KANSAS GEOLOGICAL SURVEY
OPEN-FILE REPORT 2000-86

Input Parameters for Reservoir Simulation Study—
Minneola Field, Clark County, Kansas Geological Survey

by

Saibal Bhattacharya
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Disclaimer

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Introduction

The Minneola Unit is located in Clark County, Kansas, and is part of the Norcan East Field which is approximately one mile north and two miles west of Minneola, Kansas. Initial development started in this area with the drilling of Norton #1-8 in Section 8 of T30s-R25w. This well was completed in September 1980 and upon testing flowed 157 bopd and 120 mcfd. Murfin Drilling Co. began active drilling in this area in 1983. Effective July 1993, Murfin Drilling purchased all of Swift Energy's (successor to Ladd Petroleum) interest in the general area. Figure 1 is a map showing the locations of wells in the general area that includes the Minneola unit. The figure also shows the boundary of the Minneola unit along with the well locations, well names, and corresponding unit numbers.

The producing interval in the Minneola Unit is Morrow sandstone. The reservoir drive mechanism is understood to be primarily solution-gas drive. Initial oil production varied from 38 to 164 bopd with many wells producing associated gas. DST analyses show that wells completed in early half of 1983 averaged an initial reservoir pressure of 1555 psi while those completed in 1985 averaged 817 psi. This is consistent with production from a solution gas drive reservoir without pressure support thus resulting in a rapid decline of reservoir pressure. By 1993, the wells in the unitized area were approaching their economic limit under primary production, and the field production had dropped to 26 bopd. In 1994, 13 tracts, all operated by Murfin Drilling Co., were unitized to initiate a water-flooding program. The unitized area covers about 1040 acres and includes the W/2 of the NE/4, and the S/2 of section 3; the S/2 of section 4; and the N/2 of section 10; all in T30s-R25w, Clark County, Kansas. Included in the unitized area are 12 producing wells and 2 water injection wells. This project intends to study, in detail, the unitized area along with the surrounding area to develop a 3D geomodel that will form the basis to a reservoir simulation study. Figure 1 shows the layout of the study area along with the location of the wells.

Petrophysical model for reservoir simulation

Cross-sections were generated with available wireline logs and were correlated with the production (IP and DST) data to delineate 3 sand bodies (Figure 2 to 4) in the reservoir. Resistivity and porosity logs were available for a majority of the wells in the Minneola study area, and they were analyzed with the help of Super-Pickett cross-plots (enclosed in Appendix A). Values of "m" (= 1.74) and "a" (=1.08) were obtained from petrophysical analysis of available cores. The value of "m" is not inconsistent with those obtained from channel sands in the Morrow. The average grain density (for density log interpretation) was found to be 2.647 with a standard deviation of 0.012.

Porosity and initial water saturation maps were constructed using the Super Pickett analysis and the net pay at each well. Figures 5 to 7 display the porosity distribution while Figures 8 to 10 highlight the initial water saturation maps of the three sand bodies. Cores from the producing interval was available at two of the wells in the study area, namely, Patton # 1-3 (Murfin) and Statton #2-12 (Murfin). Plugs taken from these cores

were analyzed for *in situ* porosity, *in situ* Klinkenberg permeability and capillary pressure. Three distinct trends between permeability and porosity were developed based on the gamma log readings, i.e., a trend was developed for sands with average gamma readings less than 30 API units, another for sands with gamma readings between 30 and 39 API units and another for sands with gamma readings greater than 40 API units. Figure 11 displays the different permeability-porosity trends prevalent in the Minneola sands. The permeability-porosity correlations were used along with the porosity distributions to develop permeability distributions (Figures 12 to 14) in the different sand bodies in the study area.

Salient features of k-phi trends are:

1) Whole-core and plugs give similar trends and thus cross bedding is not significant and fracturing at the scale of whole core is not significant

2) Average grain density is 2.65 +/-0.02 g/cc (1 standard deviation).

