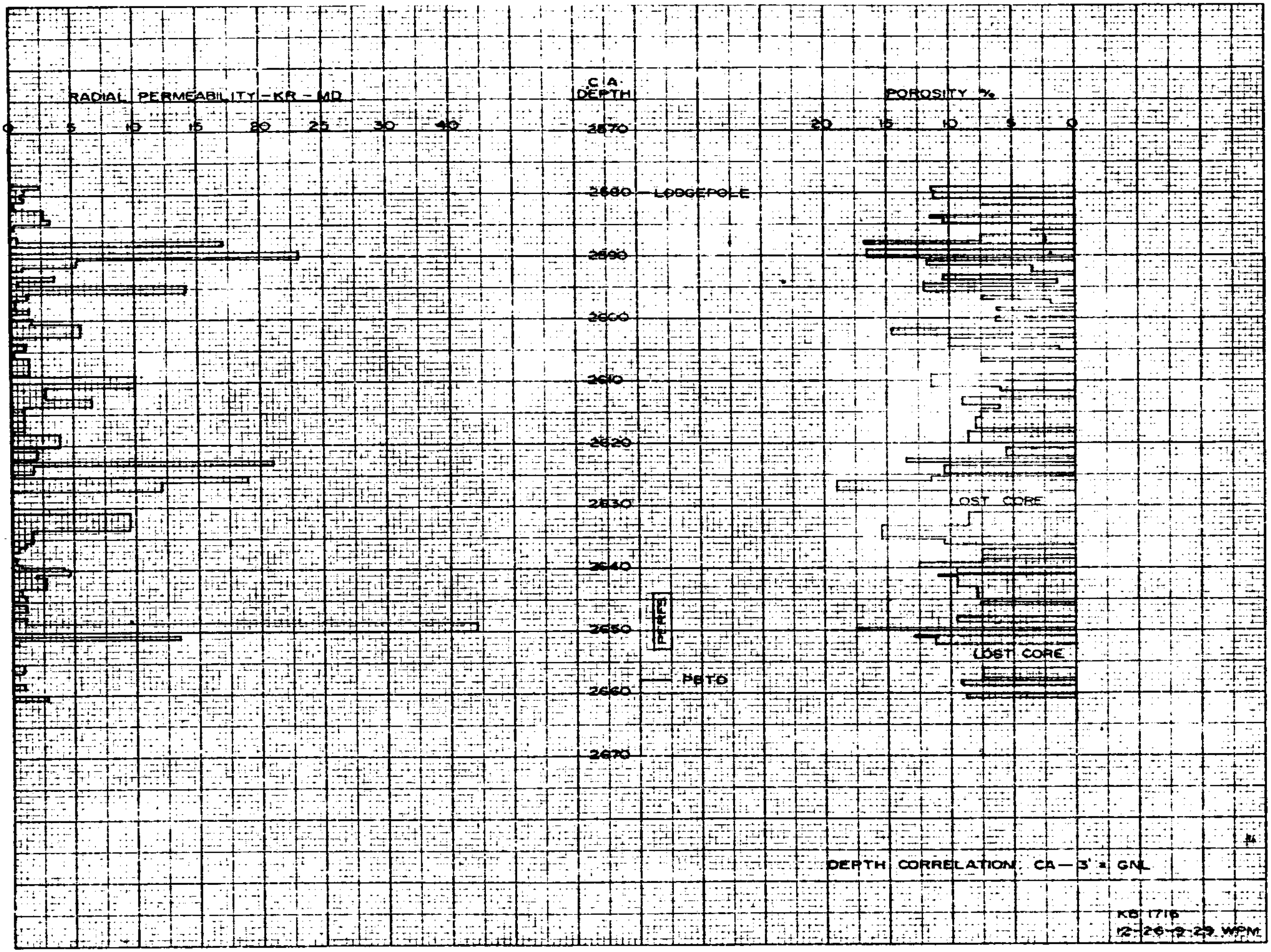

RADIAL PERMEABILITY - Kr - Md
0 5 10 15 20 25 30
C.A. DEPTH
POROSITY %
20 15 10 5 0
MISSISSIPPIAN
2600
2610
2620
2630
2640
2650
2660
2670
2680
2690
2700
2710
PERF
PERF
PERF
PBTD
DEPTH CORRELATION: CA + 1' = GNL
KB 1747
4-26-9-23 WPM

FIGURE 10



RADIAL PERMEABILITY - KR - MD
0
5
10
15
20
25
30
40
C.A. DEPTH
2580 LODGEPOLE
2590
2600
2610
2620
2630
2640
2650
2660
2670
PERFS
PBTD
POROSITY %
20
15
10
5
0
LOST CORE
LOST CORE
DEPTH CORRELATION CA — 3' = GNL
KB 1716
12-26-9-29 WPM

