

Production / Drilling / Completion

- ☺ **Production Data**
- ☺ **Drilling Information**
- ☺ **Completion Information**
- ☺ **Workover Performance**
- ☺ **Commingled Wells**

Drilling and Completion Data

Well Location Map

No. of Wells

184	Penetrated the Bakken.
86	Completed in Bakken.
78	Produced or Producing from Bakken.
6	Wells injecting water in Bakken.
66	Currently COOP from Bakken.

Production Data

Discovery Well 13-21-10-29 WPM:

- On production on October, 1985.
- Initial Prod. 8.5 m³/day oil & 0.2 m³/day water.
- Cumulative Prod. 11,668 m³ oil & 352 m³ water.

Total Bakken Production:

- Prod. 104 m³/day oil & 140 m³/day H₂O (59 wells).
- 1.8 m³/day/well oil & 2.4 m³/day/well water
- Cum. Prod. 182,270 m³ oil & 132,763 m³ water.



Type :

Cum	011	m3	11668
Cum	Gas	E3m3	0
Cum	Water	m3	352



DALY BAKKEN POOLS (NON-CONF. WELLS)

04/25/95 16:56

Date 8510-9412

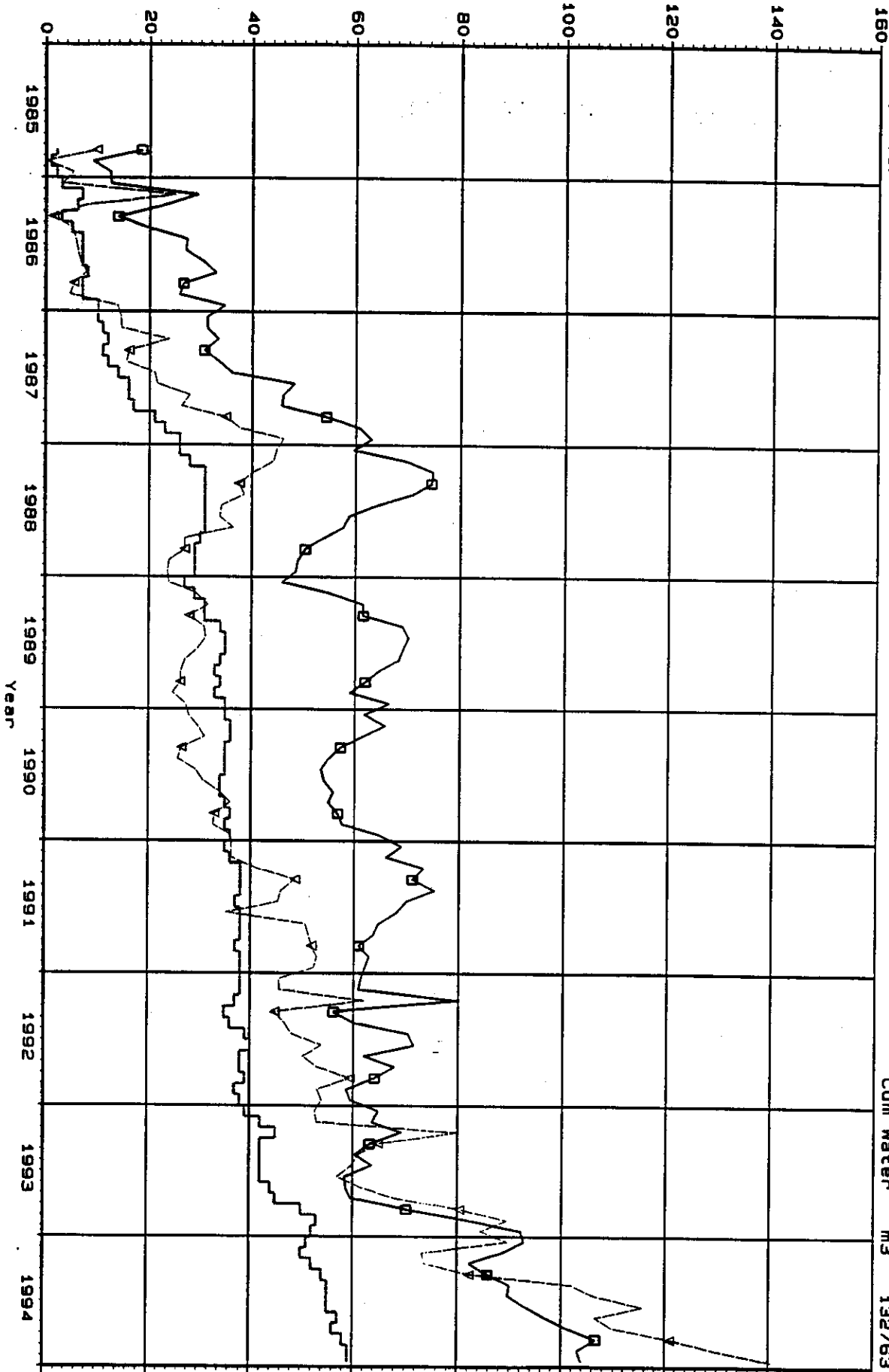
Operator :

Field :

Zone/Pool:

Type :

Cum Oil m3 162270
Cum Gas E3m3 0
Cum Water m3 132763



V Avg Daily Water m3/d
 O Avg Daily Oil m3/d

Num Wells

"A" Pool Production Data

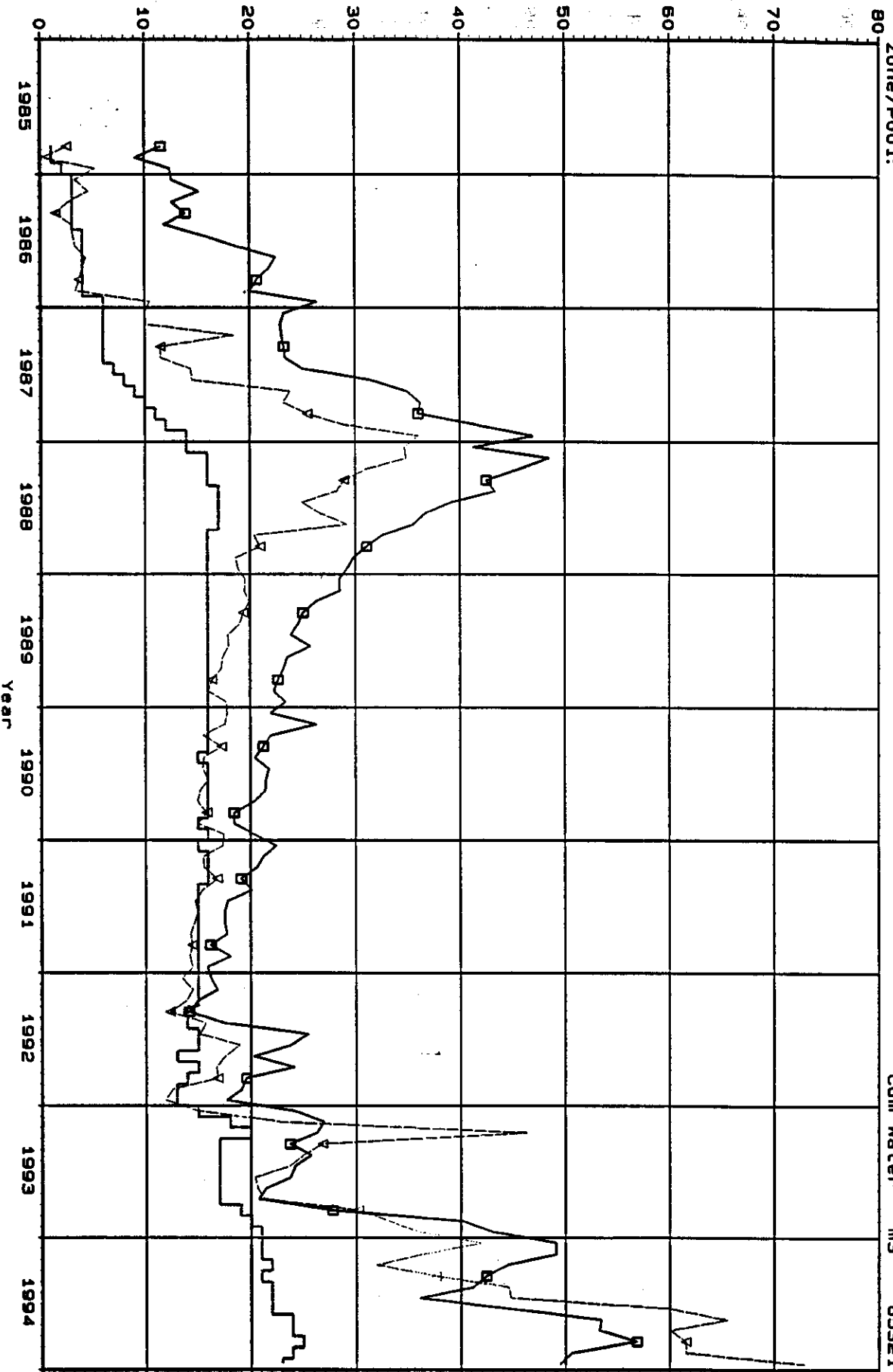
- ☺ On production on October 1985.
- ☺ 15% - 20% Decline rate per Year.
- ☺ Waterflood Implemented in 1992.
- ☺ Current Prod. 50 m³/day oil & 73 m³/day water
(23 wells).
- ☺ 2.2 m³/day/well oil & 3.2 m³/day/well water.
- ☺ Cum. Prod. 83,776 m³ oil & 65,321 m³ water.

DALY BAKKEN "A" (01-60A)

04/10/95 12:07

Date 8510-9412
Operator :
Field :
Zone/Pool:

Type :
Cum Oil m3 83776
Cum Gas E3m3 0
Cum Water m3 65321



--- V Avg Daily Water m3/d
--- D Avg Daily Oil m3/d

Num Wells

"B" Pool Production Data

- ☉ On production - February 1986.
- ☉ $\pm 20\%$ Decline Rate per Year.
- ☉ Current Prod. 2.7 m³/day oil & 3.5 m³/day water
(9 wells).
- ☉ 0.3 m³/day/well oil & 0.4 m³/day/well water.
- ☉ Cum. Prod. 16,029 m³ oil & 8,692 m³ water.

DALY BAKKEN "B" (01-608)

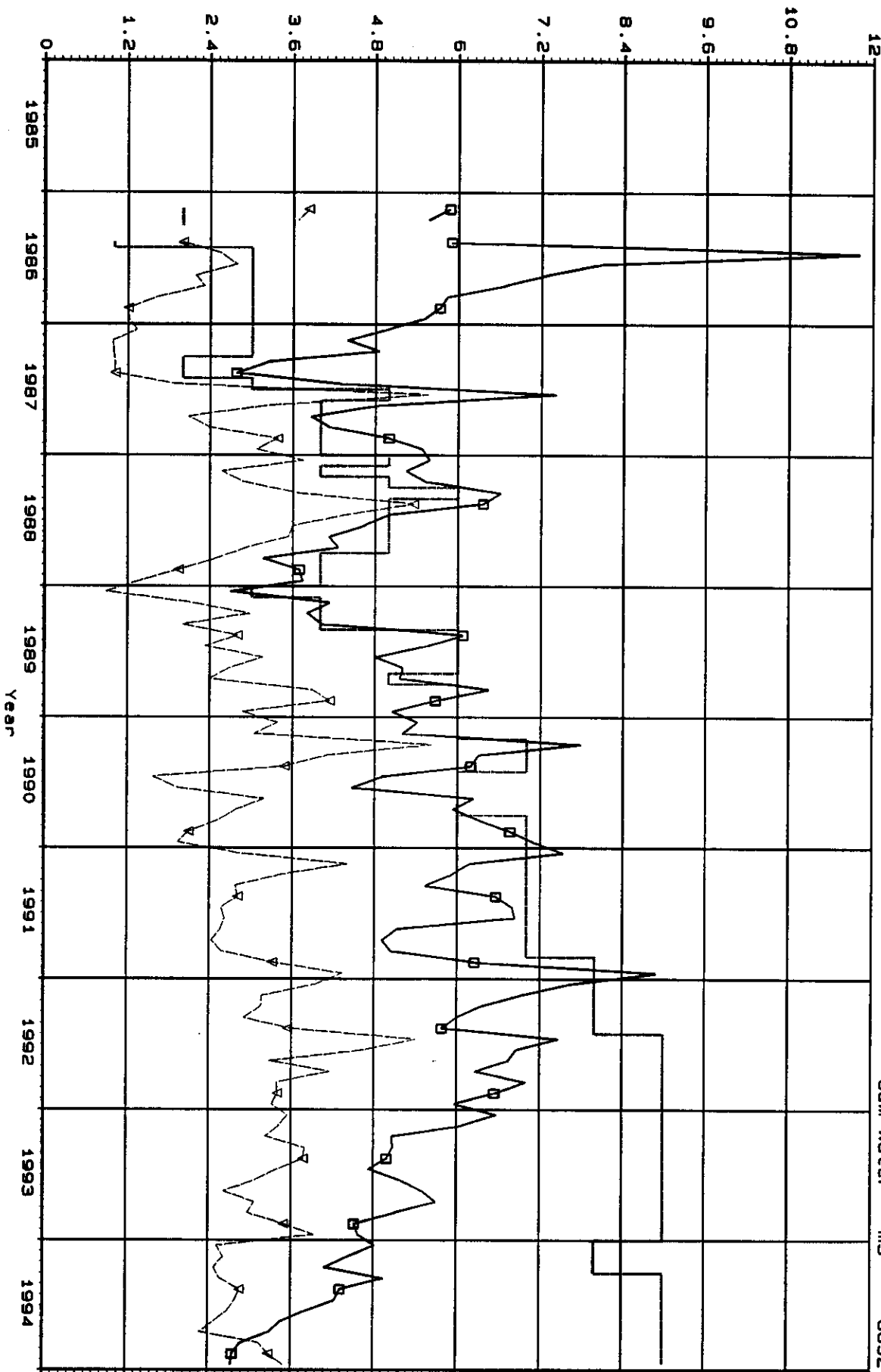
04/17/95 10:52

Date 8602-9412

Type :

Operator :
Field :
Zone/Pool:

Cum Oil m3 16029
Cum Gas E3m3 0
Cum Water m3 8692



V Avg Daily Water m3/d
 O Avg Daily Oil m3/d

Num Wells

"D" Pool Production Data

- ☉ On production - December 1986.
- ☉ \pm 20% Decline Rate per Year.
- ☉ Current Prod. 23 m³/day oil & 42 m³/day water
(12 wells).
- ☉ 1.9 m³/day/well oil & 3.5 m³/day/well water.
- ☉ Cum. Prod. 70,766 m³ oil & 50,496 m³ water.