3) Both Patton 1-3 and Statton 2-12 show a fining-upward sequence that also correlates with increasing GRI upward. Since permeability decreases with increasing shalyness, the clean rocks stay good and the dirty ones get worse - same old rule of thumb - the good stay good, the marginal get worse, and the bad become abysmal.

4) The division of the Minneola reservoir into 3 layers is consistent with subdivision of the fining upward sequence.

5) If layers 1,2, and 3 are reasonably consistent in their grain size and argillacoeousness then the equation can be simplified by using an average GRI for each layer.

6) *In situ* porosities were calculated from routine porosities using previously determined Morrow sandstone trend. They average about 97% of routine but are slightly less for lower porosity (lower porosity is more compressible due to higher shalyness).

7) *In situ* Klinkenberg permeability is highly correlative with routine air permeability

8) Archie parameters were as "m"= 1.74, and "a"= 1.08.

9) Standard error on permeability prediction is factor of 3.3. Statistically this means that 15% of the population has permeability greater than 3.3 times the predicted value. If layering is parallel, these higher perm layers can exert significant influence on flow. If one believes that layering is parallel, and not series, then using a slightly higher permeability (e.g. adding 0.25 to intercept) is consistent with larger scale flow. Adding 0.5 to intercept will give maximum permeability for the best sands.

The Swi vs. *in situ* Klinkenberg permeability trend lines are shown in Figure 15. The trend lines clearly show Swi increasing with decreasing permeability though the clean sandstones, and not surprisingly they have a lower slope and are shifted down. Figures 16

to 20 show the air-brine capillary-pressure curves. Agreement between air-mercury and air-brine is good though a little poorer in the most argillaceous sample - which is not unexpected since the degree of argiallaceousnes can vary even across a plug and so two paired plugs may not be identical.

The lease production data and the available production test data at individual wells were used to generate a production history for most of the wells. Figure 21 shows the production declines for oil and gas in the study area with time. Appendix B details the production history of each well in the study area. Due to lack of production test data at the well level, the individual well production history could not be generated for the following wells: Patton #1-3 and #2-3 (Murfin), Tedford # 4-10 and #1-10 (Murfin) and Statton #1-12 and #2-12 (Murfin).

Relative permeability measurements on the available representative core plugs will be completed in the near future. Table 1 lists the different PVT properties generated for the fluids in the Minneola field.

This study completes the geomodel buildup for the reservoir simulation study of the Minneola field.

Table 1

PVT properties for Minneola field

Projected reservoir pressure (from DST) as of June 1982	1800 psi
Reservoir temperature	124 $^{\circ}$F
Rock compressibility at 1800 psi	
Layer 1	$4.95*10^{-6}$ 1/psi
Layer 2	$3.174*10^{-6}$ 1/psi
Layer 3	$1.972*10^{-6}$ 1/psi
Water compressibility (salinity 2.5%)	$2.8*10^{-6}$ 1/psi
Viscosity of water at reference pressure (2000 psi)	0.702 cp
Pressure dependence of water viscosity	0.000108 cp/psi
Water density	68.2 lb/ft^3
Water formation volume factor (at 2000 psi and 124°F)	1.01
Reference pressure for water formation volume factor	2000 psi
Density of formation water at 2000 psi and 124 $^{\circ}$F	67.52 lb/ft^3
Maximum reservoir pressure	2000 psi
Oil density (at 75 $^{\circ}$F)	50.89 lb/ft^3
Oil density at reservoir conditions	43.99 lb/ft^3
Gas gravity (air = 1.0)	0.765
Oil viscosity (at 2000 psi)	0.48 cp
Oil viscosity gradient	0.00004 cp/psi
Solution gas-oil ratio	600 scf/stb
Bubble point	1750 psi
Undersaturated oil compressibility	$17*10^{-6}$ 1/psi