FIGURE 11

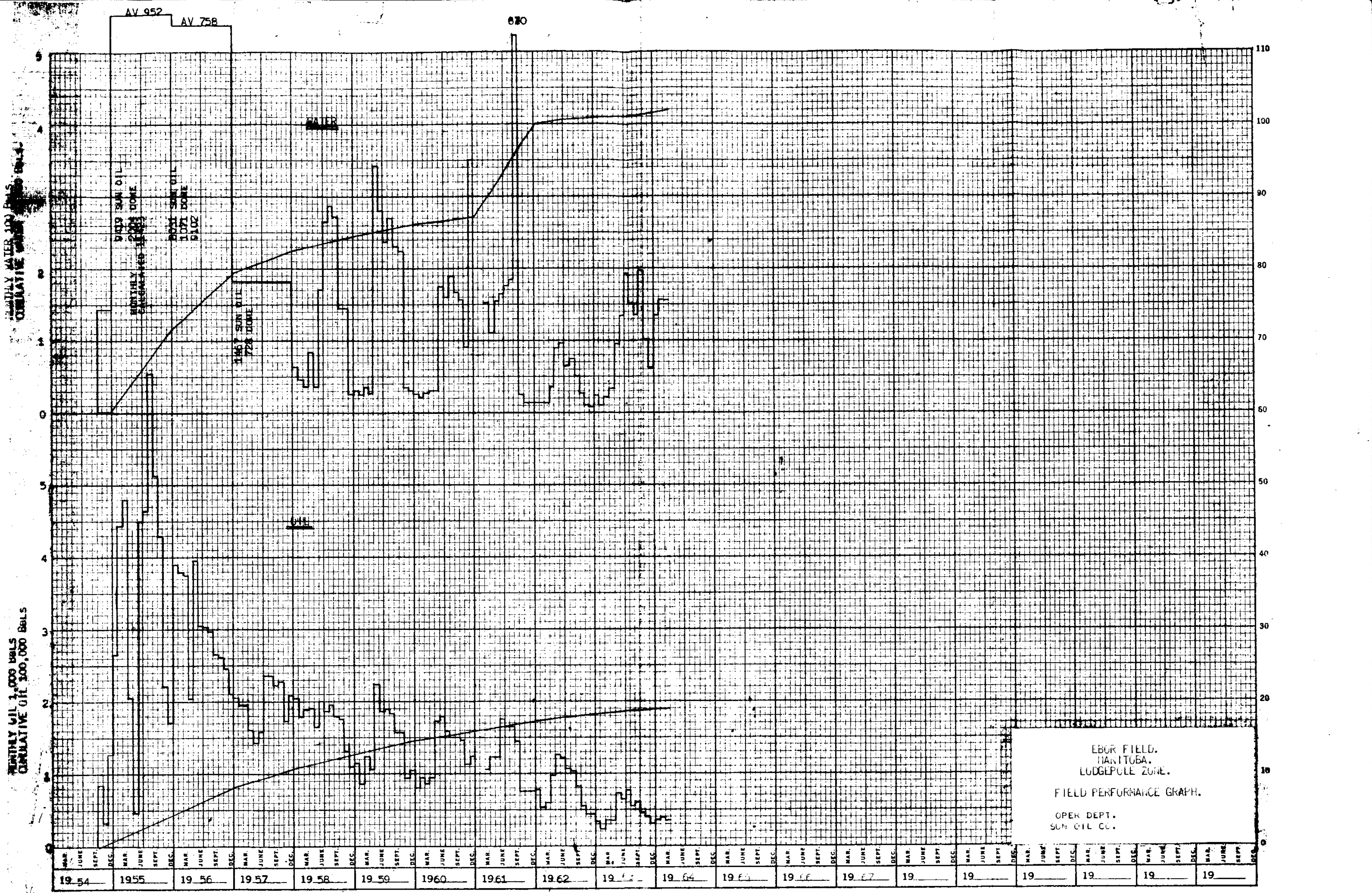
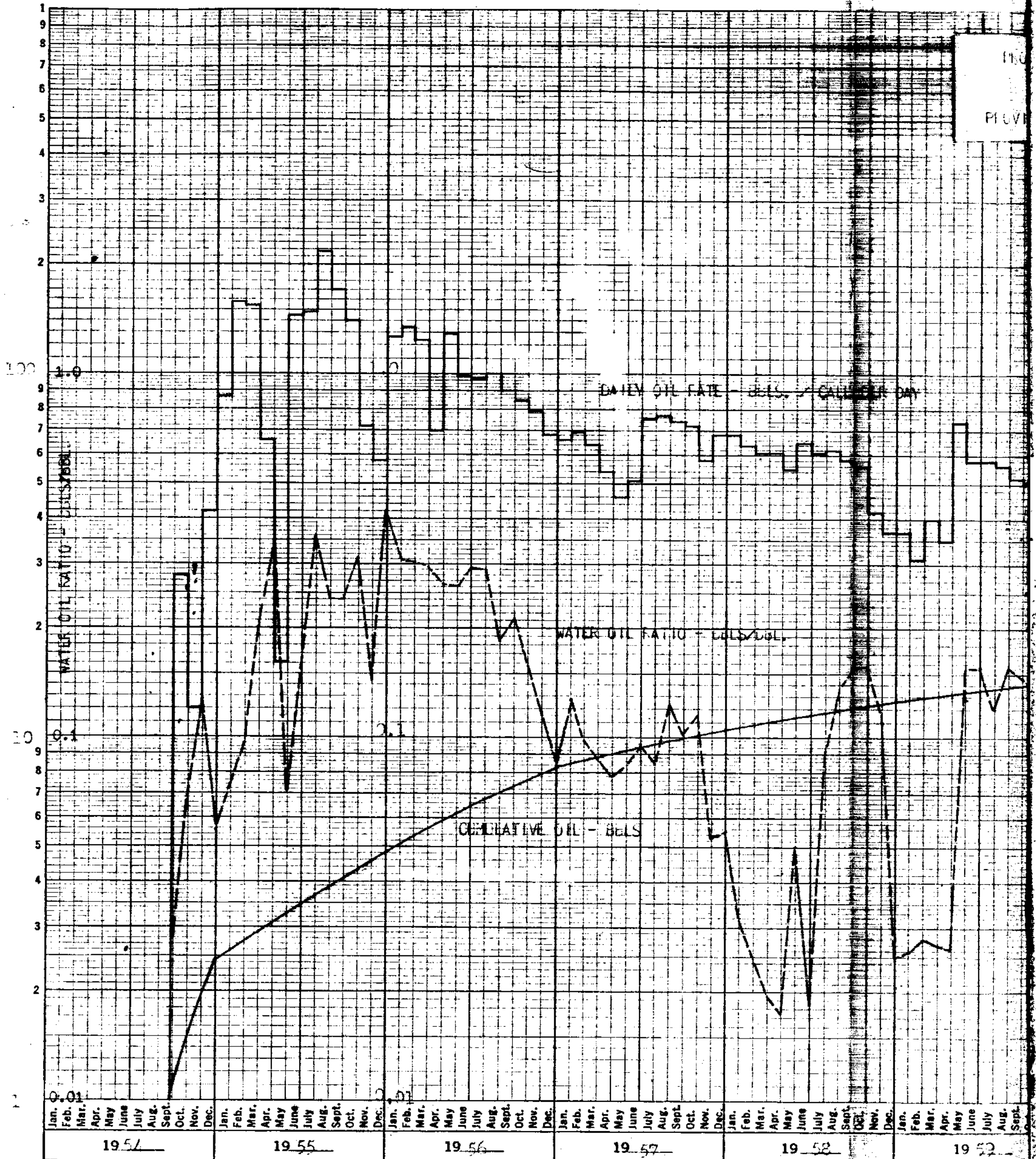
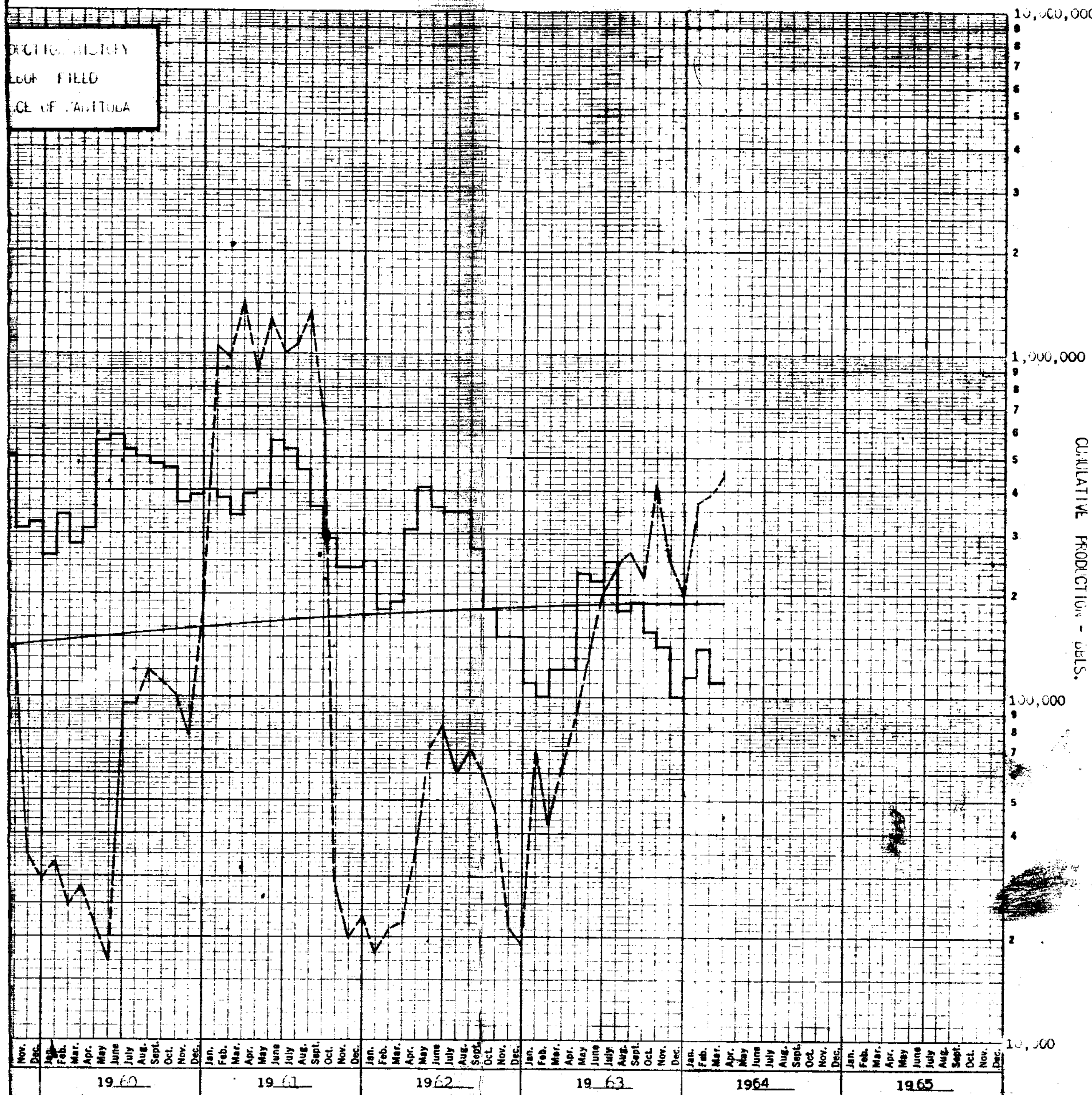

EBOR FIELD.
MANITOBA.
LODGEPOLE ZONE.
FIELD PERFORMANCE GRAPH.
OPER DEPT.
SUN OIL CO.
MONTHLY WATER 100 BBLS
MONTHLY OIL 1,000 BBLS
CUMULATIVE OIL 100,000 BBLS
WATER
OIL
AV 952
AV 758
9019 SUN OIL
2204 DOME
8031 SUN OIL
1071 DOME
9102
1967 SUN OIL
728 DOME
1955
1960
1961
1962

FIGURE 12a


DAILY OIL RATE - B.O.P.D.
WATER OIL RATIO - BBLS/BBL.
DAILY OIL RATE - BBLS. / CALENDAR DAY
WATER OIL RATIO - BBLS/BBL.
CUMULATIVE OIL - BBLS
1954
1955
1956
1957
1958
1959
K+E KEUFFEL & ESSER CO.