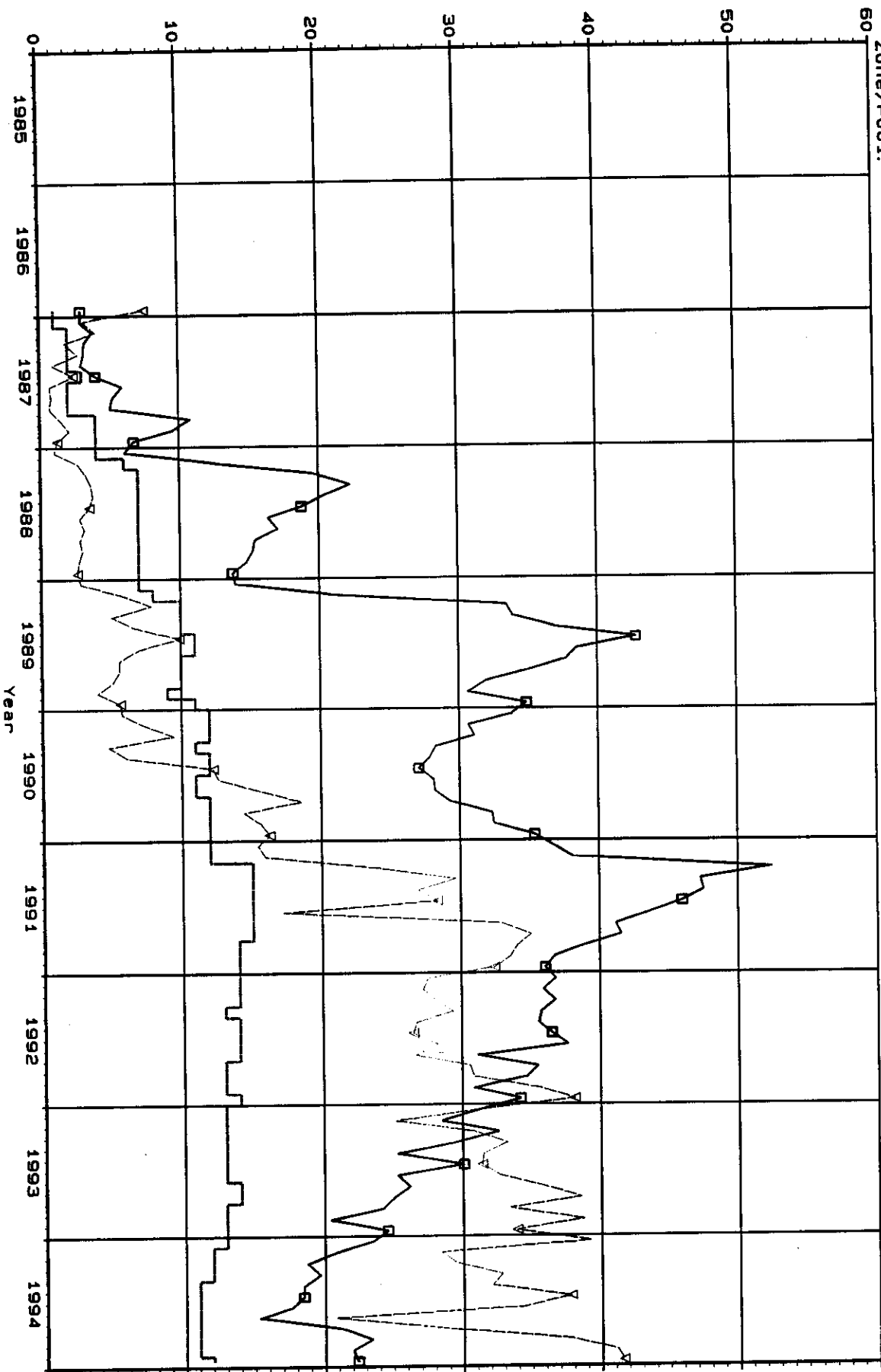
DALY BAKKEN "D" (01-60D)

04/14/95 09:29

Type :

Data 8612-9412
Operator :
Field :
Zone/Pool:

Cum Oil m3 70766
Cum Gas E3m3 0
Cum Water m3 50496



Δ Avg Daily Water m3/d
□ Avg Daily Oil m3/d

Num Wells

"I" Pool Production Data

- ☉ On production - July 1992.
- ☉ Prod. 13.5 m³/day oil & 1.5 m³/day water
(6 wells).

- ☉ 2.25 m³/day/well oil & 0.25 m³/day/well water.
- ☉ Cum. Prod. 6,583 m³ oil & 1,168 m³ water.

DALY BAKKEN "I" (01-601)

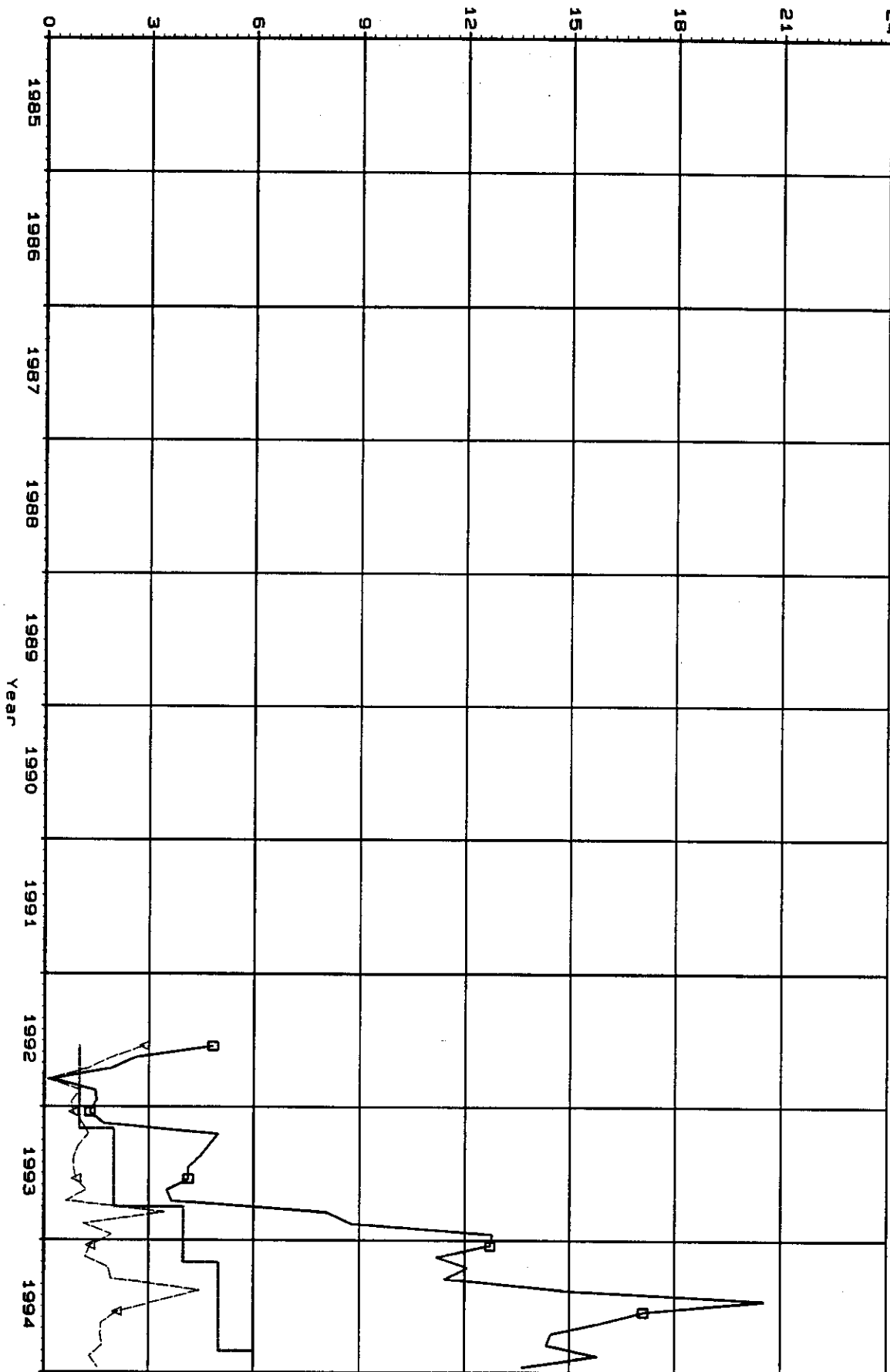
04/25/95 19:11

Date 9207-9412

Type :

Operator :
Field :
Zone/Pool:

Cum Oil m3 6583
Cum Gas E3m3 0
Cum Water m3 1168



V Avg Daily Water m3/d
O Avg Daily Oil m3/d

Num Wells

"K" Pool Production Data

- ☺ On production - August 1993.
- ☺ Prod. 6.6 m³/day oil & 5.0 m³/day water
(4 wells).
- ☺ 1.65 m³/day/well oil & 1.25 m³/day/well water.
- ☺ Cum. Prod. 1,988 m³ oil & 1,819 m³ water.

DALY BAKKEN "K" (01-60K) NON-CONF WELLS

04/25/95 19:05

Type :

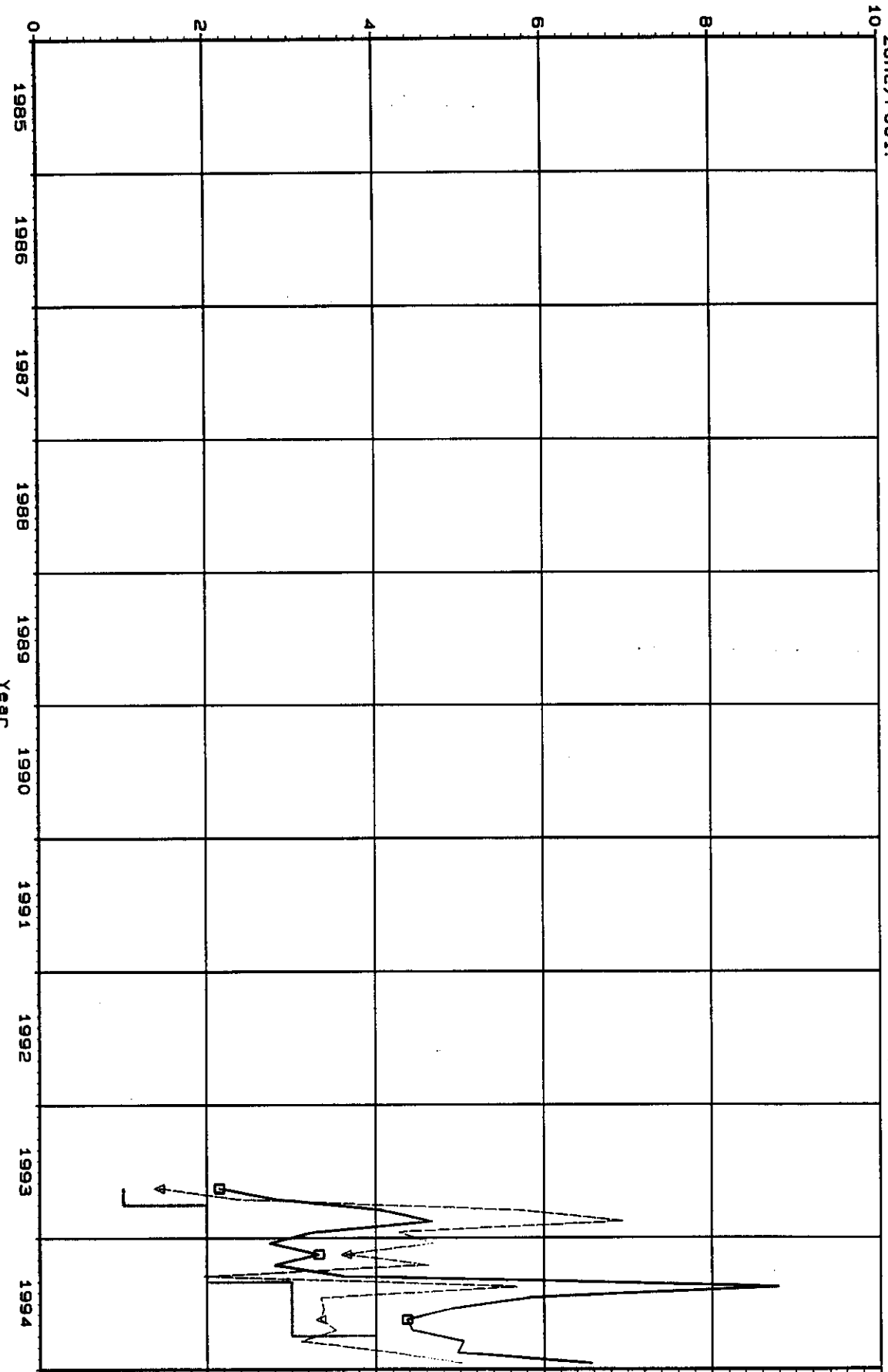
Date 9308-9412

Operator :

Field :

Zone/Pool:

Cum Oil m3 1986
Cum Gas E3m3 0
Cum Water m3 1819



Δ Avg Daily Water m3/d
□ Avg Daily Oil m3/d

Num Wells

"N" Pool Production Data

- ☺ On production - November 1993.
- ☺ Current Prod. 3.5 m³/day oil & 11.5 m³/day water

(3 wells).

- ☺ 1.7 m³/day/well oil & 3.8 m³/day/well water.
- ☺ Cum. Prod. 821 m³ oil & 3,178 m³ water.

DALY BAKKEN "N" (01-60N)

04/14/95 09:43

Type :

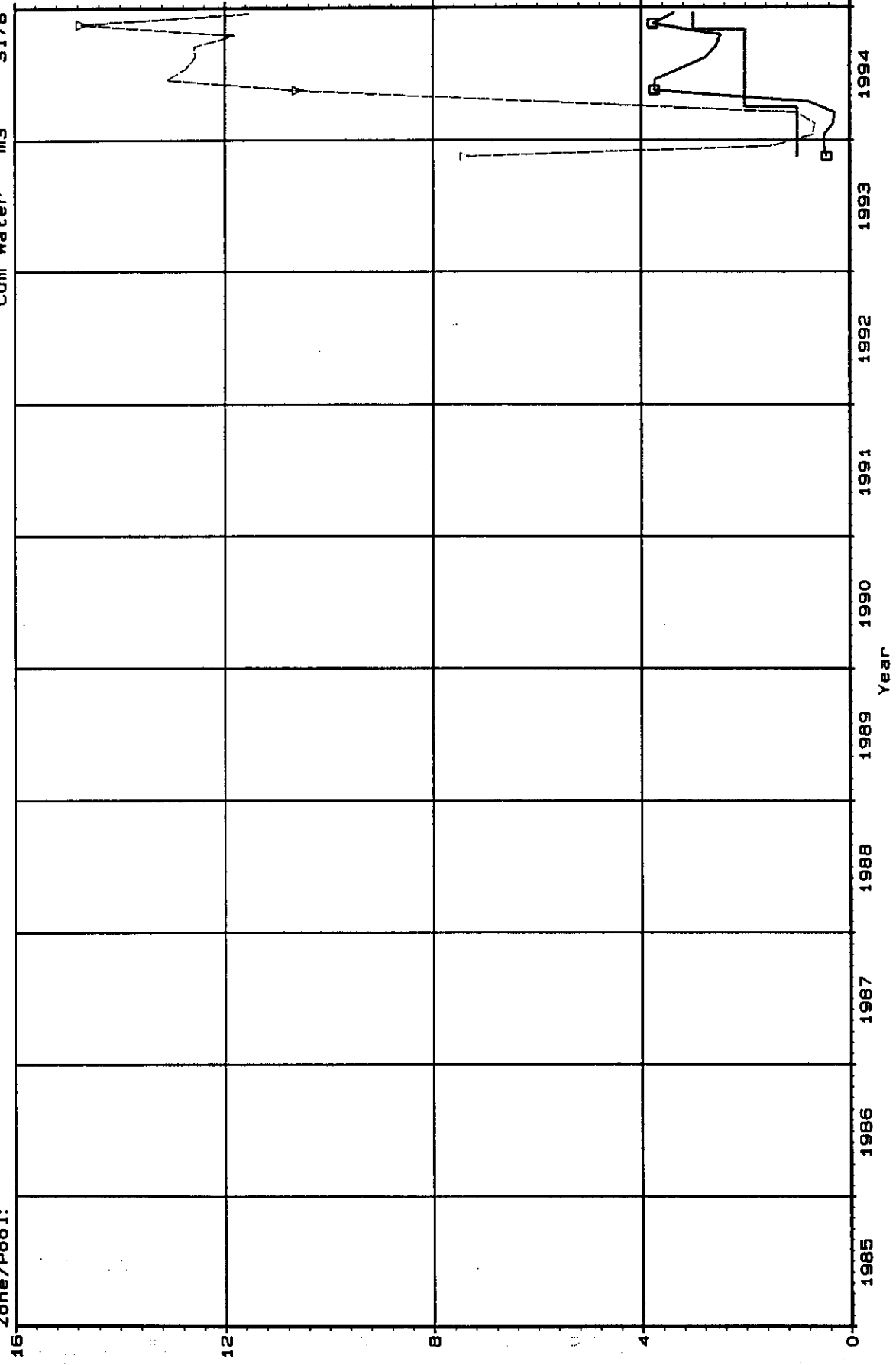
Date 9311-9412

Operator :

Field :

Zone/Pool:

Cum Oil m3 821
Cum Gas E3m3 0
Cum Water m3 3178



Num Wells

V Avg Daily Water m3/d
 O Avg Daily Oil m3/d

BAKKEN DRILLING INFORMATION													CASING
LJC. NO.	STATUS			DRILLED / SPUD/REENTRY				CORE			/LINER SIZE		
	BAKKEN	WELL		DEEPEMED	MONTH	LOGGED	CORED	ANALYSIS	DST				
11	9	10	28	4081	ABD. DRY	COOP	DRILLED	Jul-88	YES	YES	NO	NO	139.7
12	9	10	28	3959	N/C	COOP	DRILLED	Nov-87	YES	NO	NO	NO	139.7
1	10	10	28	220	N/C	ABD. P.	DRILLED	Oct-52	YES	YES	NO	NO	177.8
16	10	10	28	3697	COOP	COOP	DEEPEMED	Aug-93	YES	NO	NO	NO	114.3
10	12	10	28	167	N/C	WIW	DRILLED	Jun-52	YES	YES	YES	NO	177.8
A 10	12	10	28	2571		ABD. STH.	DRILLED	Aug-77	YES	NO	NO	NO	139.7
8	14	10	28	666	N/C	ABD. WIW	DRILLED	Dec-54	YES	YES	YES	YES	177.8

Drilling Data

Bakken Oil Wells

<u>No. of Wells</u>	
170	Drilled into Bakken using drilling rig.
14	Deepened in Bakken using service rig.
184	Total
52	Cored in Bakken.
42	Core analysis done.

BAKKEN COMPLETION INFORMATION

PERFORATING				ACID WASH				ACID SQUEEZE				FRAC.				FIRST FIVE DAY TEST			
DATE	INTERVAL	METHOD		DATE	TYPE	VOL		DATE	TYPE	VOL		DATE	TYPE	AMT. FLUSH		DATE	OIL	WATER	
12-Mar-87	828.0-832.0	U. B.						13-Mar-87	MDA	0.50		14-Mar-87	GEL CRUDE (40/60)	5.0		21-Mar-87	0.9	1.0	
31-Mar-94	842.0-846.0	U. B.		31-Mar-94	15% HCL	0.45		31-Mar-94	15% HCL	0.45		06-May-94	POLY EML. (20/40)	5.0	-0.3	06-Apr-94	2.7	0.0	
15-Oct-93	839.0-843.0	U. B.		18-Oct-93	MDA	1.00		18-Oct-93	15% HCL	1.00		20-Nov-93	GEL (20/40)	5.0	-0.5	24-Oct-93	2.6	0.0	
12-Oct-94	835.2-838.5	OPEN HOLE										11-Oct-94		5.0					
	835.2-838.5	OPEN HOLE										06-May-94	POLY EML. (20/40)	5.0		04-Nov-93	8.7	1.0	
11-Mar-93	836.8-838.3	U. B.		30-Jun-93	MDA	0.50						07-May-94	POLY EML. (20/40)	0.5		14-Mar-93	6.5	0.0	
				30-Jun-93	15% HCL	0.50		17-May-94	15% HCL	1.00		28-May-94	POLY EML. (20/40)	5.0	-0.3				

Completion Data

No. of Wells

4	Completed Open Hole.
82	Perforated.
86	Total
9	Not acidized within 6 months of completion.
27	Frac'd within 6 months of completion.
15	Never Frac'd.
1	Never Acidized or Frac'd.

Recompletion Data

Bakken Oil Wells

No. of Wells

18 Re-Acidized (> 6 months of original acid job or Frac).

11 Showed significant productivity gains.

14 Re-Frac'd (> 6 months after original acid job or Frac).

13 Showed significant productivity gains.

Tundra North Ebor Unit No. 1.01-23-10-29

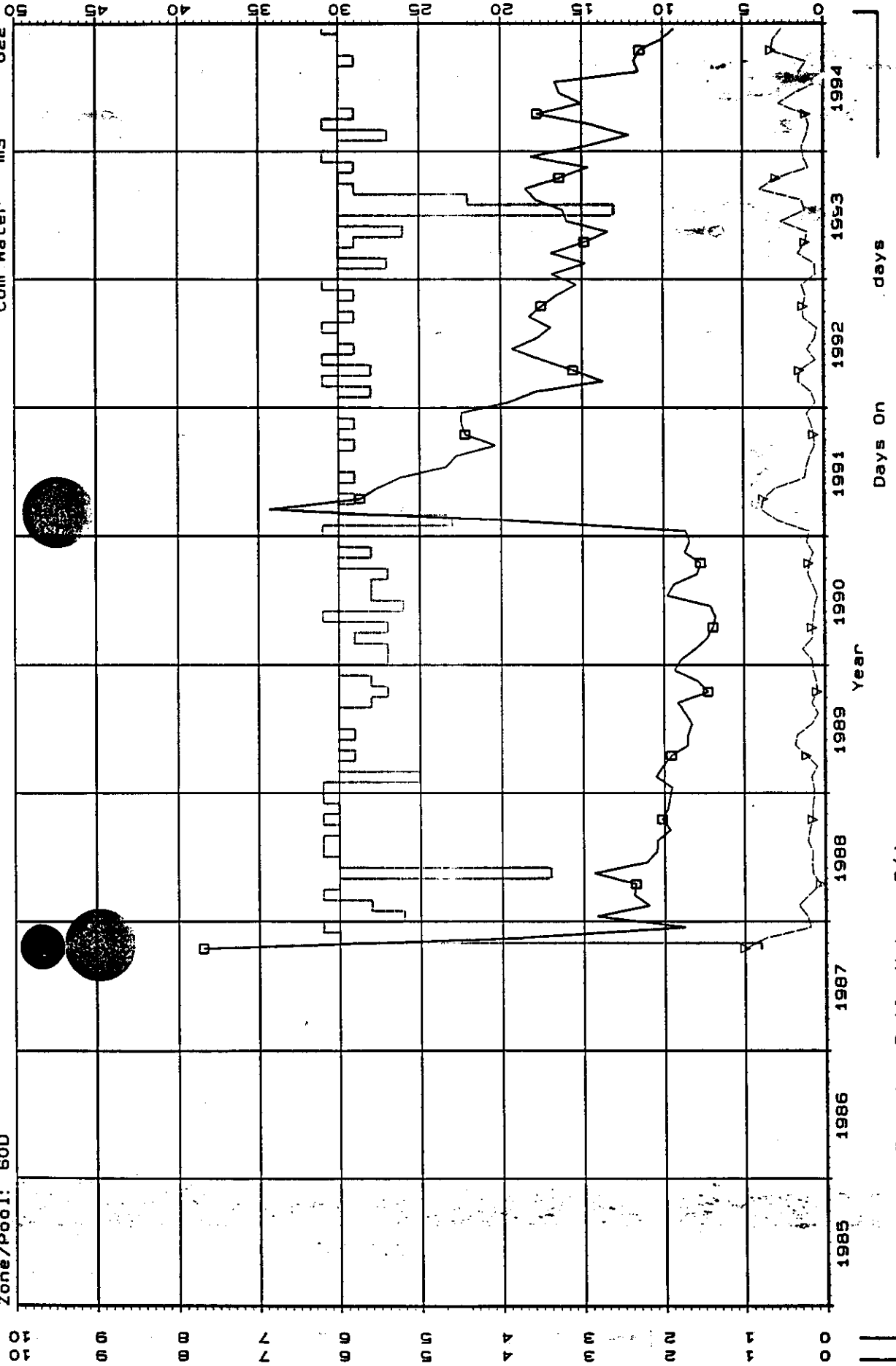
04/10/95 10:10

00/01-23-010-29W1/0 Data 8710-9412

Operator: 01
Field : 01
Zone/Pool: 60D

Type :

Cum Oil m3 6989
Cum Gas E3m3 0
Cum Water m3 622



Tundra North Ebor Unit No. 1 02-23-10-29

04/10/95 10:11

00/02-23-010-29W1/0 Data 8906-9412

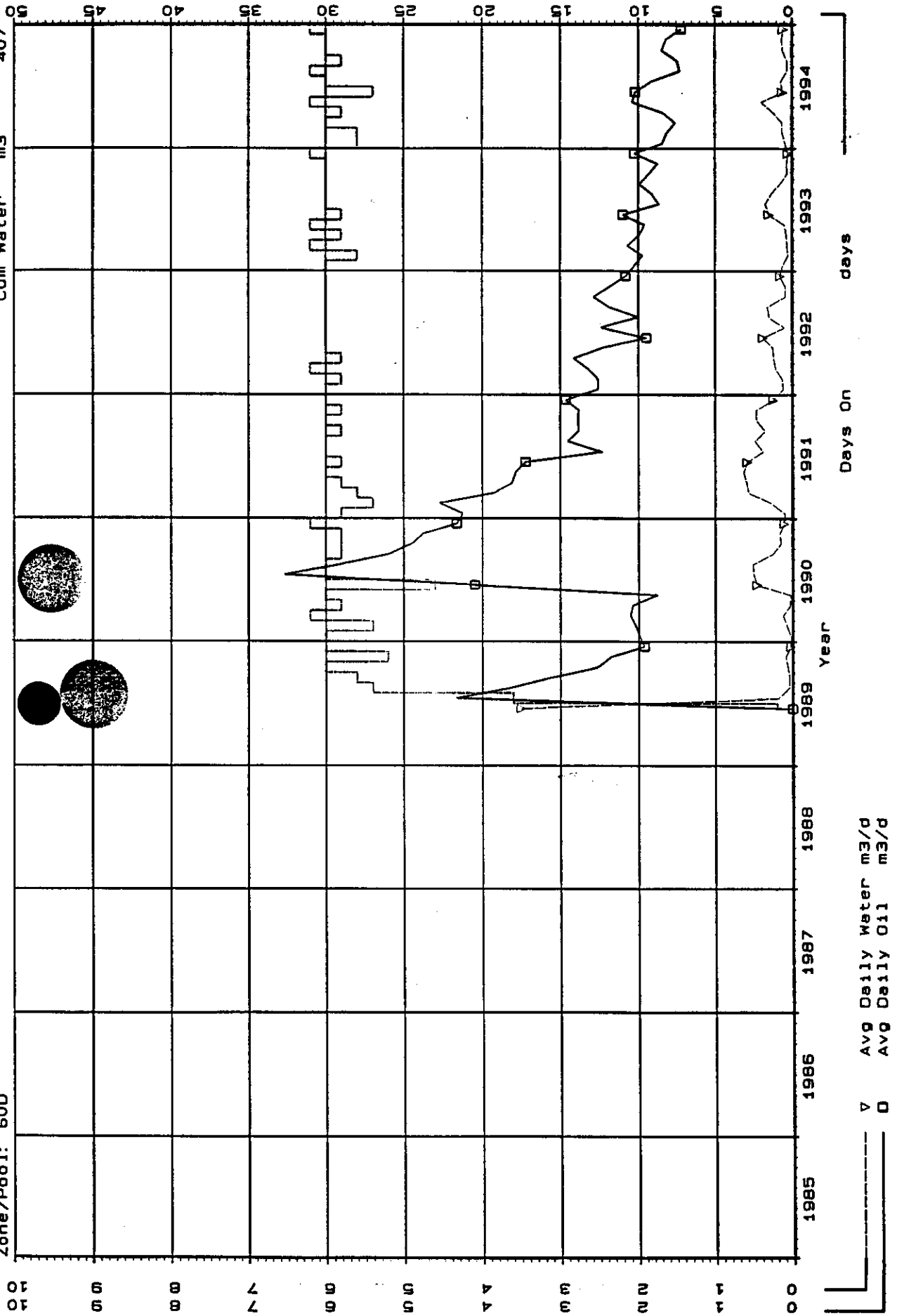
Operator :