EBOR FIELD
LODGEPOLE FORMATION

FIGURE 12b

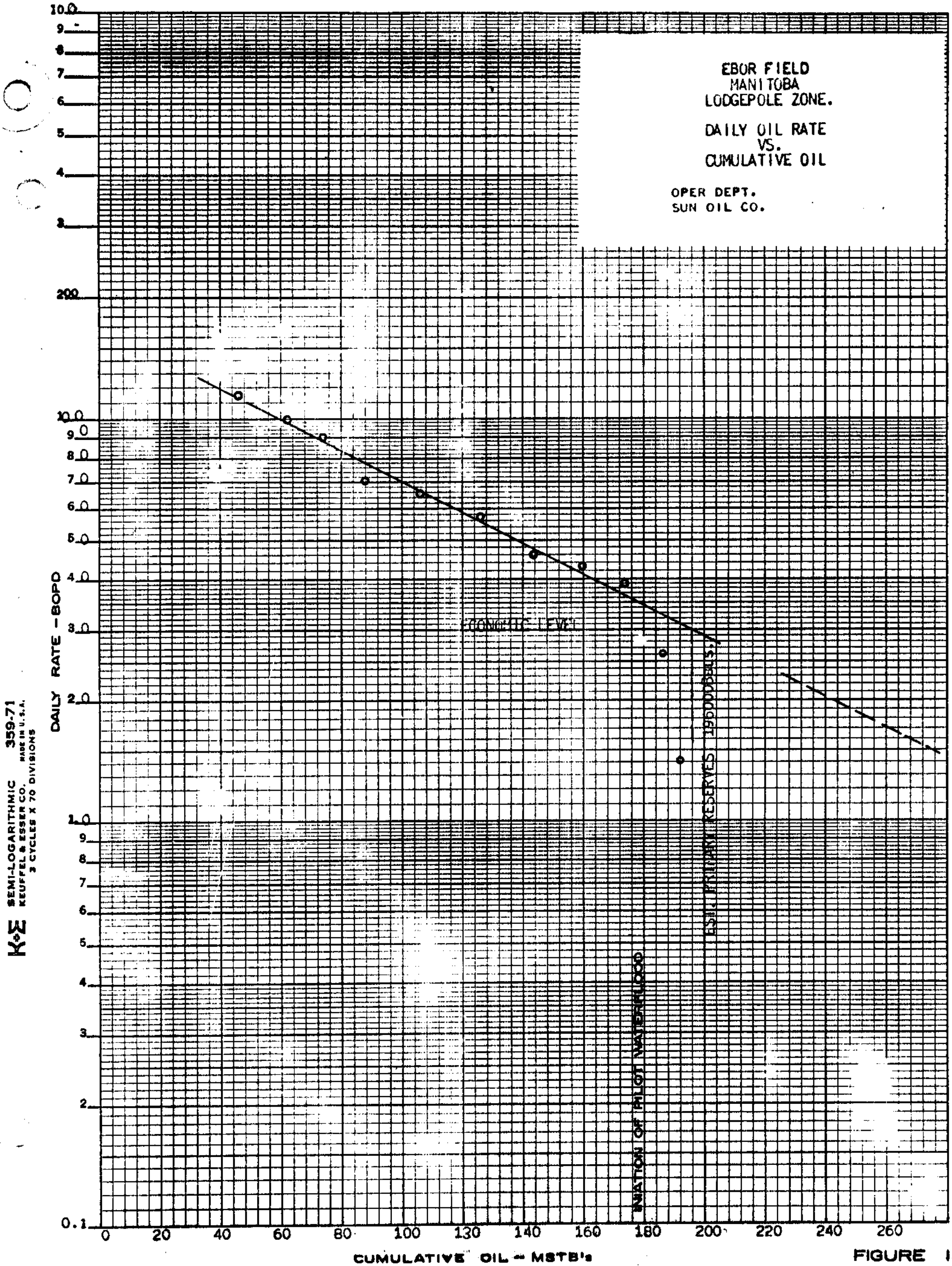

EBOR FIELD
MANITOBA
LODGEPOLE ZONE.
DAILY OIL RATE
VS.
CUMULATIVE OIL
OPER DEPT.
SUN OIL CO.
DAILY RATE - BOPD
CUMULATIVE OIL - MSTB's
ECONOMIC LEVEL
EST. PRIMARY RESERVES 196000BBLS.
INATION OF PILOT WATERFLOOD
0
20
40
60
80
100
130
140
160
180
200
220
240
260
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.1
K+E SEMI-LOGARITHMIC 359-71
KEUFFEL & ESSER CO. MADE IN U.S.A.
3 CYCLES X 70 DIVISIONS

FIGURE 13

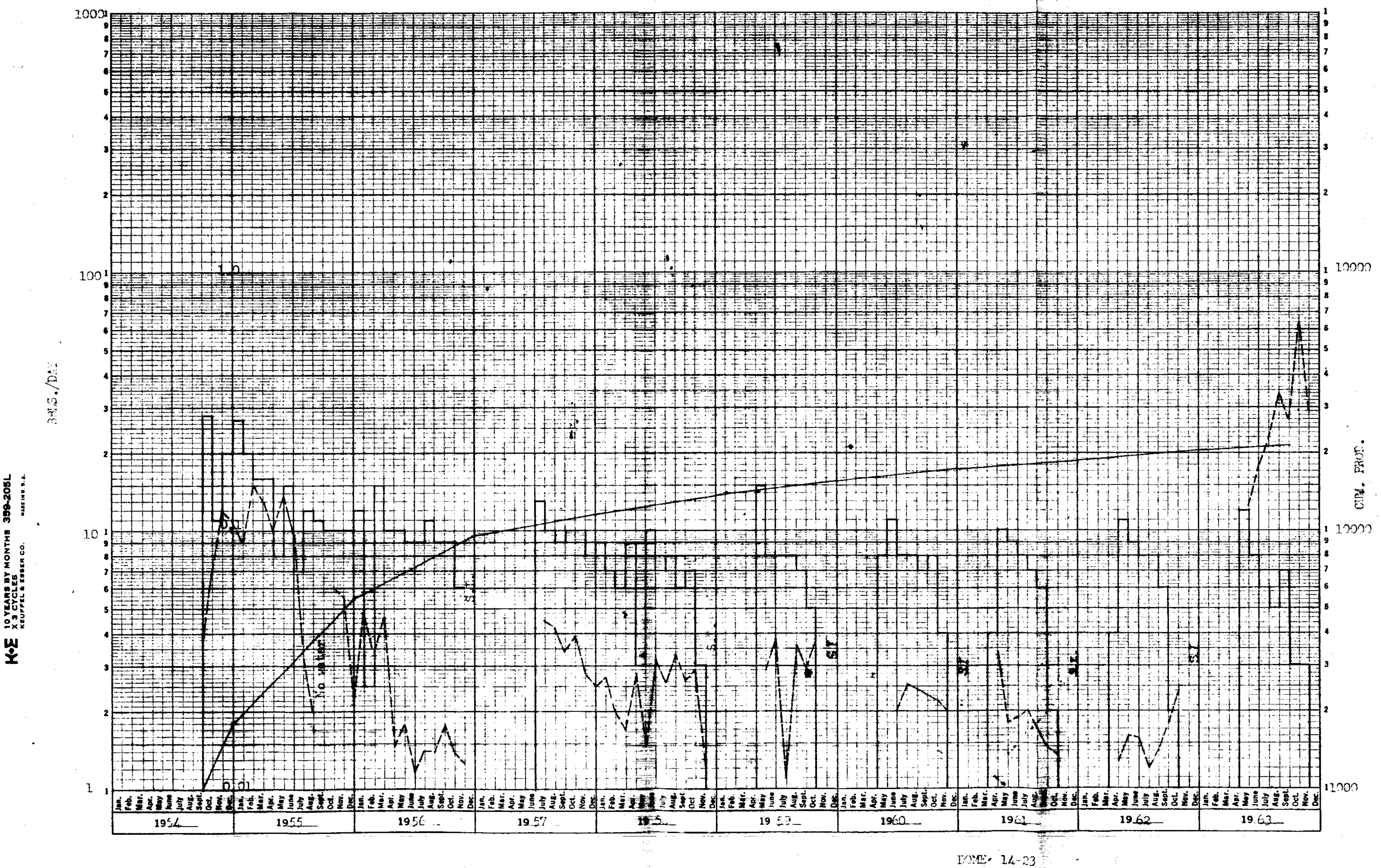

K+E 10 YEARS BY MONTHS X 3 CYCLES 359-205L
KEUFFEL & ESSER CO. MADE IN U.S.A.
BBLS./DAY
CUM. PROD.
No water
0.01
1.0
ST
ST
S.I.
ST
1954
1955
1956
1957
1959
1960
1961
1962
1963
POME 14-23