Field : 01

Zone/Pool: 60D

Type :

Cum Oil m3 5093
Cum Gas E3m3 0
Cum Water m3 407



Tundra Kola Unit No. 1 04-28-10-29W1

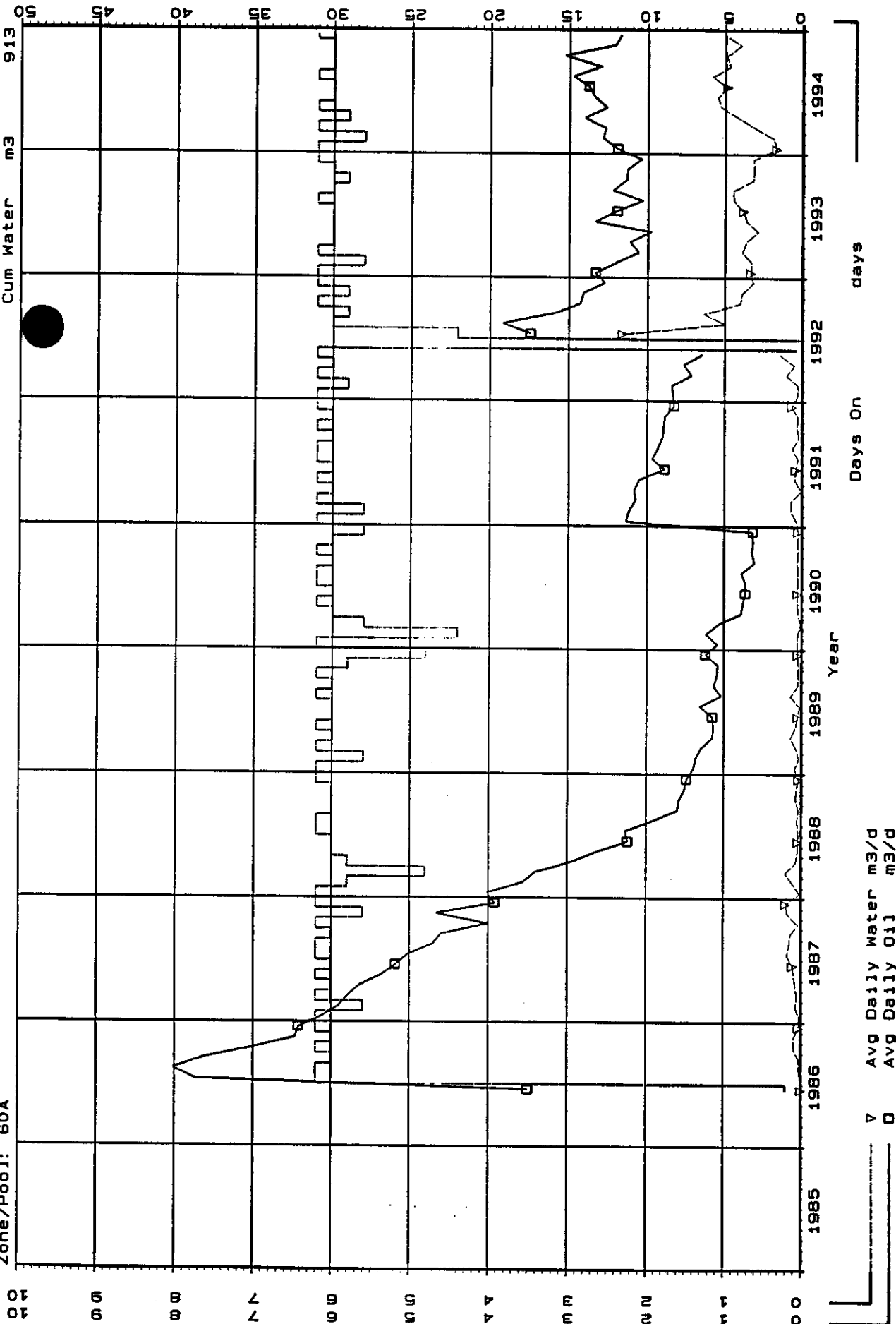
04/10/95 10:41

00/04-28-010-29W1/0 Data 8505-9412

Operator : 01
Field : 50A
Zone/Pool: 50A

Type :

Cum Oil m3 8036
Cum Gas E3m3 0
Cum Water m3 913



Tundra Kola Unit No. 1 Prov. 11-28-10-29W1

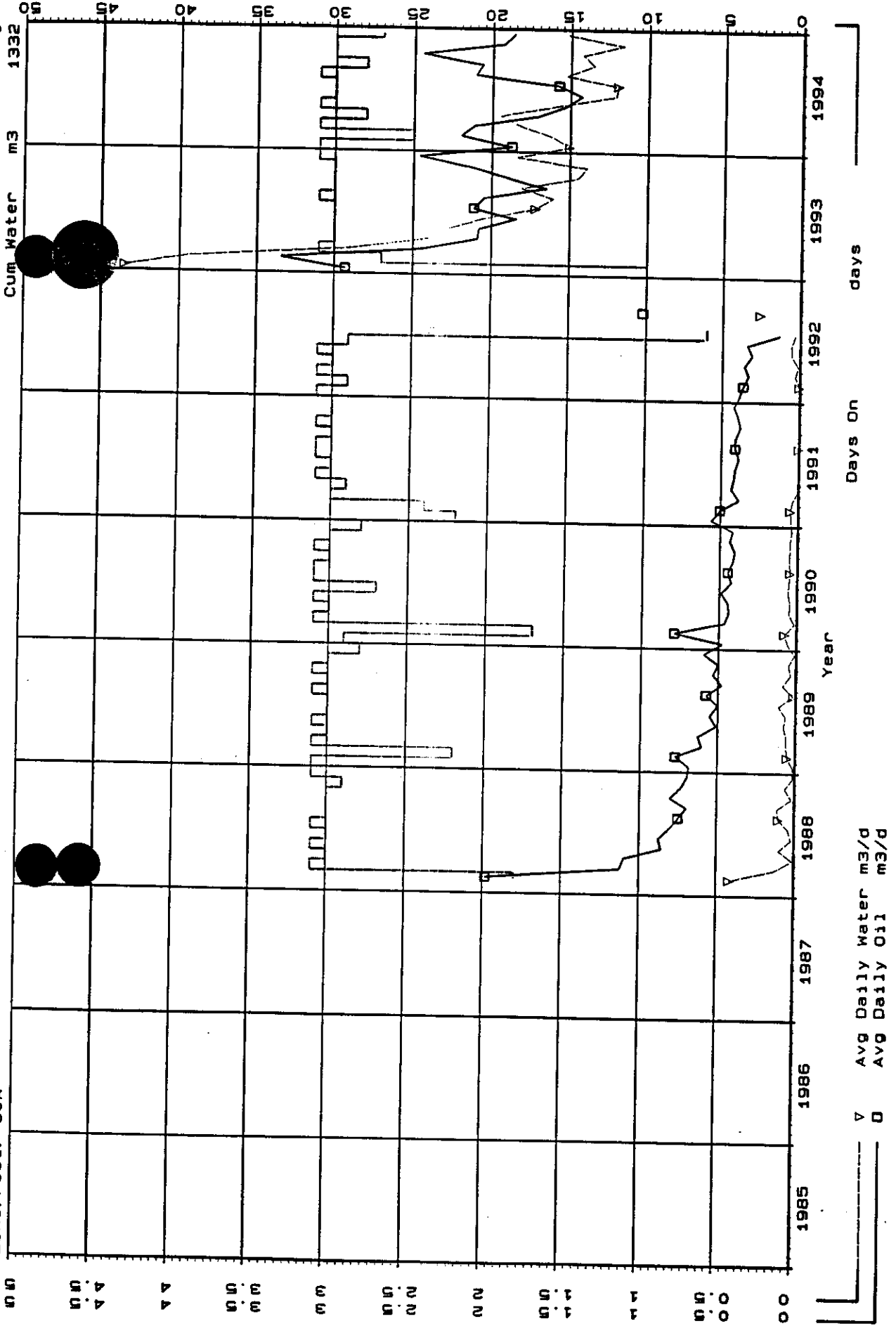
04/10/95 11:43

00/11-28-010-29W1/0 Data 8802-9412

Operator :
Field : 01
Zone/Pool: 60A

Type :

Cum Oil m3 2288
Cum Gas E3m3 0
Cum Water m3 1332



Commingling Lodgepole and Bakken

- ☉ Currently 12 Lodgepole/Bakken commingled wells.

Advantage Of Commingling:

- ☉ Allow operators to extend life of marginal wells.
- ☉ Increased oil recovery from marginal wells.

Commingle Lodgepole and Bakken

Regulatory Requirements

Application to Commingle Production

- ☺ Economic justification for commingling.
- ☺ Proposed production allocation method.

Typical Approval Conditions

- ☺ Keep well pumped off / minimize downtime.
- ☺ Provide annual report to Petroleum Branch.

Bakken Formation Geology: Lithology and Trapping Mechanisms

by C. Martiniuk

MANITOBA STRATIGRAPHIC COLUMN

and productive formations

SYSTEM					MAXIMUM THICKNESS (m)			
MESOZOIC	JURASSIC (part)	MIDDLE	AMARANTH FORMATION	UPPER (Evaporites) Mbr.	45			
				Lower (Red Beds) Mbr. ★	40			
	TRIASSIC	(?)	St. Martin complex		300			
	PERMIAN							
PALEOZOIC	PENNSYLVANIAN	MISSISSIPPIAN	MADISON GROUP	CHARLES FORMATION		20		
				MISSION CANYON FORMATION	MC-3 Member ★	120		
					MC-2 Member			
					MC-1 Member ★			
				LODGEPOLE ★ FORMATION	FLOSSIE LAKE MBR.	185		
					WHITEWATER LAKE MBR.			
					VIRDEN MEMBER			
					SCALLION MEMBER			
				BAKKEN FORMATION	UPPER MEMBER	20		
					MIDDLE MEMBER ★			
					LOWER MEMBER			
	DEVONIAN			QU'APPELLE GROUP	THREE FORKS (LYLETON) FORMATION		245	
					SASKATCHEWAN GROUP	BIRDBEAR (NISKU) FORMATION		
						DUPEROW FORMATION		

★ PRODUCTIVE FORMATIONS / INTERVALS

LODGEPOLE FORMATION

- Upper Member
- mainly black, massive, noncalcareous shale
 - thickness: 2 m (average); 18 m (max.)
-

- Middle Member
- dolomitic, siltstone to sandstone
 - thickness: 4 m (average); 16 m (max.)
-