FIGURE 14

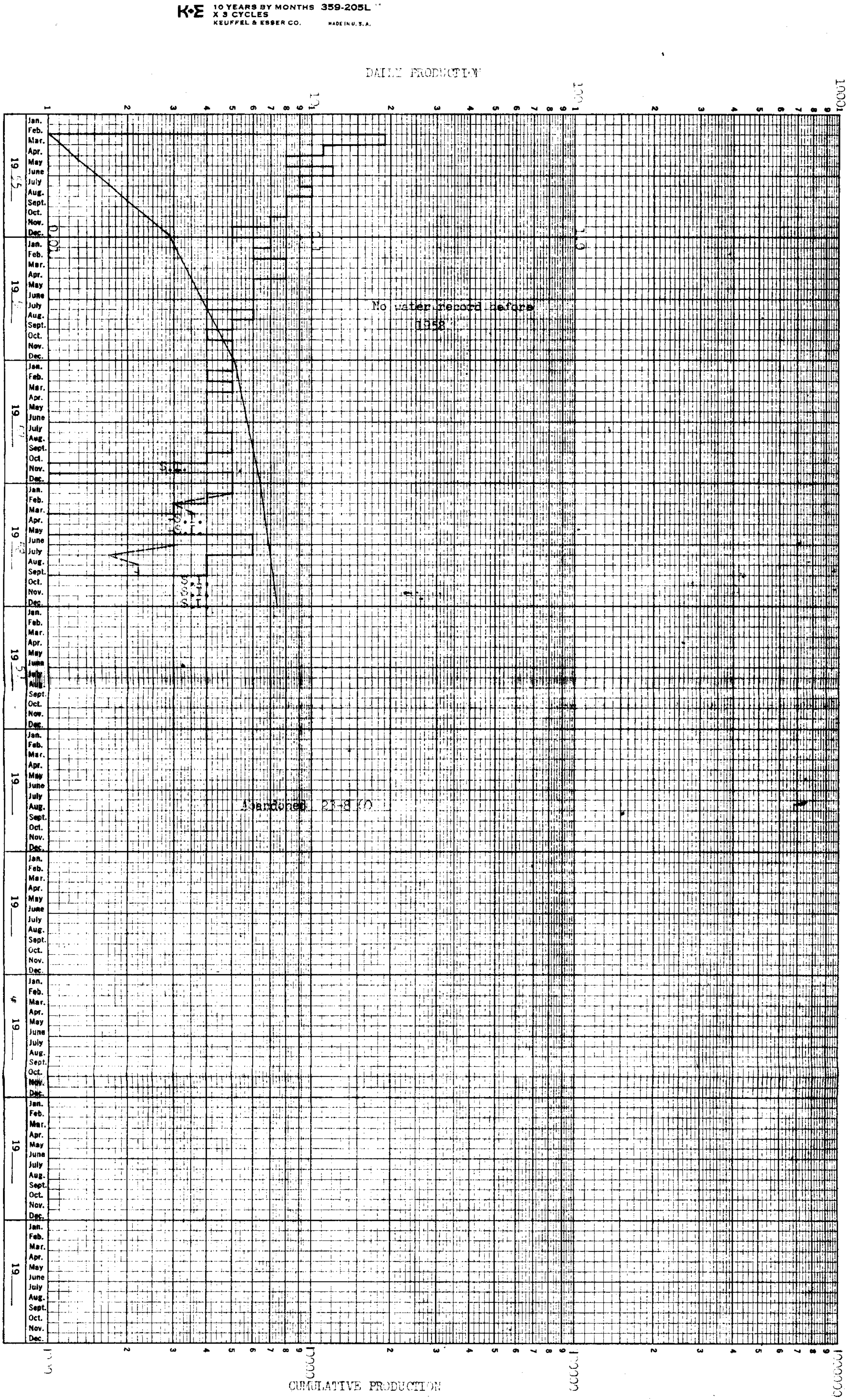

K+E 10 YEARS BY MONTHS 359-205L
X 3 CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.
DAILY PRODUCTION
No water record before