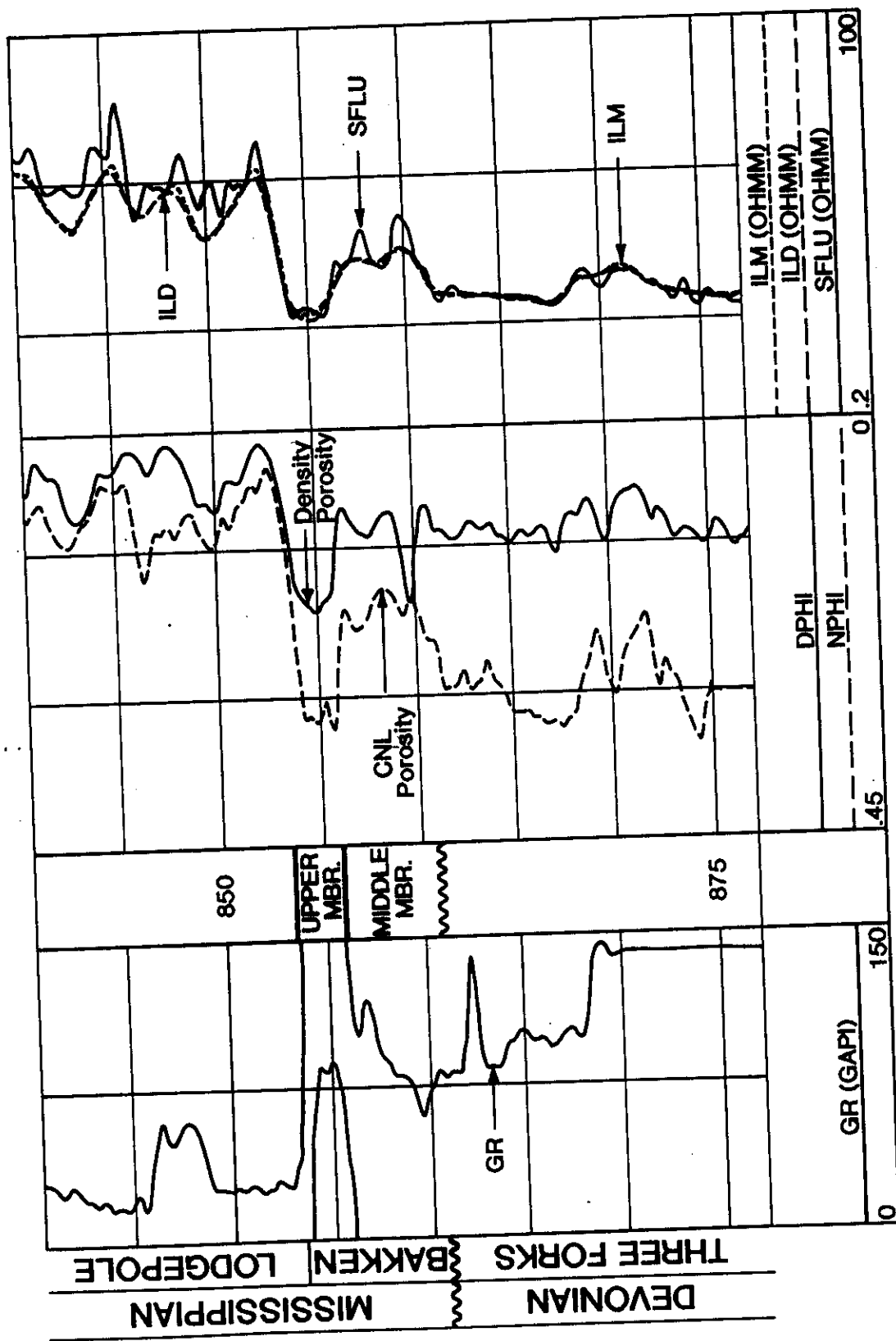
PRODUCTIVE

- Lower Member
- same lithology as Upper Member
 - thickness: 13 metres (max.)
 - present only in Waskada area
-

BAKKEN FORMATION

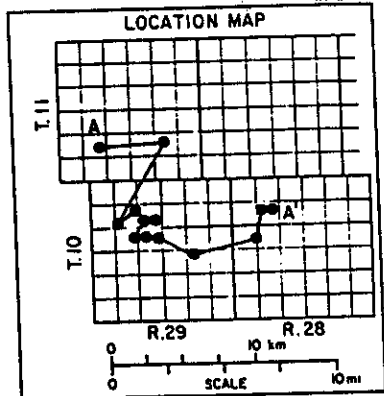
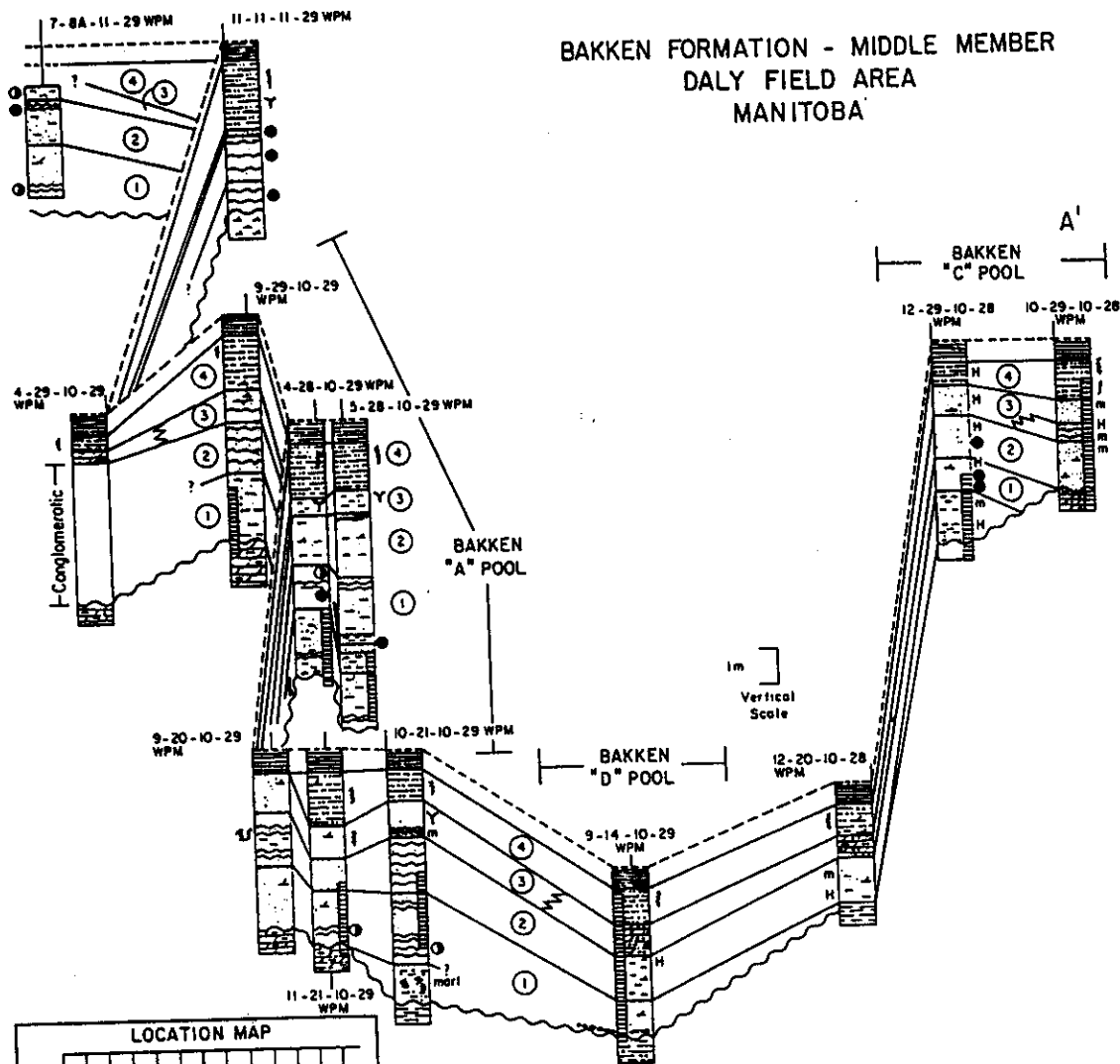
THREE FORKS FORMATION

Tundra Daly 9-14-10-29 (WPM) Bakken Formation



A

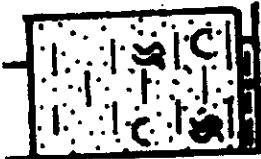
BAKKEN FORMATION - MIDDLE MEMBER DALY FIELD AREA MANITOBA

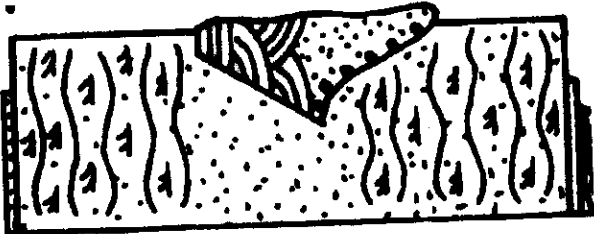


EXPLANATION

- CORED INTERVAL :
- PERFORATED INTERVAL :
- LOG TOPS :
- LITHOFACIES
- BAKKEN FORMATION
- MIDDLE MEMBER
- DISTURBED, CONVOLUTED BEDDING
- MOTTLED BRACHIPODS
- FOSSILS
- OIL STAINS
- EVEN PATCHY OR SPOTTY HEMATITE - RED
- BURROWED
- VARICOLORED
-
-
-
-
-
-

UPPER MEMBER

	Lithofacies 4	shaly siltstone / silty shale
	Lithofacies 3	interbedded siltstone

	Lithofacies 2	interbedded silty sandstone	PRODUCTIVE
	Lithofacies 1	sandstone	PRODUCTIVE

THREE FORKS FORMATION

Lithofacies 1

- ✓ Very fine to fine grained sandstone
- ✓ Mainly quartz
- ✓ Dolomite cement
- ✓ Well sorted, subangular to subrounded
- ✓ Massive to wavy bedded
- ✓ Fair to good intergranular porosity (10 to 15%)
- ✓ 0.7 to 4 m thick
- ✓ Erosive lower contact - Three Forks

PRIMARY RESERVOIR FACIES

Lithofacies 2

- ✓ Interbedded very fine to fine grained silty sandstone and silty shale
- ✓ Mainly quartz
- ✓ Dolomite cement
- ✓ Thin, parallel laminated or wavy bedded
- ✓ Fair to poor intergranular porosity (5 to 10%)
- ✓ 0.6 to 1.8 m thick

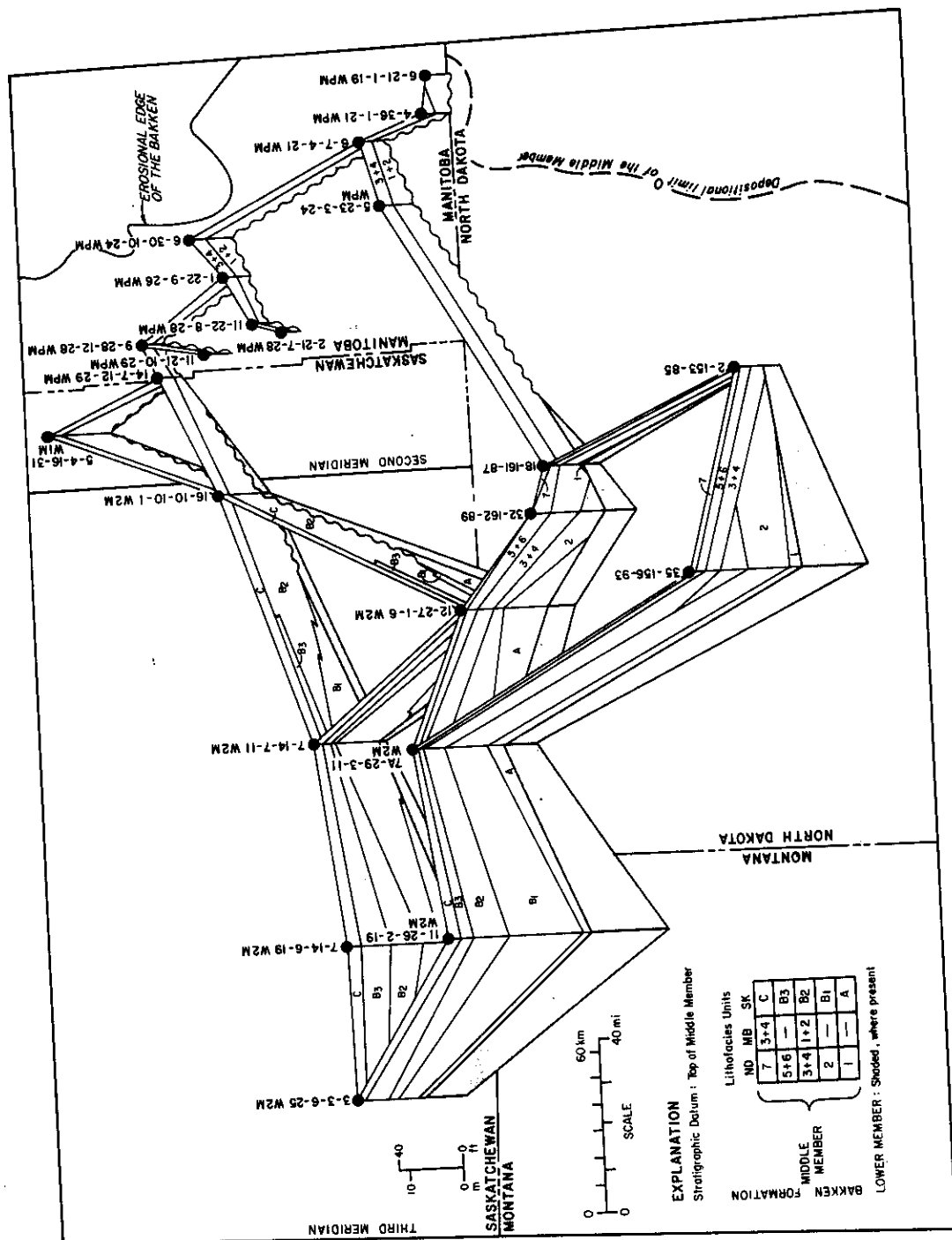
SECONDARY RESERVOIR FACIES

Lithofacies 3

- ✓ Interbedded very fine-grained sandstone to siltstone and silty shale
- ✓ Mainly quartz
- ✓ Dolomite cement
- ✓ Wispy laminated, mottled
- ✓ Brachiopods
- ✓ 0.3 to 2.7m thick

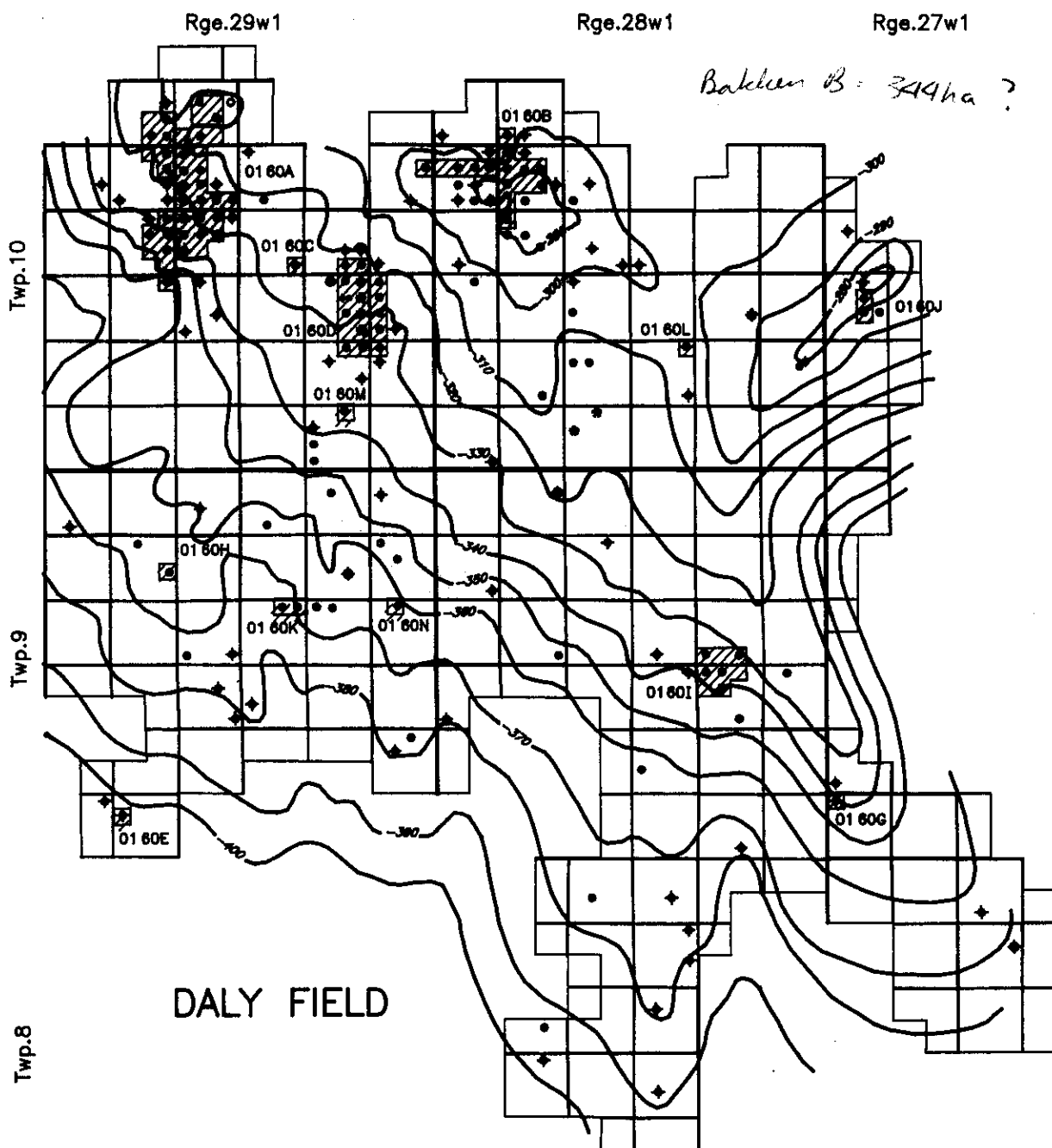
Lithofacies 4

- ✓ Shaly siltstone / silty shale
- ✓ Massive
- ✓ Dolomitic, argillaceous
- ✓ Brachiopod - rich zones
- ✓ 0.3 to 2 m thick
- ✓ Sharp upper contact - Upper Member



Factors Influencing Trapping

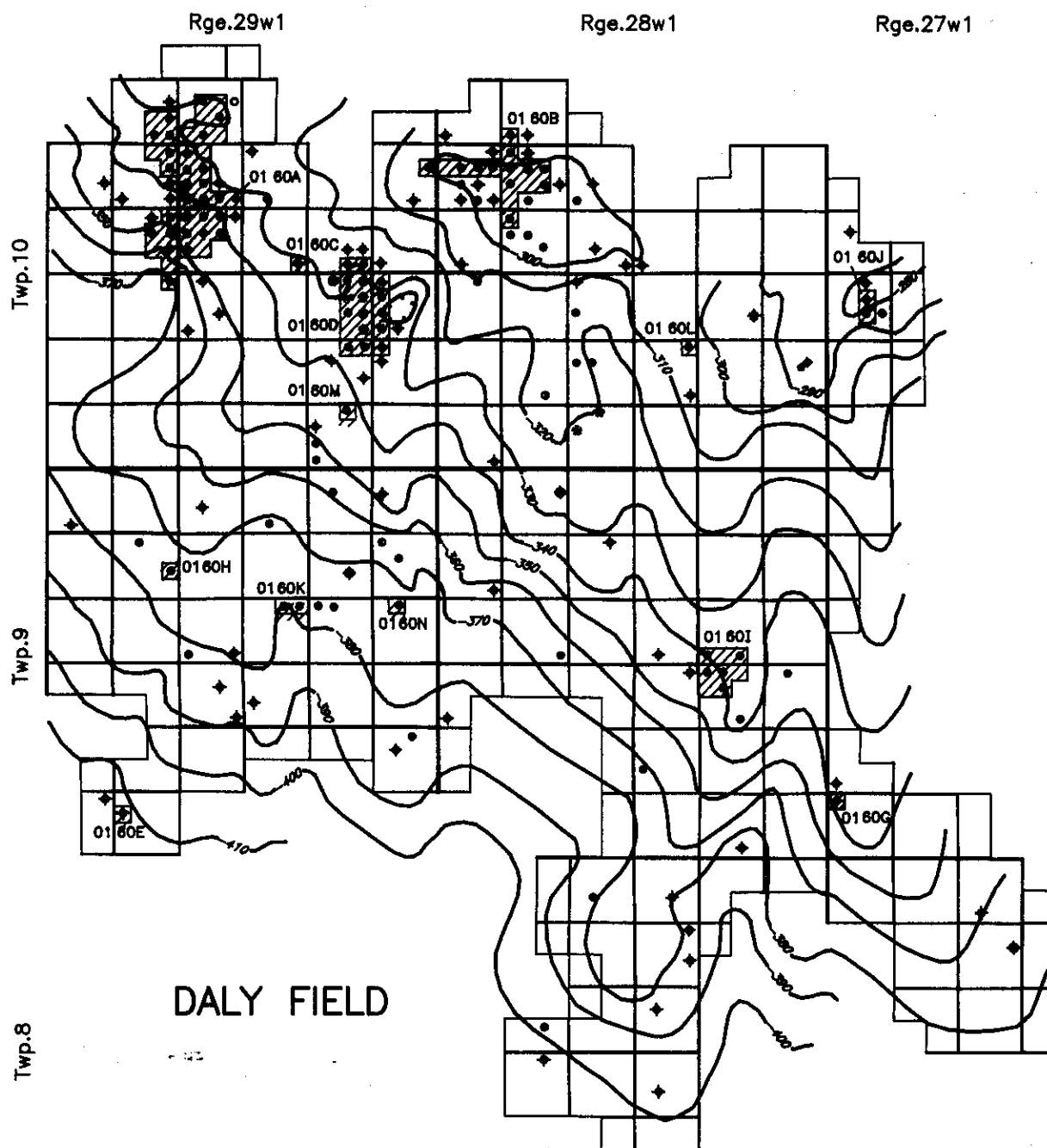
- ✓ Depositional pattern strongly influenced by topography of underlying Devonian surface
- ✓ Structure of secondary importance



STRUCTURE MAP
ON TOP OF
THE BAKKEN FORMATION
(showing Bakken Pools)

C.I. = 10m

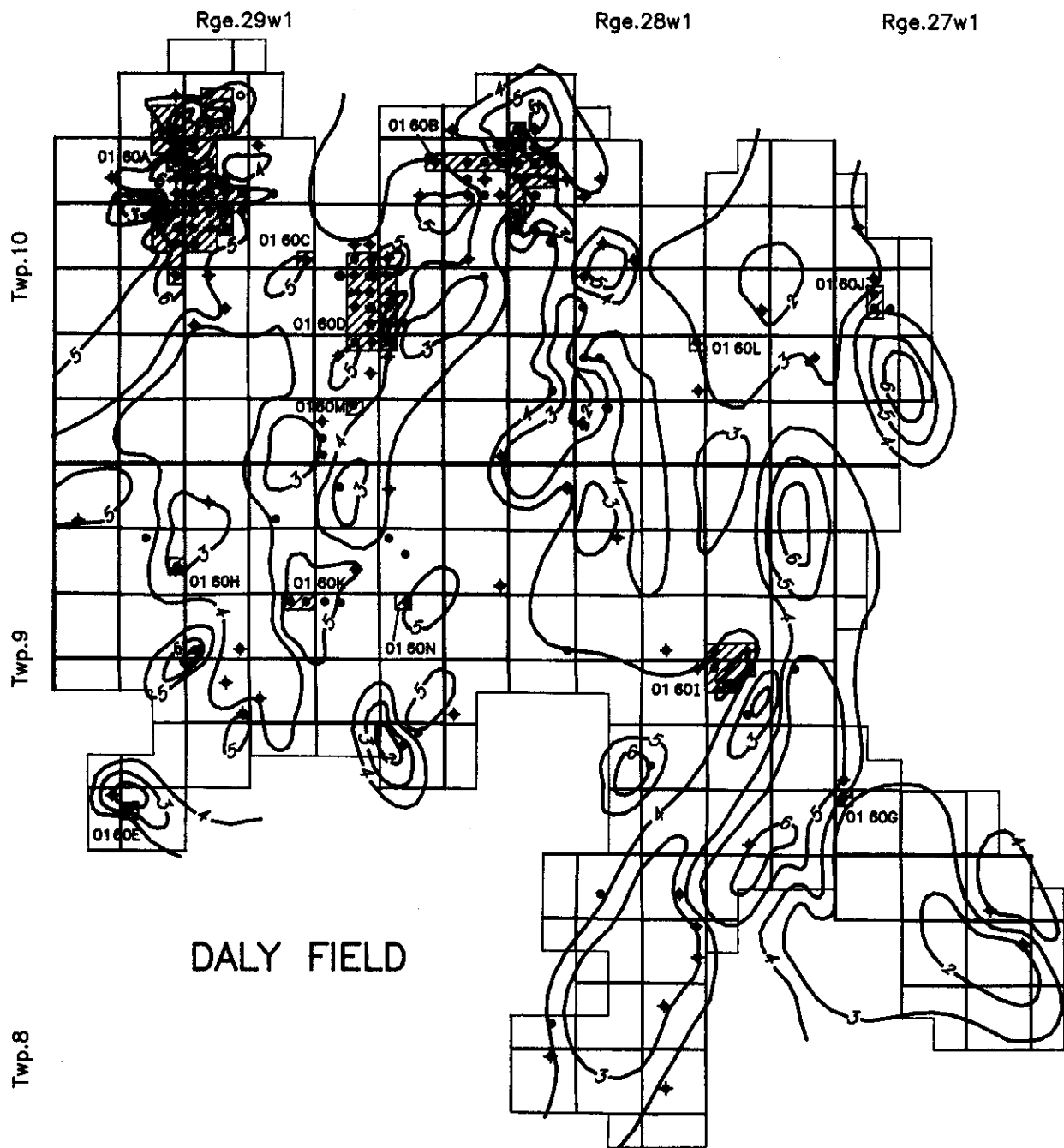
March 31, 1995



STRUCTURE MAP
ON TOP OF
THE THREE FORKS FORMATION
(showing Bakken Pools)

C.I. = 10m

March 31, 1995



C.I. = 1m

March 31, 1995

Bakken Development Prospects

✓ Bakken A, Bakken I and Bakken K Pools

Bakken Exploration Prospects

- ✓ Paleotopographic lows on Devonian erosional surface
- ✓ Oil shows north of Daly Field
- ✓ Subcrop play, Virden Field - east

BAKKEN FACTS

▶ **DISCOVERY WELL 13-21-10-29 DRILLED IN 1985**

▶ **BAKKEN ACTIVITY 1993-95**

WELLS DRILLED 17

WELLS RE-ENTERED 9

WELLS DEEPENED 20

▶ **NUMBER OF BAKKEN POOLS 13**

▶ **BAKKEN PRODUCERS (DEC/94) 59**

▶ **1994 BAKKEN OIL PRODUCTION 29 596 m³**

▶ **CUMULATIVE BAKKEN PRODUCTION 179 869 m³**

▶ **REMAINING PROVEN BAKKEN RESERVES 95 186 m³**

BAKKEN RESERVOIR PROPERTIES

DEPTH	800-950 m
INITIAL RESERVOIR PRESSURE	7900-8750 kPa
BUBBLE POINT PRESSURE	2376 kPa (abs)
PRIMARY RECOVERY/DRIVE MECHANISM	- OIL EXPANSION ABOVE POINT BUBBLE - SOLUTION GAS DRIVE
OIL DENSITY	40-43 °API
SOLUTION GOR	17.7 m³/m³
FORMATION VOLUME	1.06 m³/m³

BAKKEN POROSITY AND WATER SATURATION DETERMINATION

The Middle Member is composed mainly of quartz, clay minerals (principally illite) and dolomite, with minor amounts of anhydrite, calcite, halite, feldspars, hematite and pyrite⁴.

Dolomite is the most abundant intergranular material and occurs as the primary cementing material and also in the form of microcrystalline fines. The amount of clay minerals and dolomite increases upwards through the Middle Member⁴.