1958
CUMULATIVE PRODUCTION

FIGURE 15

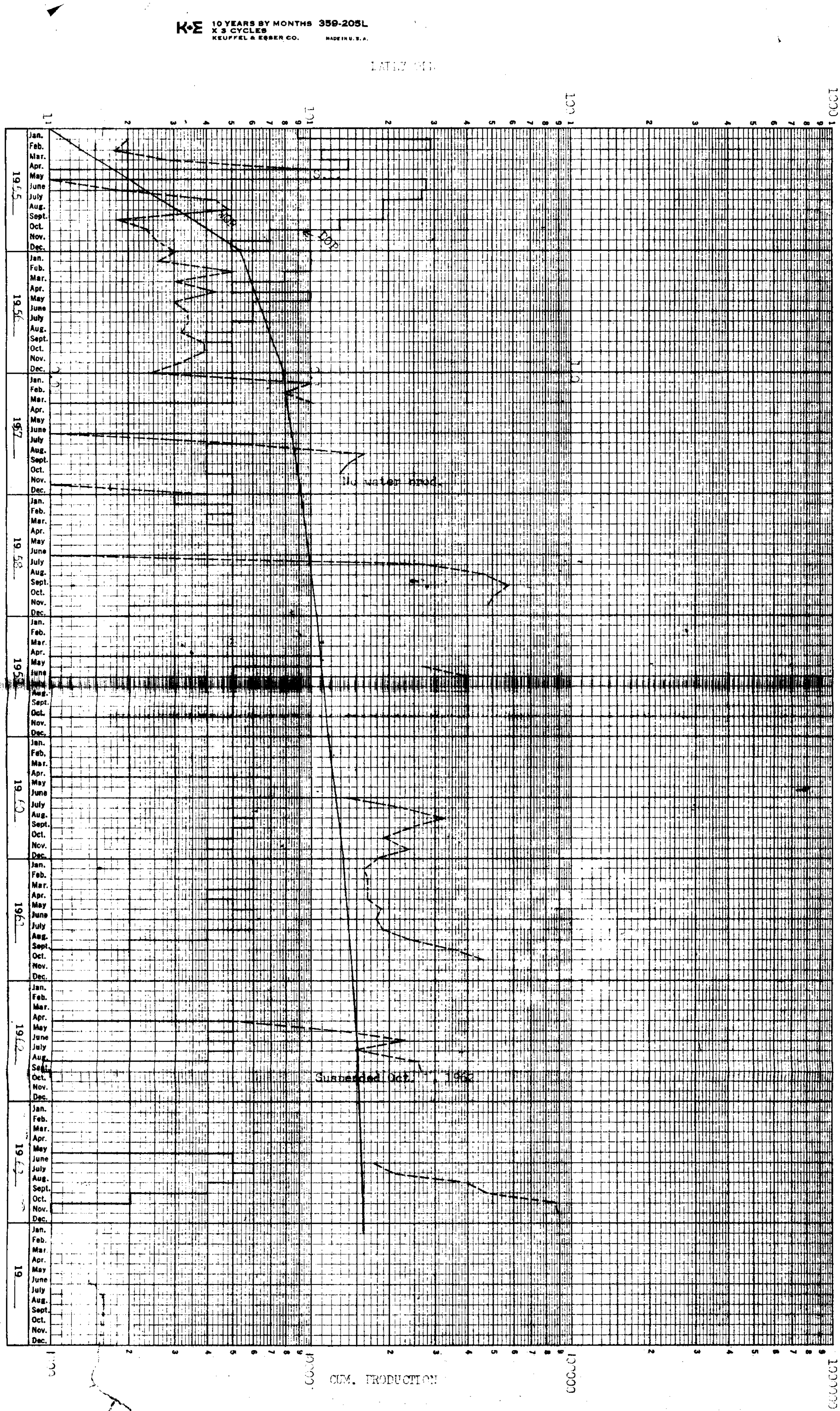
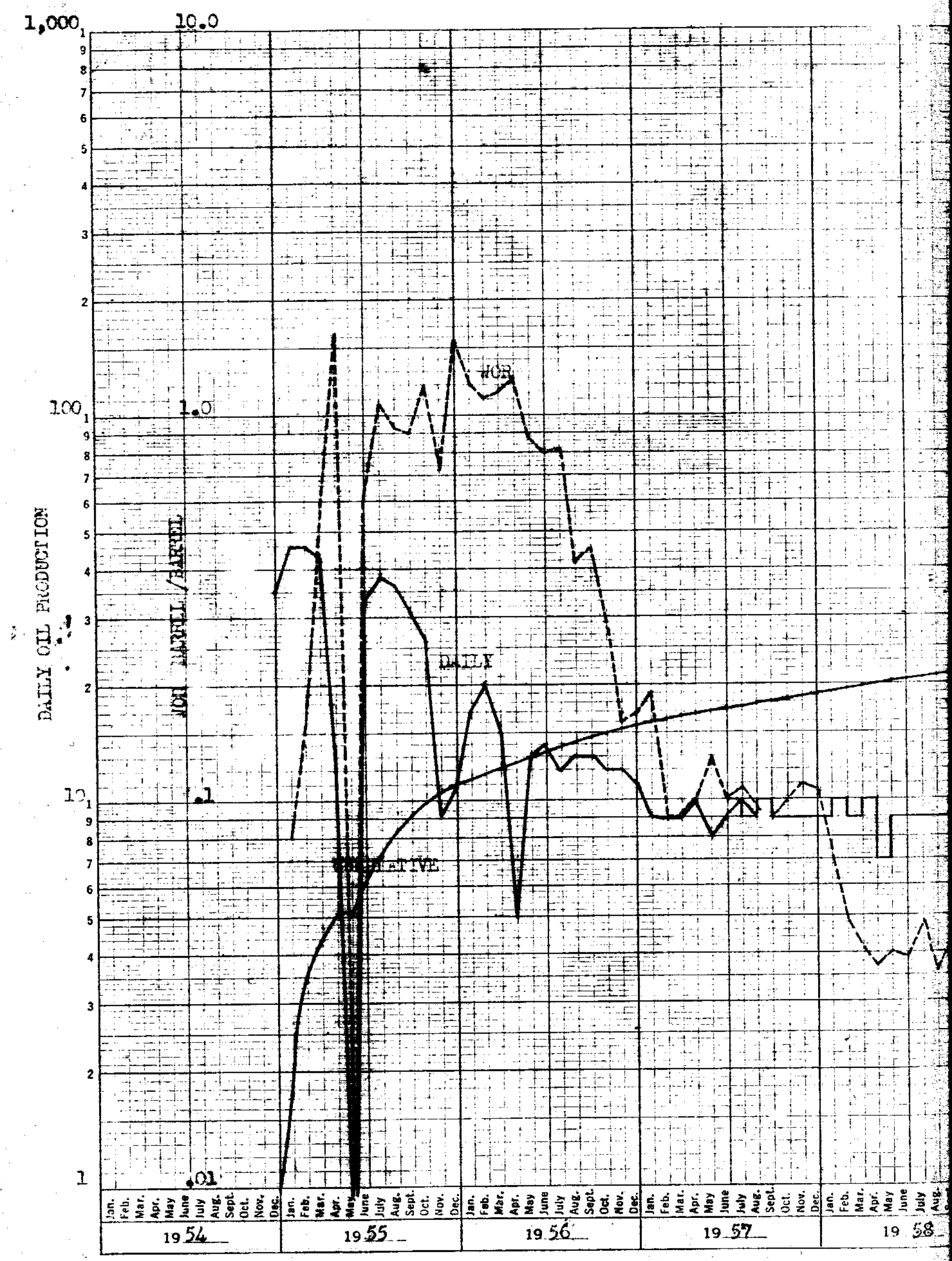
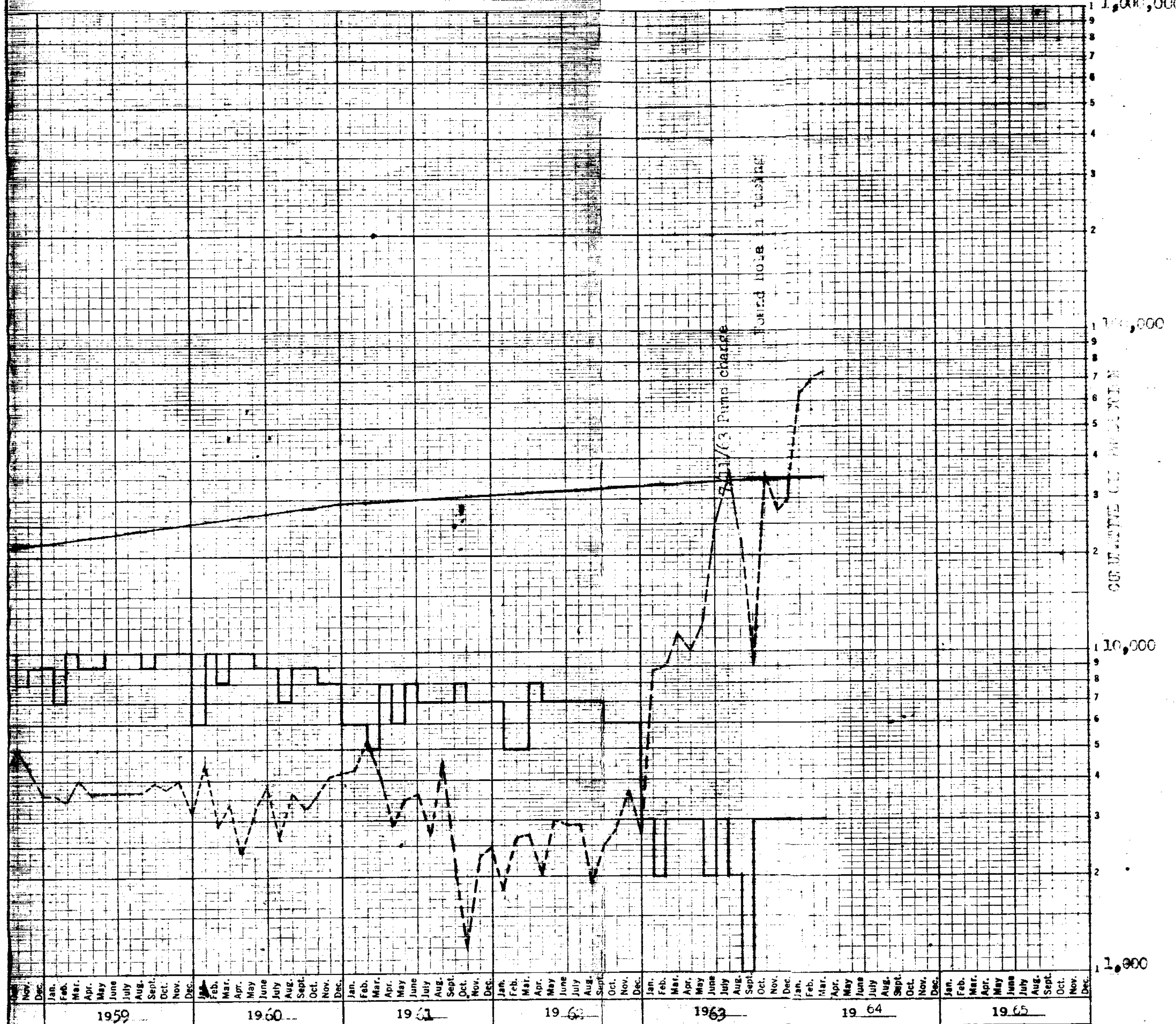

K+E 10 YEARS BY MONTHS 359-205L
X 3 CYCLES
KEUFFEL & ESSER CO.
MADE IN U.S.A.
No water prod.
Suspended Oct. 1962
CUM. PRODUCTION

FIGURE 16

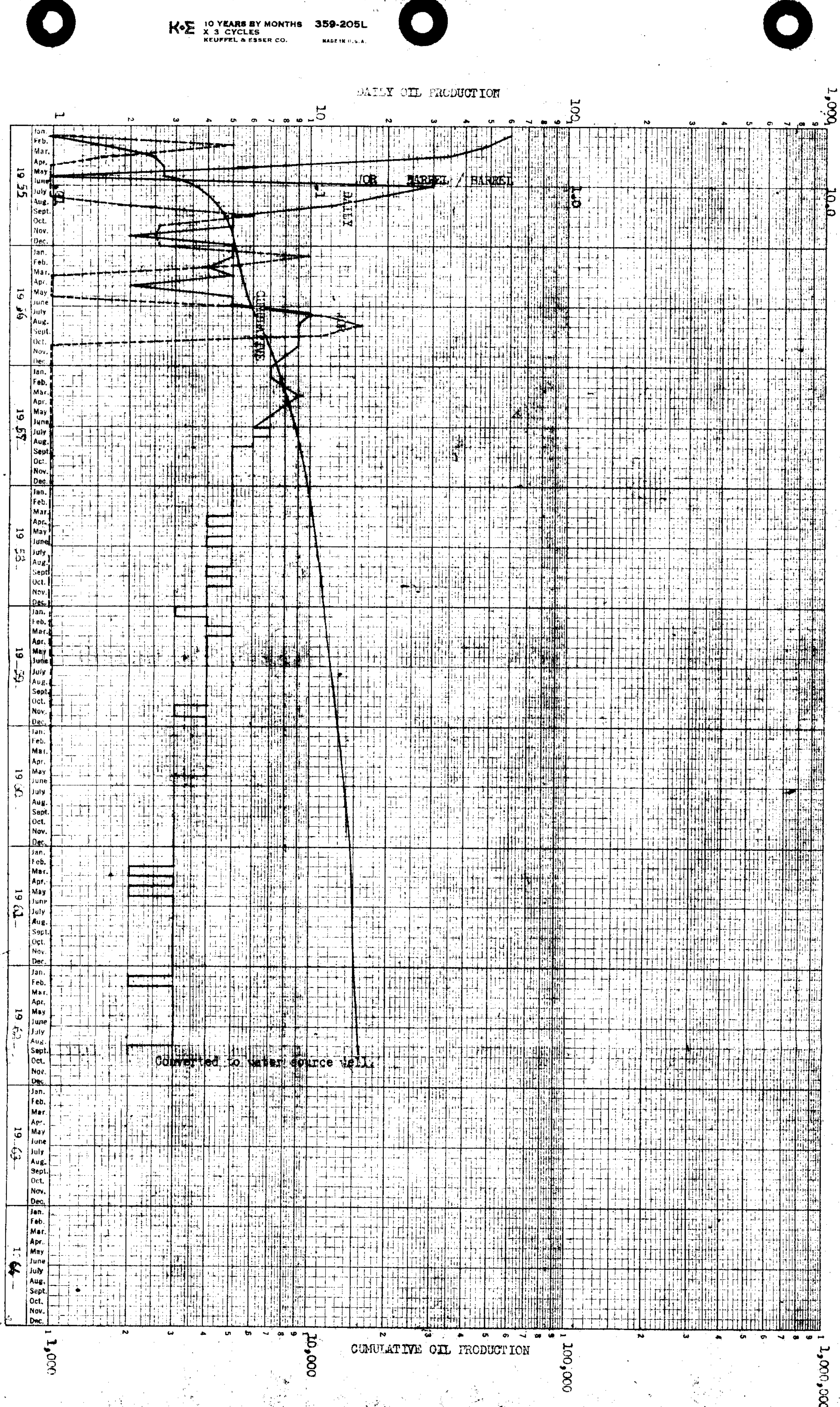

DAILY OIL PRODUCTION
WOR BARREL/BARREL
1,000
100
10
1
10.0
1.0
.1
.01
WOR
DAILY
CUMULATIVE
1954
1955
1956
1957
1958



T. McDOUGALL 3-26

LODGEPOLE

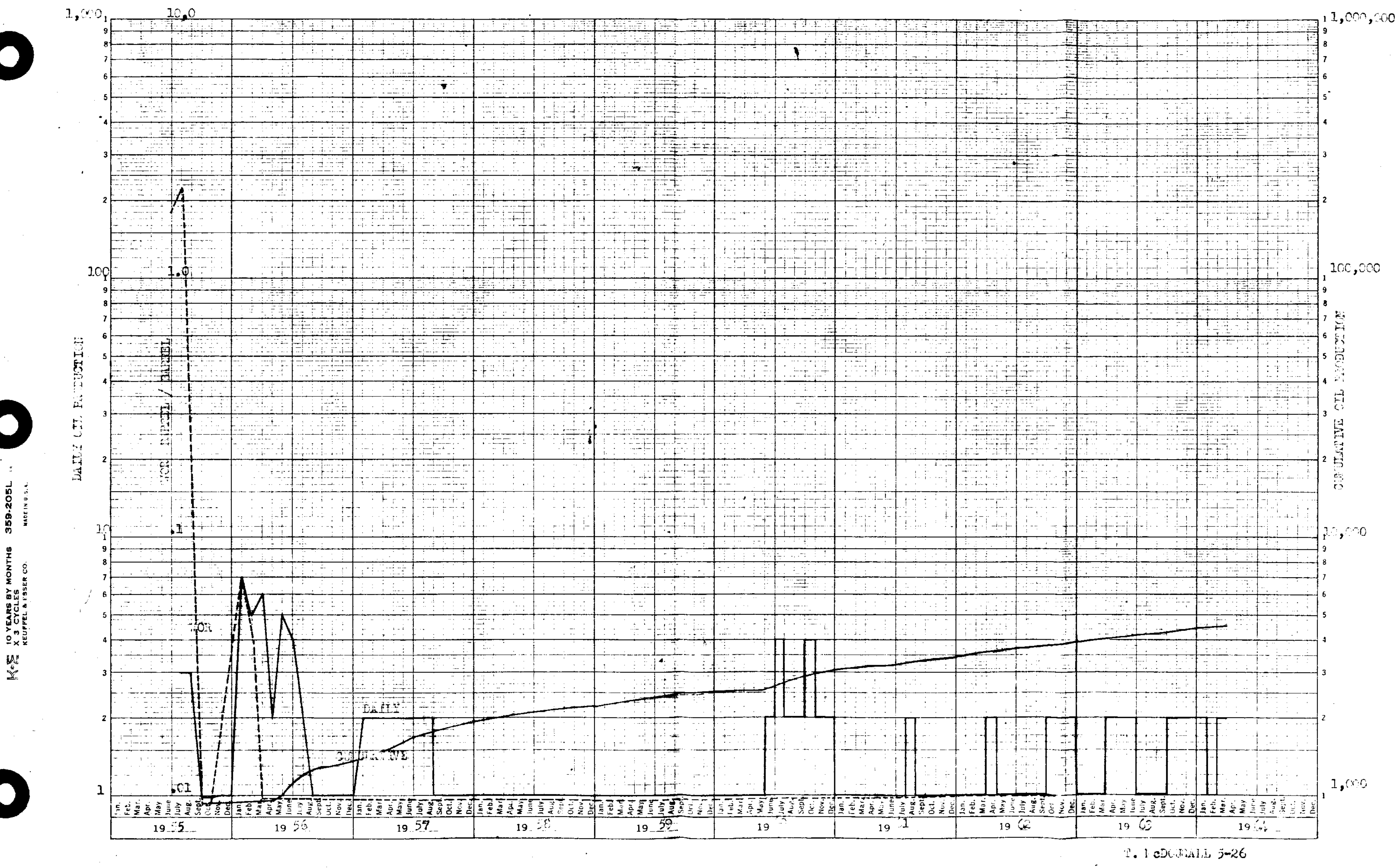
FIGURE 17



T. McDOWELL 4-26

LODGEPOLE

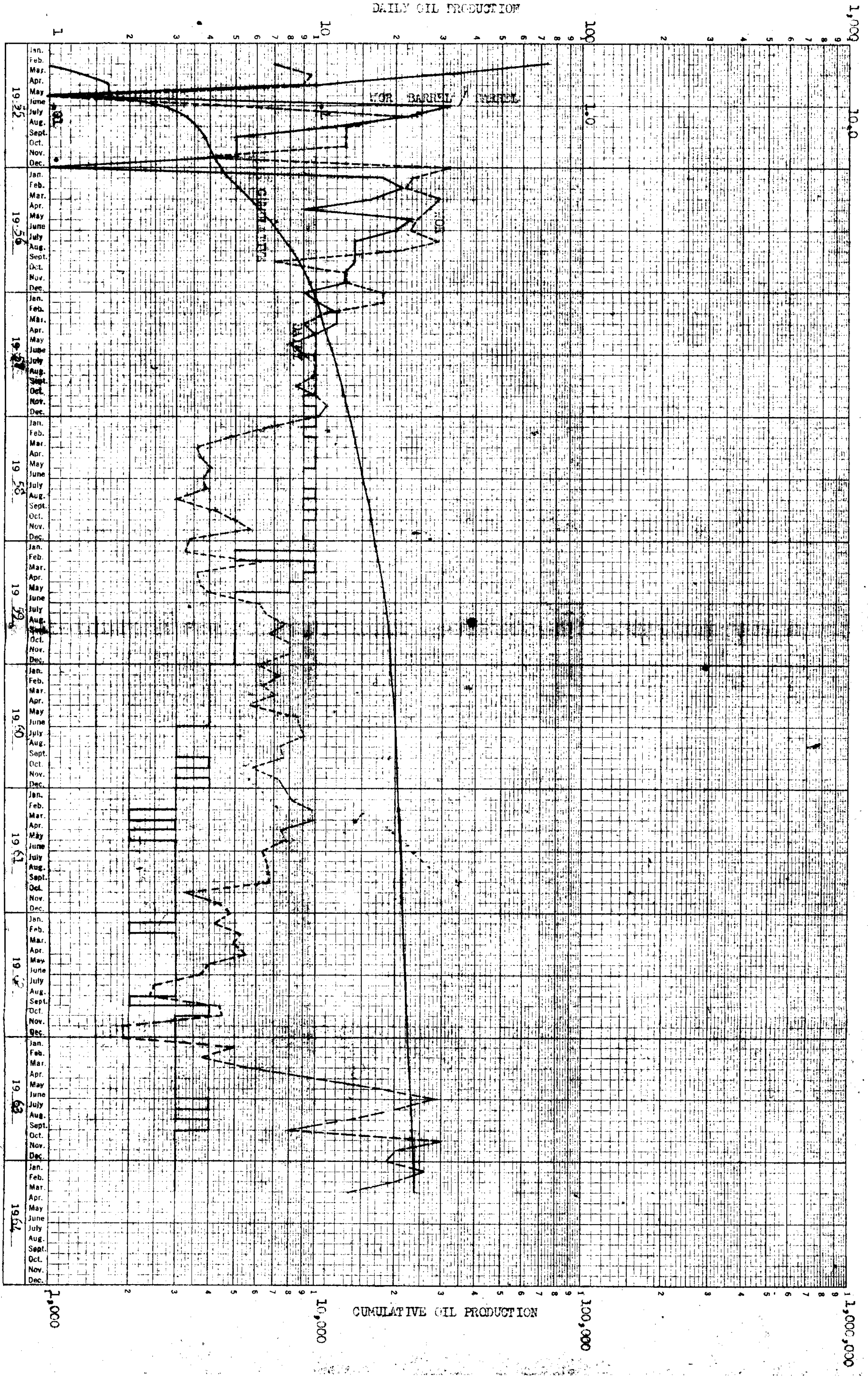
FIGURE 18



DAILY OIL PRODUCTION
GOR CUBIC FEET / BARREL
CUMULATIVE OIL PRODUCTION
GOR
DAILY
CUMULATIVE
1955
1956
1957
1958
1959
1961
1962
1963
1964
T. McDOUGALL 5-26
LODGEPOLE

FIGURE 19

K+E 10 YEARS BY MONTHS X 3 CYCLES 359-205L
KEUFFEL & ESSER CO. MADE IN U.S.A.