In the lithologically complex Middle Member, it is difficult to accurately determine porosity and water saturation. Conventional log analysis techniques result in erroneous porosity and water saturation values. A correlation between core and log porosity has been developed to determine total porosity for the Middle Member⁵:

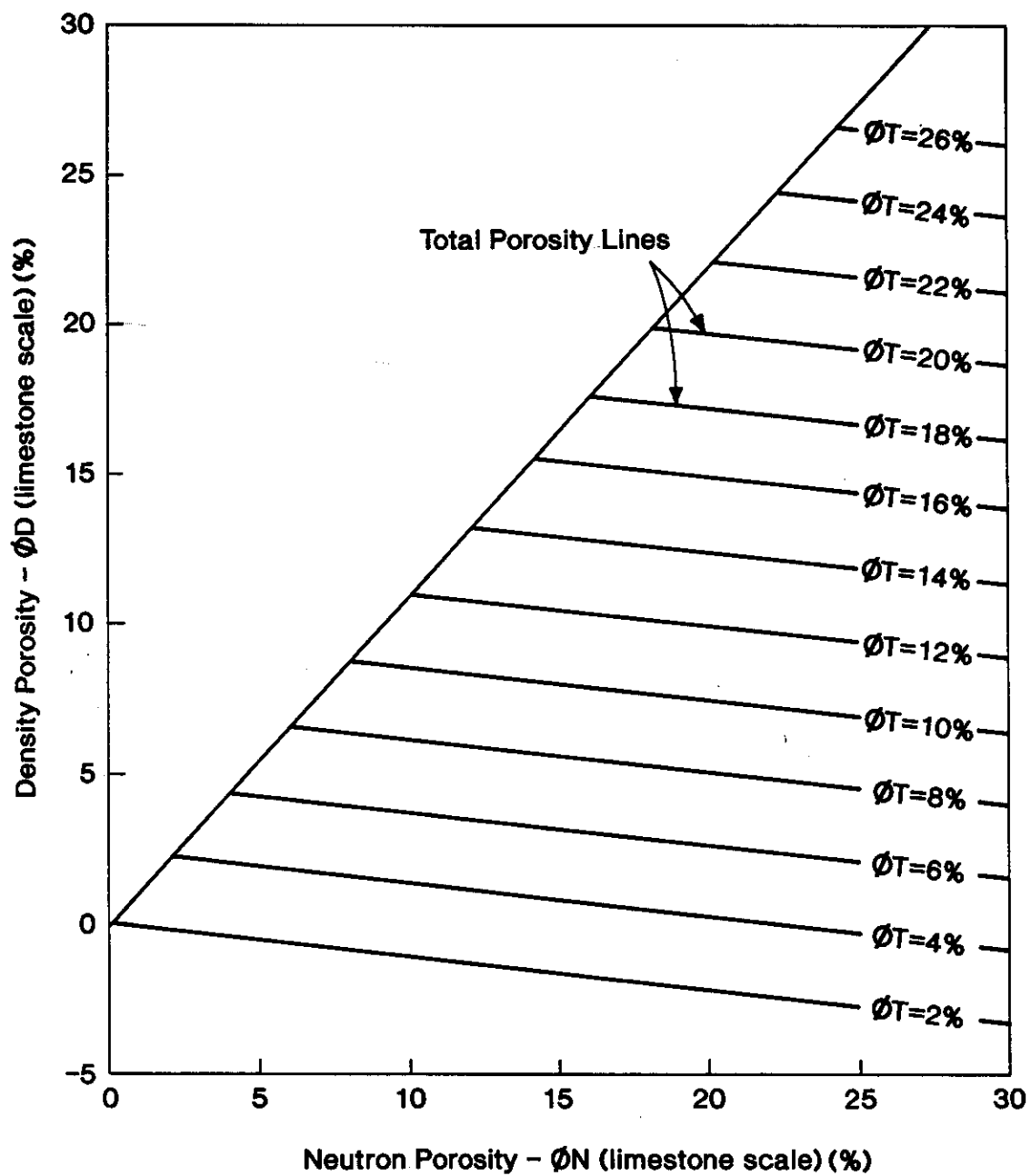
$$\varnothing_T = 0.82 \varnothing_D + 0.09 \varnothing_N + 0.023$$

Where: \varnothing_T = total porosity, (fraction)
 \varnothing_D = density porosity, (fraction),
limestone scale
 \varnothing_N = neutron porosity, (fraction),
limestone scale

The Waxman-Smiths shaly sand model has been used to successfully calculate water saturation for the Middle Member. In recognition of the complexity of this model, a modified Archie equation has been developed that yields water saturations within $\pm 3.0\%$ of those calculated by the Waxman-Smiths equation⁵:

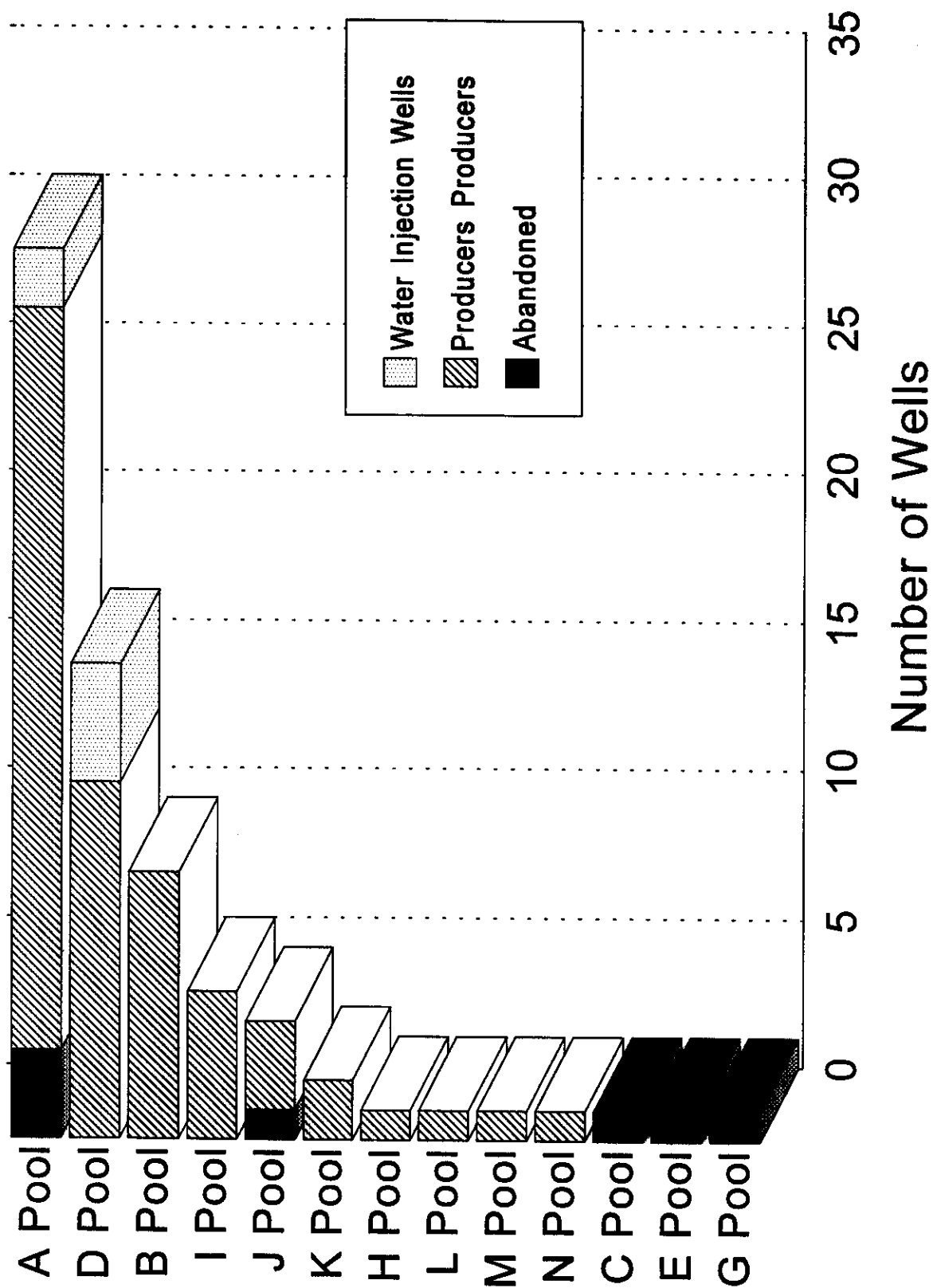
$$S_w = \left[\frac{0.59 R_w}{\varnothing_D^{1.74} R_t} \right]^{0.5}$$

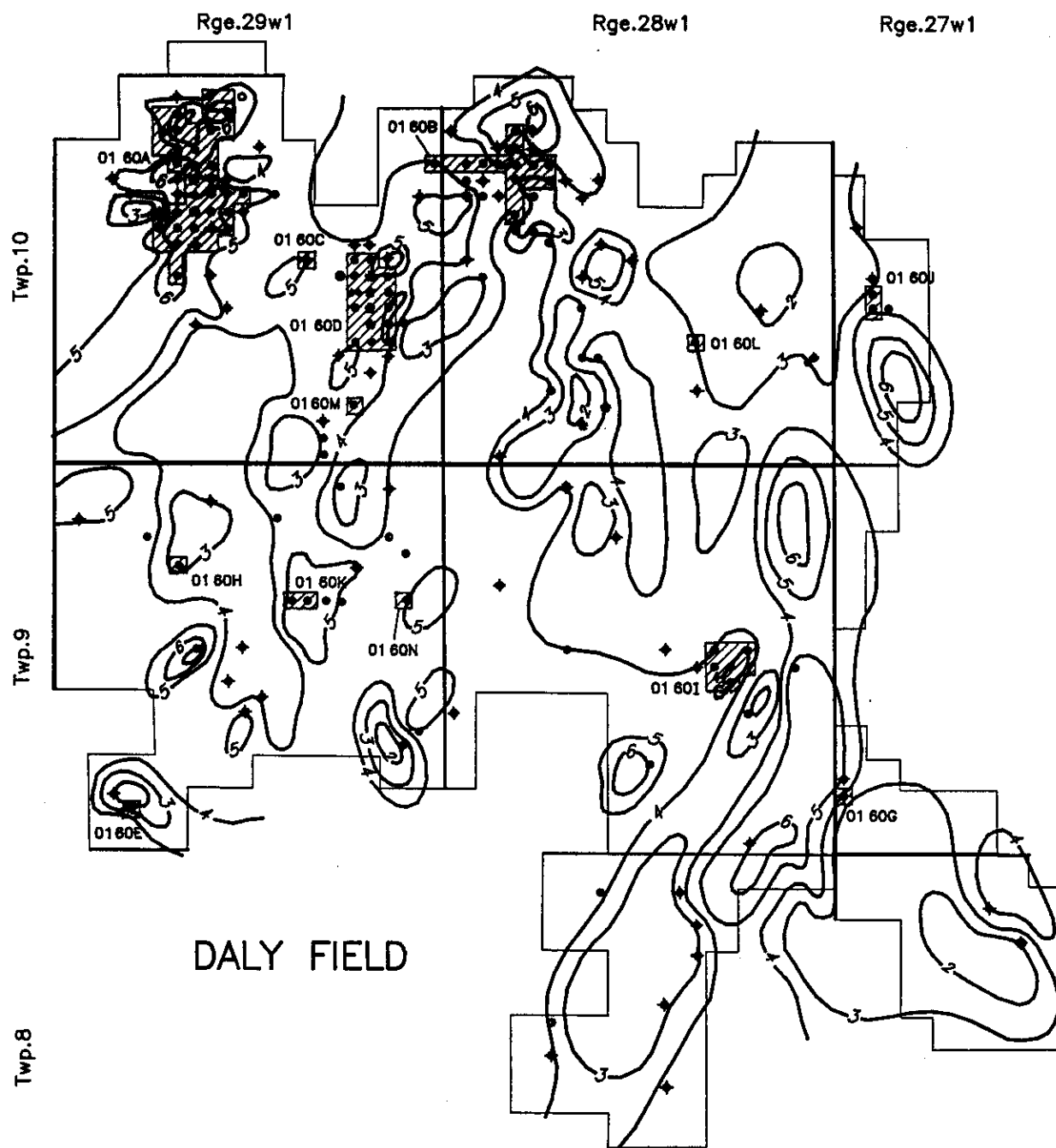
Where: S_w = water saturation, (fraction)
 \varnothing_D = density porosity, (fraction),
limestone scale
 R_w = formation water resistivity,
(ohm-metres)
 R_t = deep resistivity, (ohm-metres)



Neutron - Density Porosity Crossplot

Bakken Pool Well Counts (December 1994)





ISOPACH MAP—
MIDDLE MEMBER
OF THE BAKKEN FORMATION
(showing Bakken Pools)