T. McDOUGALL 6-26
EBOR - LODGEPOLE

FIGURE 20

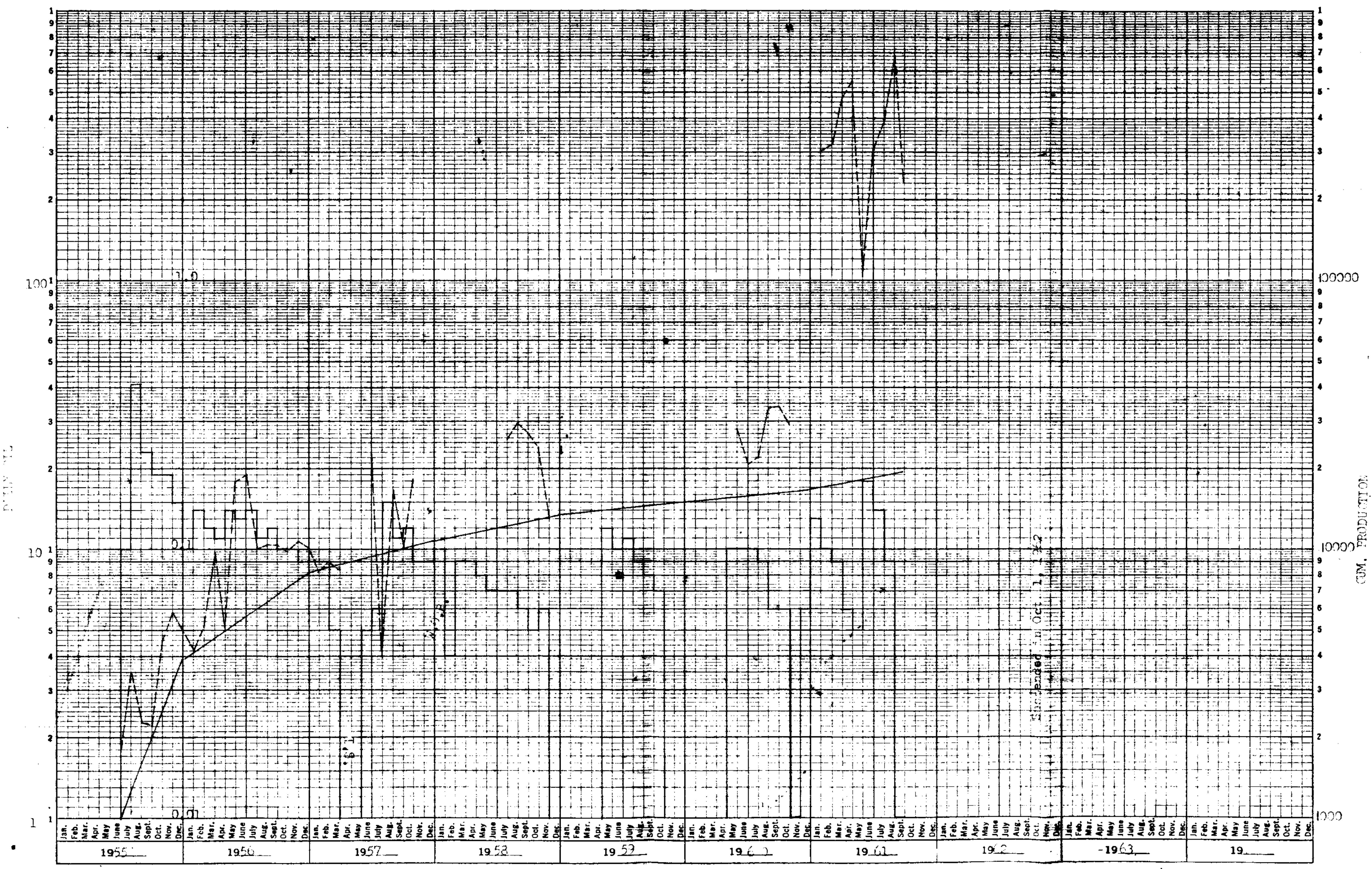
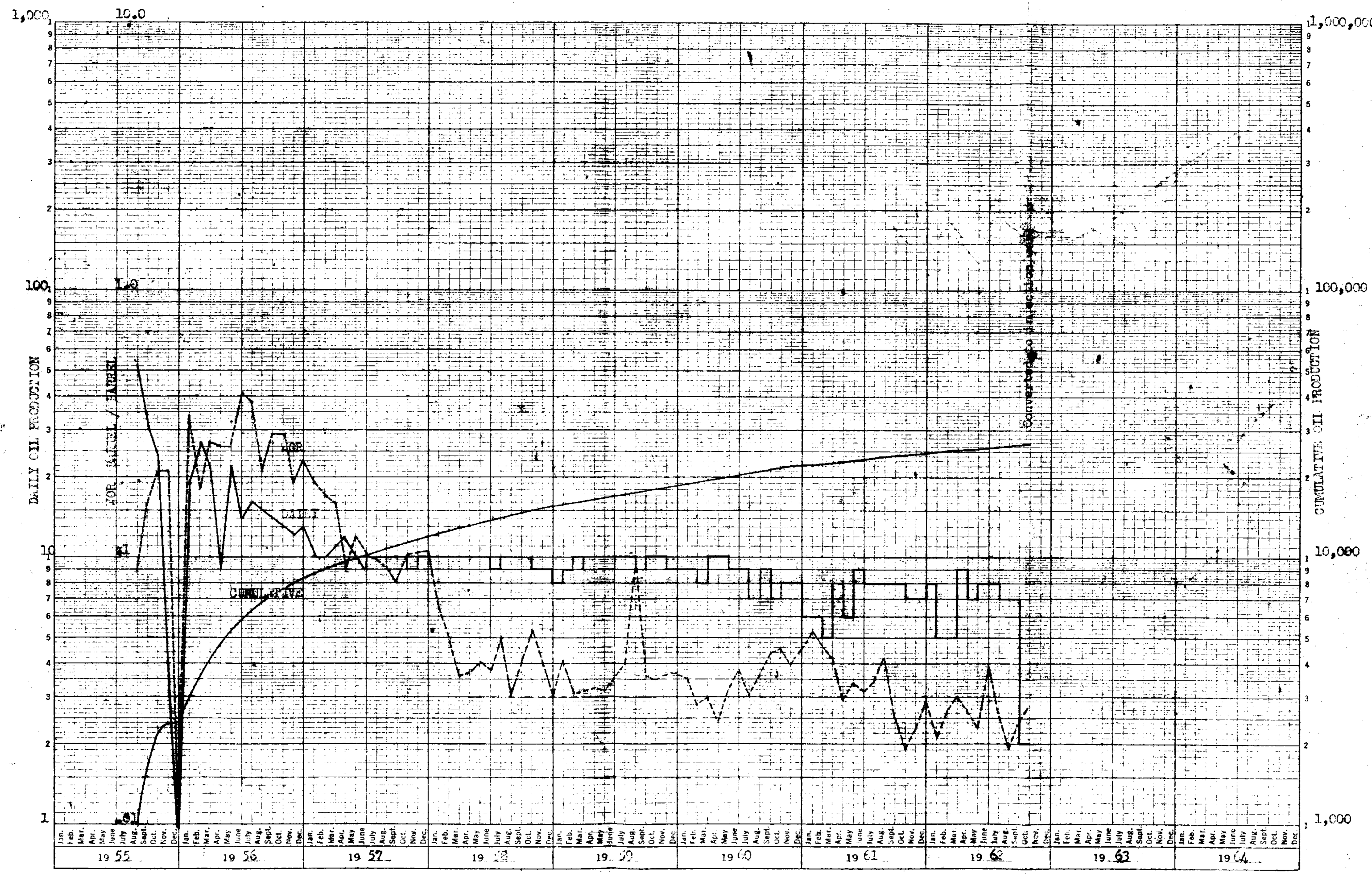

K+E 10 YEARS BY MONTHS 359-205L
X 3 CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.
CUM. PRODUCTION
1000
10000
100000
1955
1956
1957
1958
1959
1960
1961
1962
1963
19
Suspended in Oct. 1, 1962

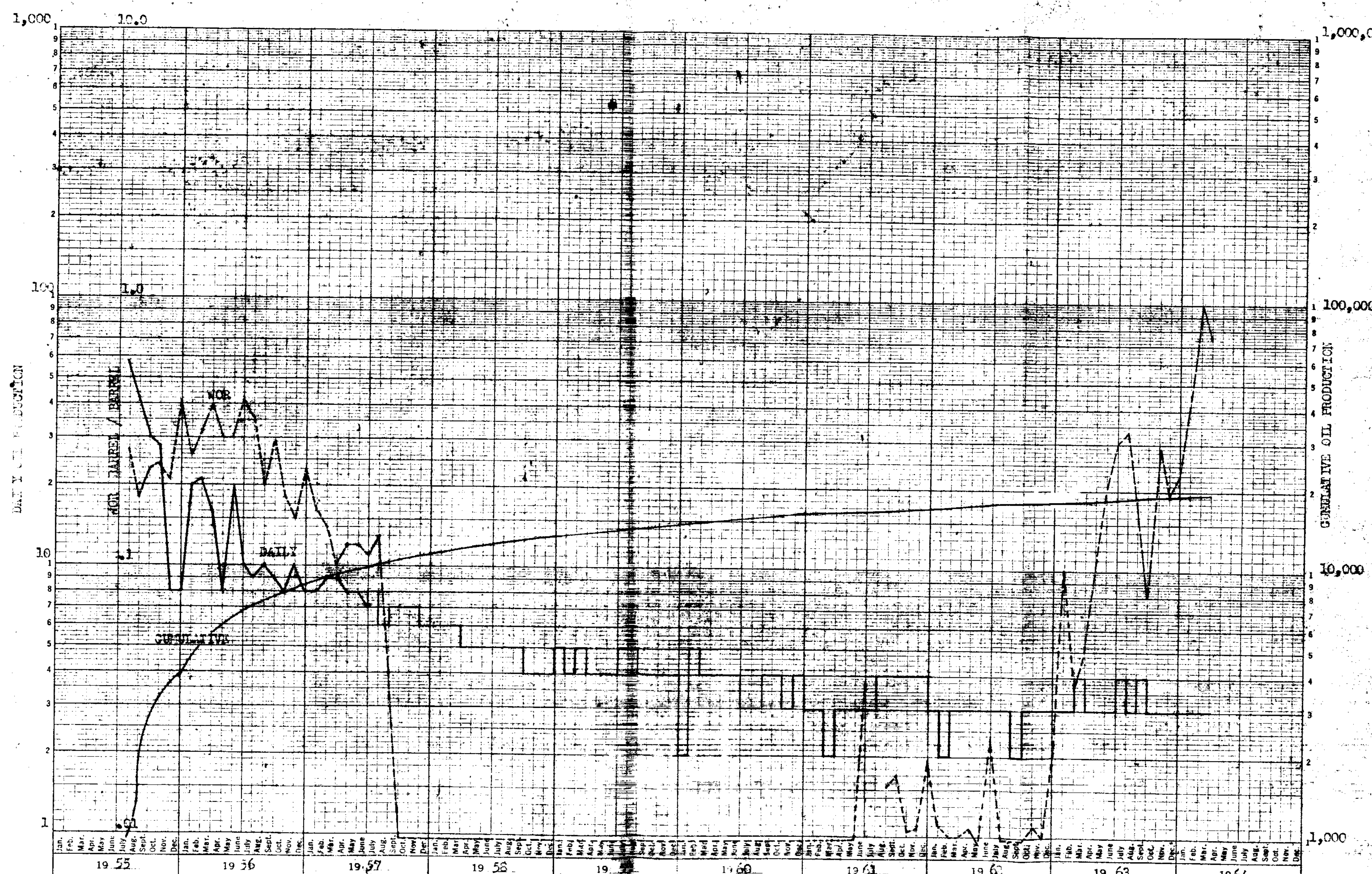
FIGURE 21



T. McDOUGALL

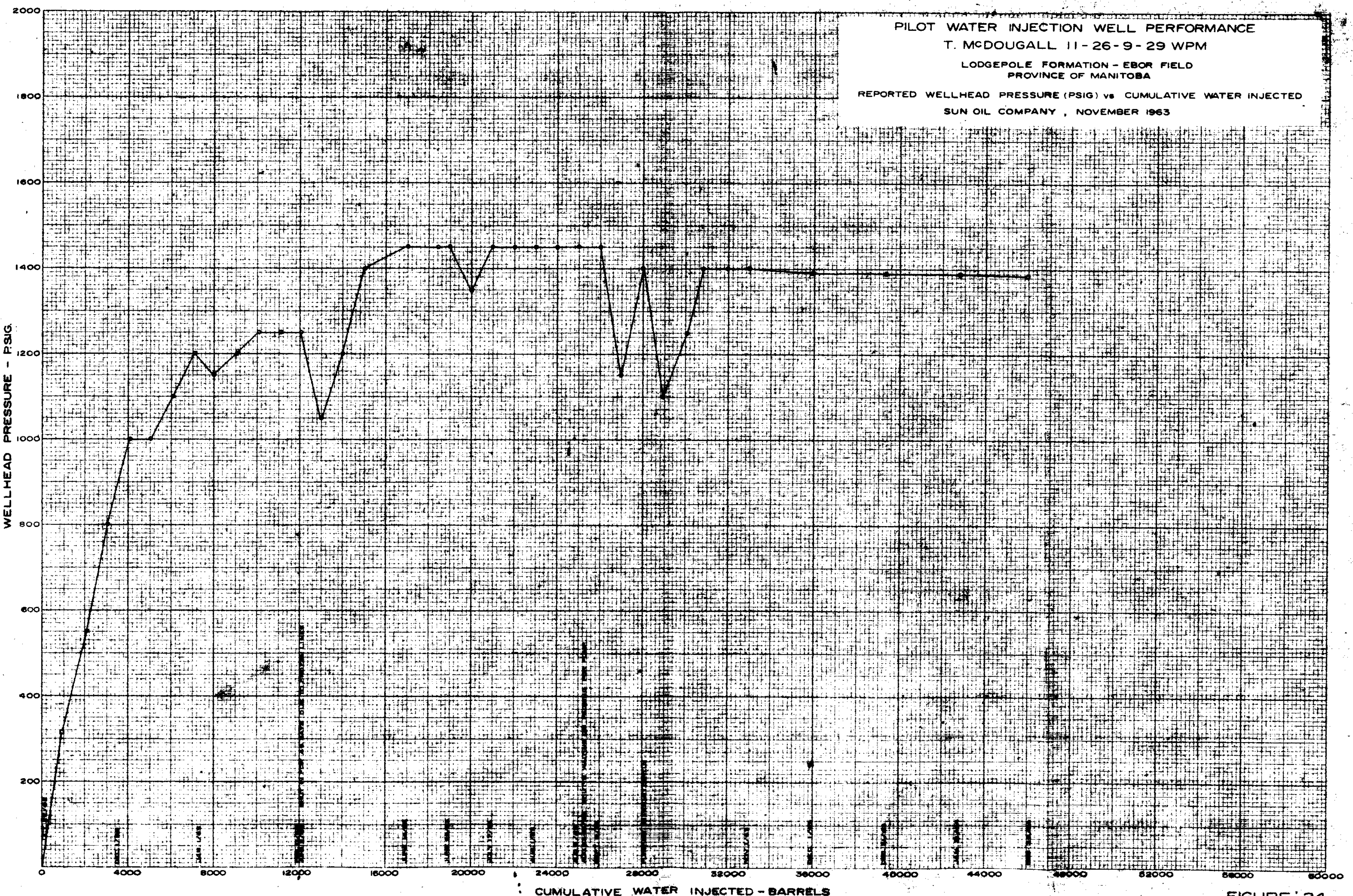
EBOR LOCKPORT

FIGURE 22



T. McDOUGALL 12-26

EBCR LODGEPOLE FIGURE 23



PILOT WATER INJECTION WELL PERFORMANCE
T. McDOUGALL 11-26-9-29 WPM
LODGEPOLE FORMATION - EBOR FIELD
PROVINCE OF MANITOBA
REPORTED WELLHEAD PRESSURE (PSIG) vs CUMULATIVE WATER INJECTED
SUN OIL COMPANY, NOVEMBER 1963
WELLHEAD PRESSURE - P.SIG.
CUMULATIVE WATER INJECTED - BARRELS
20 X 20 PER INCH
0
200
400
600
800
1000
1200
1400
1600
1800
2000
4000
8000
12000
16000
20000
24000
28000
32000
36000
40000
44000
48000
52000
56000
60000

FIGURE 24

CORE LAB

CORE LABORATORIES-CANADA LTD.

PETROLEUM RESERVOIR ENGINEERING

CALGARY, ALBERTA

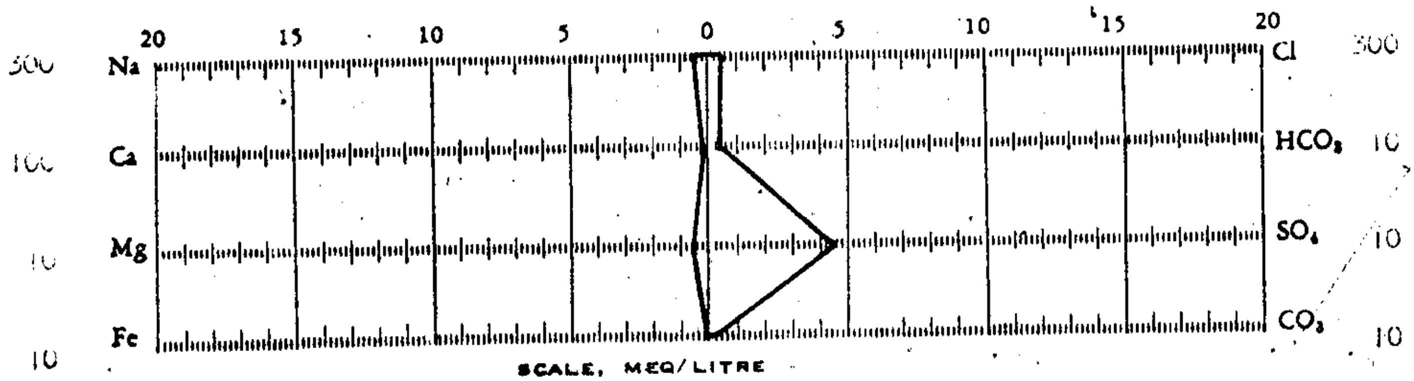
WATER ANALYSIS

Compatability

File CPL-2 WA-1626

Company Sun Oil Company	Well Name: Sun McDougall 4-26	Sample No. 9
Formation Jurassic	Depth -	Sampled From Swab
Location LSD 4-26-9-23 W2M	Field Ebor	Province Saskatchewan
Date Sampled Oct. 4, 1962	Date Analyzed Oct. 15, 1962	Analyst WZ:RY

Constituents		*Constituents*	Meq/L	ppm	*Constituents*	Meq/L	ppm
1. Total Solids	11796 ppm	6. Sodium	181	4163	11. Chloride	140	4970
2. pH	8.5	7. Calcium	5	104	12. Bicarbonate	4	275
3. Sp. gr	1.0113 @ 60 °F.	8. Magnesium	5	58	13. Sulfate	45	2180
4. Resistivity	0.62 @ 71 °F OHMS/M^2M	9. Iron	Absent		14. Carbonate	2	48
5. Hydrogen Sulfide	Absent	10. Barium	Absent		15. Hydroxide	Absent	



HYPOTHETICAL COMBINATIONS

Constituent	ppm	*Constituent*	ppm
1. Calcium Chloride	288	4. Sodium Chloride	7956
2. Magnesium Bicarbonate	327	5. Sodium Sulfate	3195
3. Magnesium Chloride	48		

Testing Jurassic for source water
producing quantities of fine sand by W. Cunningham

FIGURE 25