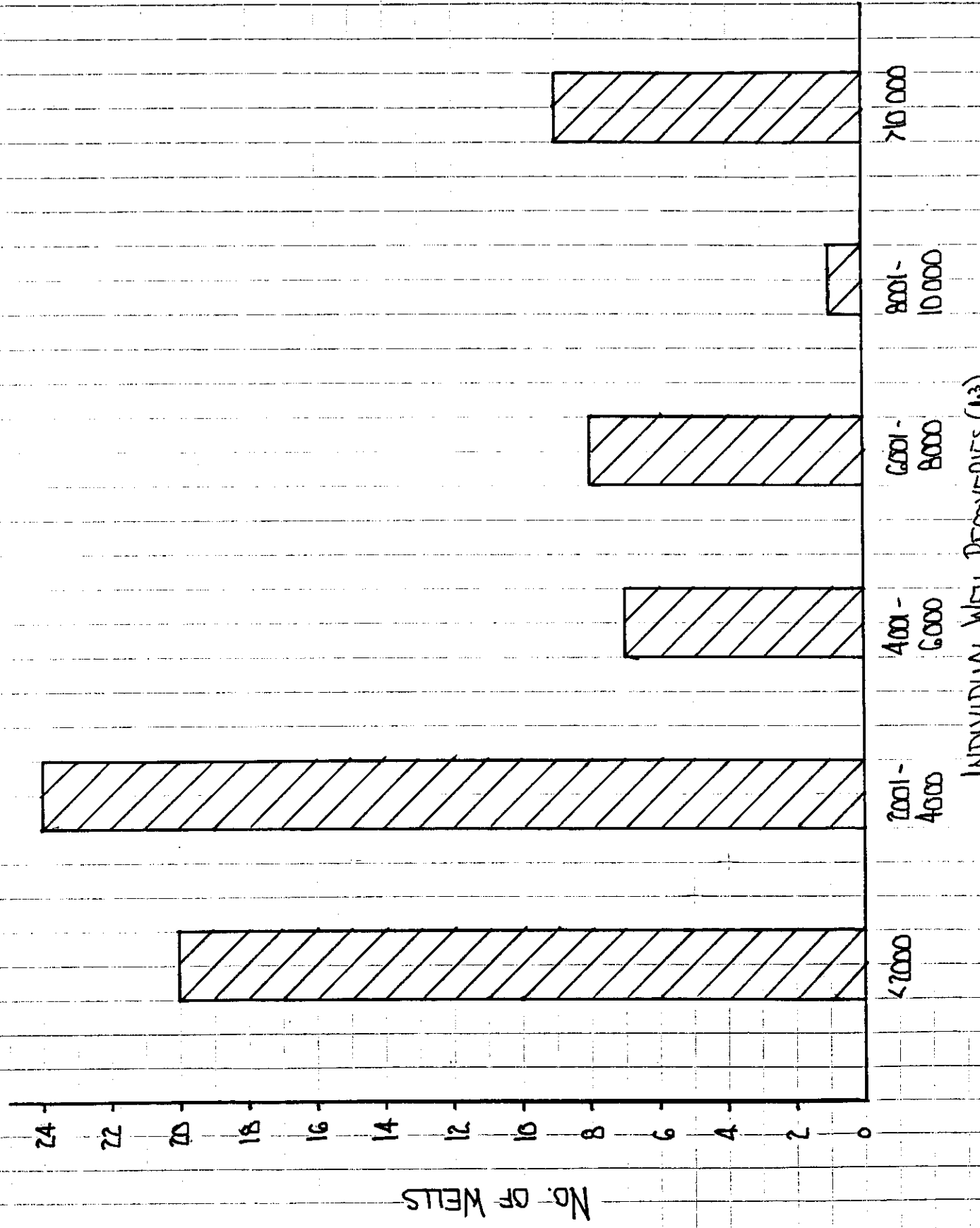
C.I. = 1m

March 31, 1995

BAKKEN A, B & D POOL RESERVOIR PARAMETERS

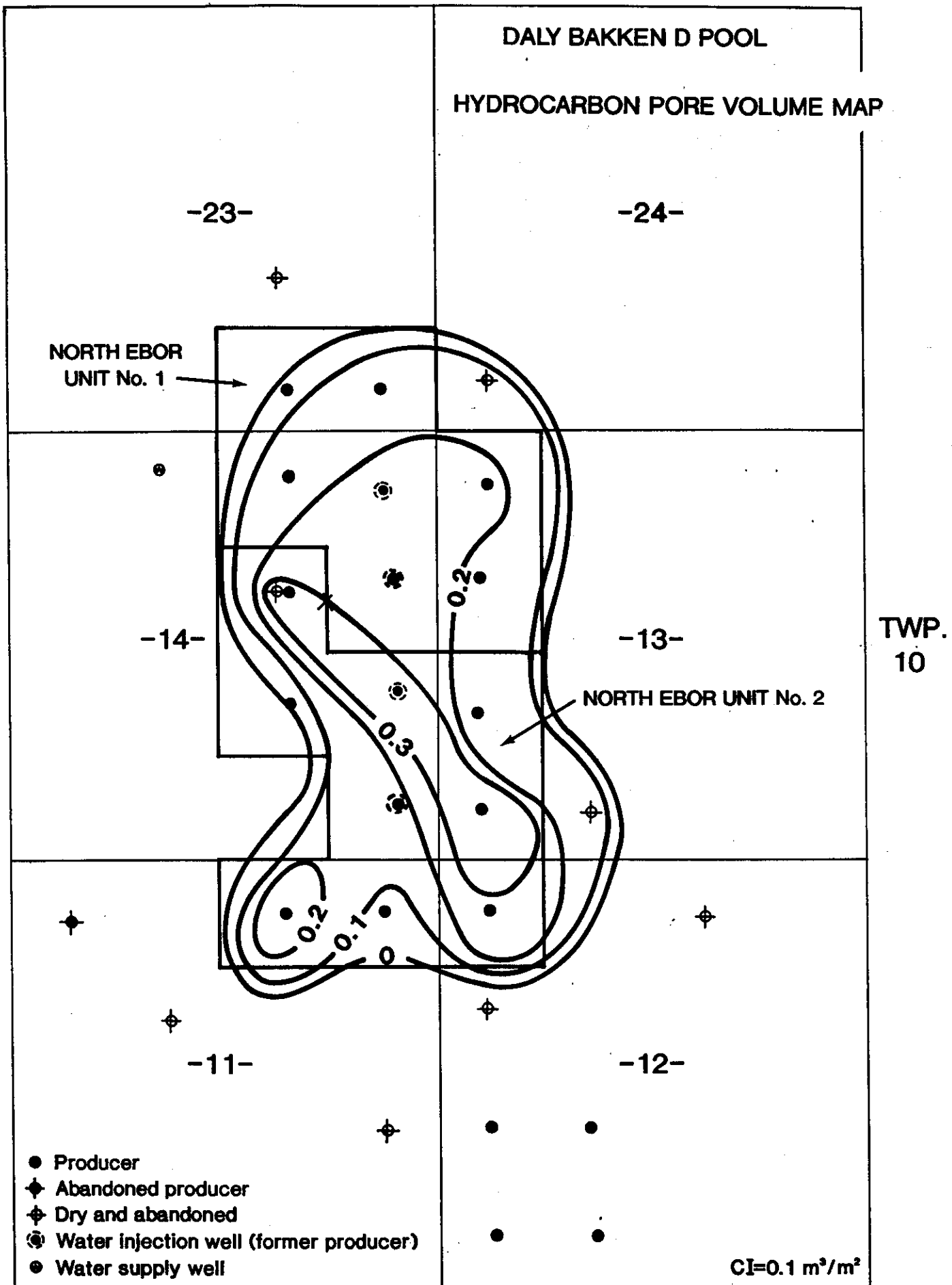
	A POOL	B POOL	D POOL
Area (ha)	572	344	276
Net Pay (m)	2.2	2.6	2.7
Porosity (%)	17	15.9	14.5
Water Saturation (%)	45	56.8	47.7
Shrinkage (Fract.)	0.94	0.94	0.94
Original Oil-in-Place (10^3m^3)	1098.1	550.4	503.7
Recovery Factor			
Primary (%)	11.3	3.1	11.8
Secondary (%)	13.4	--	18.6
Total Proven Reserves (10^3m^3)	146.9	17.3	93.8
Cumulative Production (94-12-31) (10^3m^3)	83.8	16.0	70.8
Remaining Proven Reserves (10^3m^3)	63.1	1.3	23.0
Number of Producing Wells	25	9	12
Current Production			
Daily Oil (m^3/d)	48.1	2.6	21.6
WOR (m^3/m^3)	1.47	1.27	1.86

BAKKEN INDIVIDUAL WELL RECOVERIES



DALY BAKKEN D POOL

HYDROCARBON PORE VOLUME MAP



METRES 500 0 500 1000 1500 METRES

Daly Bakken D Pool

04/25/95 18:01

Type :

Date 8812-9412

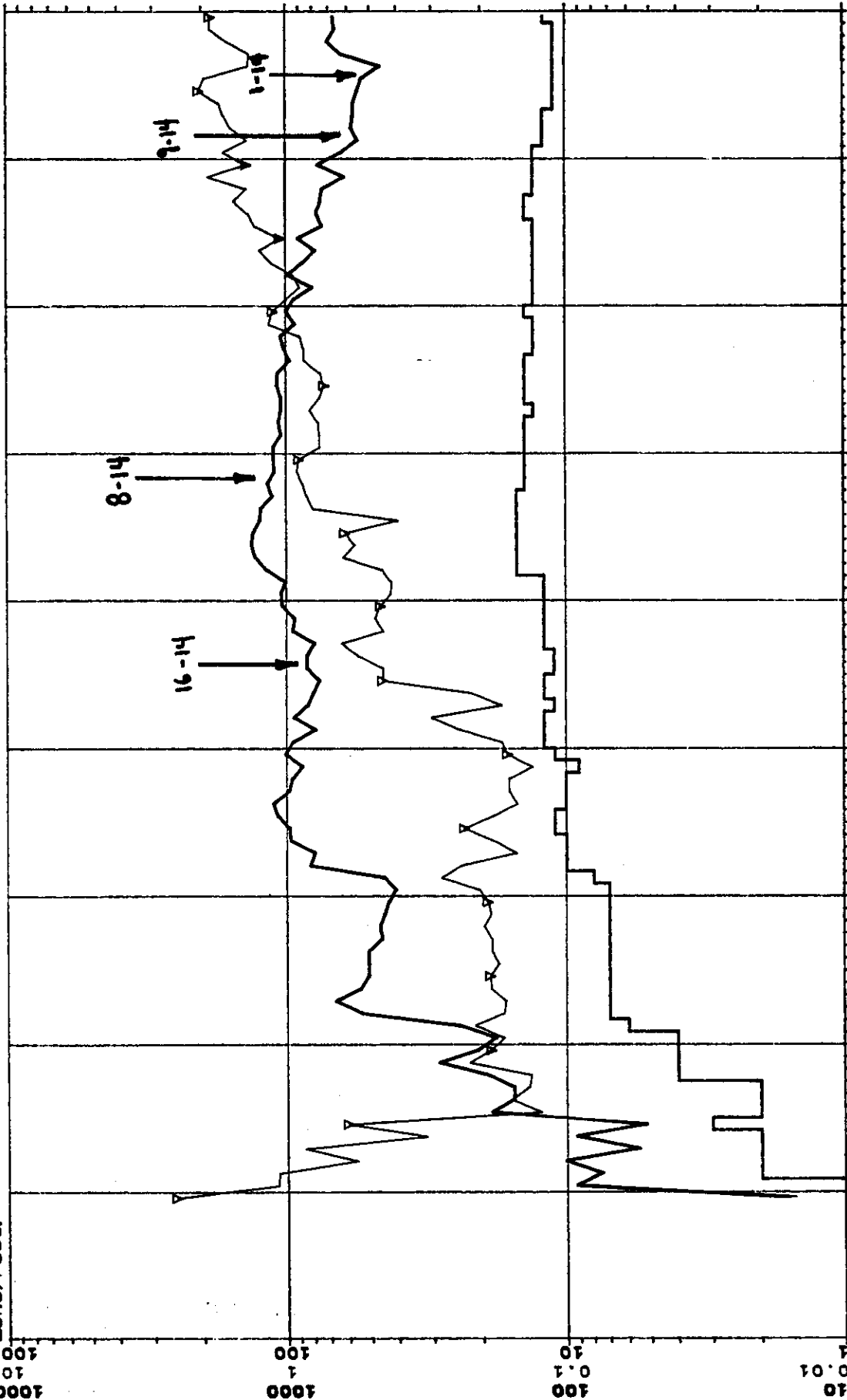
Operator :

Field :

Zone/Pool:

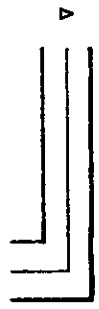
Cum Oil m3 70785
Cum Gas m3 0
Cum Water m3 50496

10000
1000
100
10
1



WELL ON
INJECTION

Num Wells m3/m3
WOR Monthly Oil m3



BAKKEN DEVELOPMENT MODEL

- **ONE SECTION IN SIZE**
- **OOIP - 500 000 M3**
- **10 OR MORE WELLS**
- **RECOVERABLE RESERVES**

PRIMARY	55 000 M3
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SECONDARY	45 000 M3
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TOTAL	100 000 M3
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Manitoba

NEW FILE:

DALY BAKKEN (01 66)

SPECIAL CORE ANALYSIS

~~NOT A BAKKEN~~



Energy and Mines

Petroleum

555 — 330 Graham Avenue
Winnipeg, Manitoba, CANADA
R3C 4E3

(204) 945-6577

FAX: (204) 945-0586

February 26, 1993

Tundra Oil and Gas Ltd.
1111 - One Lombard Place
Winnipeg, MB R3B 0X4

Attention: Mike Finn, Chief Geologist

Dear Mike:

Re: Core Sampling Program

The Petroleum Branch hereby gives approval for sampling of core requested in your letter (copy attached) for analysis.

Two(2) copies of all core analyses shall be returned to the Petroleum Branch pursuant to Section 90 of the Drilling and Production Regulation.

Sincerely,



Carol D. Martiniuk
Petroleum Geologist

c.c. L.R. Dubreuil

~~FOX~~ Fox



February 26, 1993

Ms. Carol Martiniuk
Petroleum Branch
555 - 330 Graham Avenue
Winnipeg, MB
R3C 4E3

Dear Carol:

Re: Core Sampling Program

Tundra Oil and Gas Ltd. requests permission to sample a number of cores from the Bakken Formation. The proposed program is as follows:

WELL LOCATION	INTERVAL	TYPE OF ANALYSIS
4-28-10-29 W1	875.55 - 875.85 m 876.00 - 876.28 m 876.70 - 876.92 m	Relative Permeability Relative Permeability Relative Permeability
13-14-9-28 W1	Undefined, within Interval 2750-58'	Standard Core Analysis
1-30-9-28 W1	Undefined, within Interval 2872-78'	Standard Core Analysis

All samples and plugs will be returned upon completion of analysis and two copies of all data will be forwarded to your office.

If you have any questions regarding this program, please call me at 934-5294.

Yours truly,

TUNDRA OIL AND GAS LTD.

A handwritten signature in cursive script, appearing to read "C. Mike Finn".

for C. Mike Finn, P. Geol.
Chief Geologist

CMF/bp



Memorandum

Date : February 26, 1993

To : Doug Berk
Rock Preparation Lab

From : Carol Martiniuk
Petroleum

Subject :

Telephone :

CORE ANALYSIS

Samples of core from the wells listed below have been requested by Tundra Oil and Gas Ltd. to be sent out for analysis:

<u>Well Location</u>	<u>Interval</u>
13-14-09-28 WPM	2750-2758'
01-30-09-28 WPM	2872-2878'
04-28-10-29 WPM	875.55-875.85m 876.00-876.28m 876.70-876.92m

Sampling has been authorized by Petroleum.

Two(2) copies of all core analyses are to be returned to Petroleum Branch.

Carol Martiniuk
Carol Martiniuk

c.c. L.R. Dubreuil
J.N. Fox