Figure: 1

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MINNEOLA FIELD

#1 SAND ISOPACH

Figure: 2

KANSAS GEOLOGICAL SURVEY

MINNEOLA FIELD

#2 SAND ISOPACH

Figure: 3

KANSAS GEOLOGICAL SURVEY

MINNEOLA FIELD

#3 SAND ISOPACH
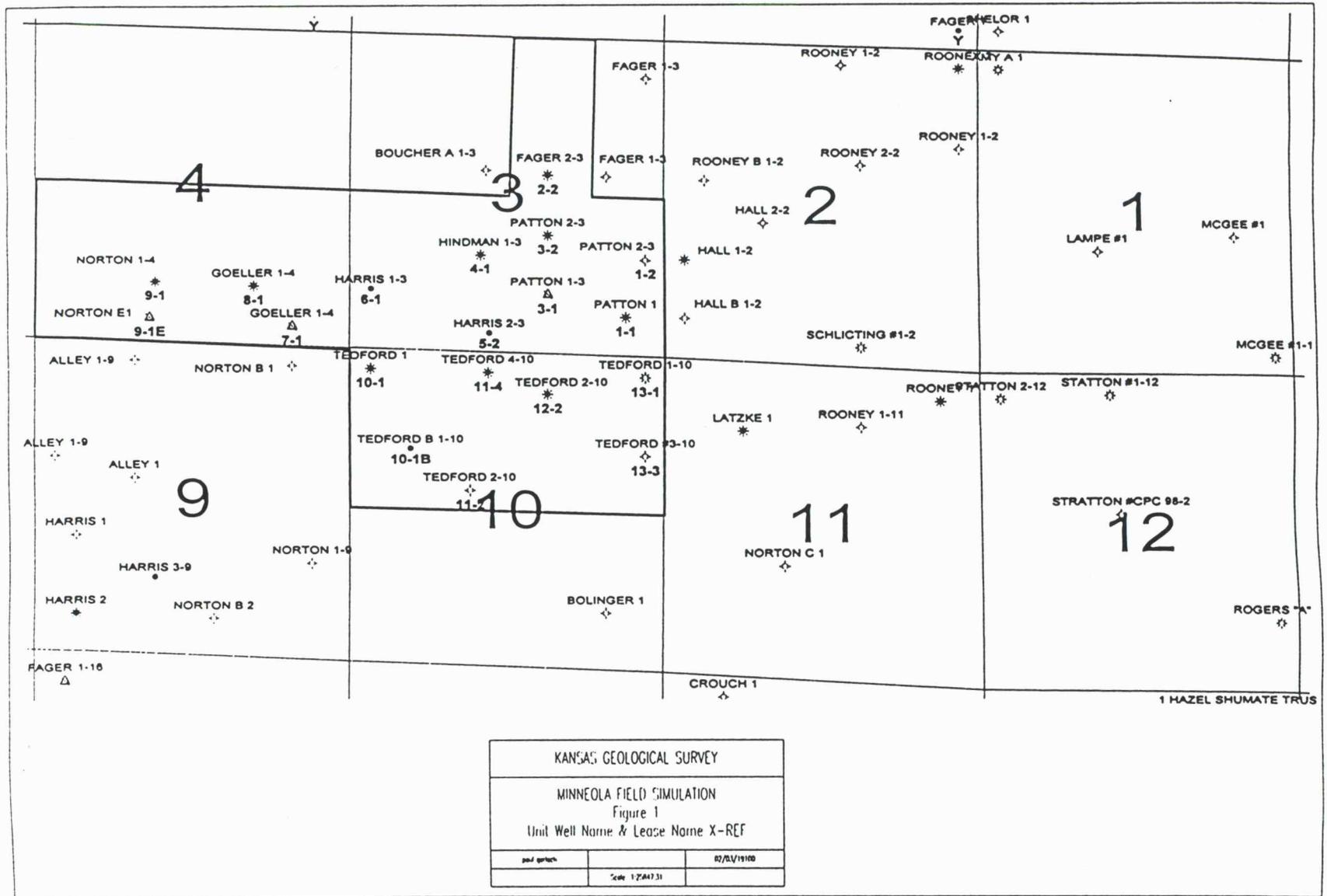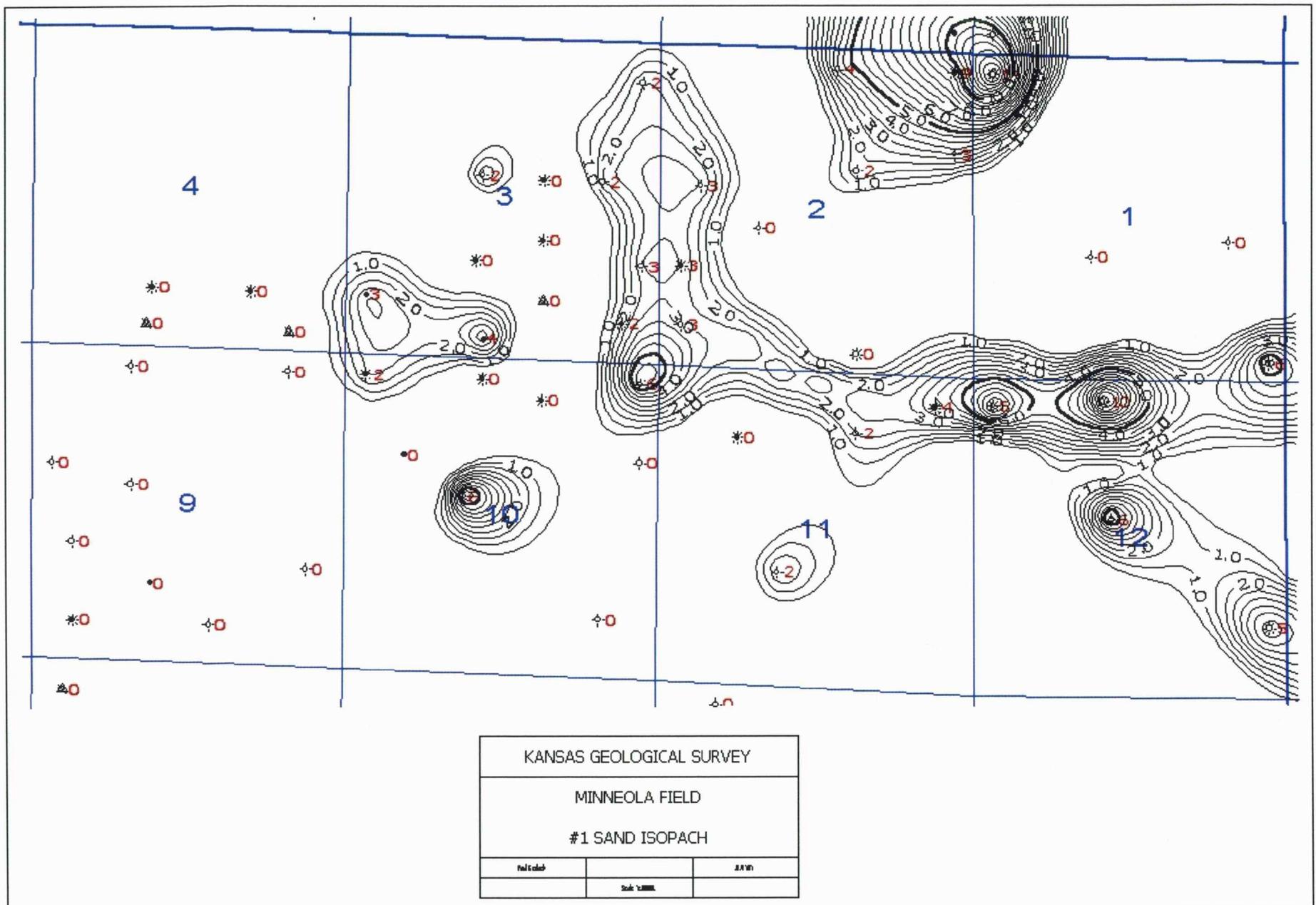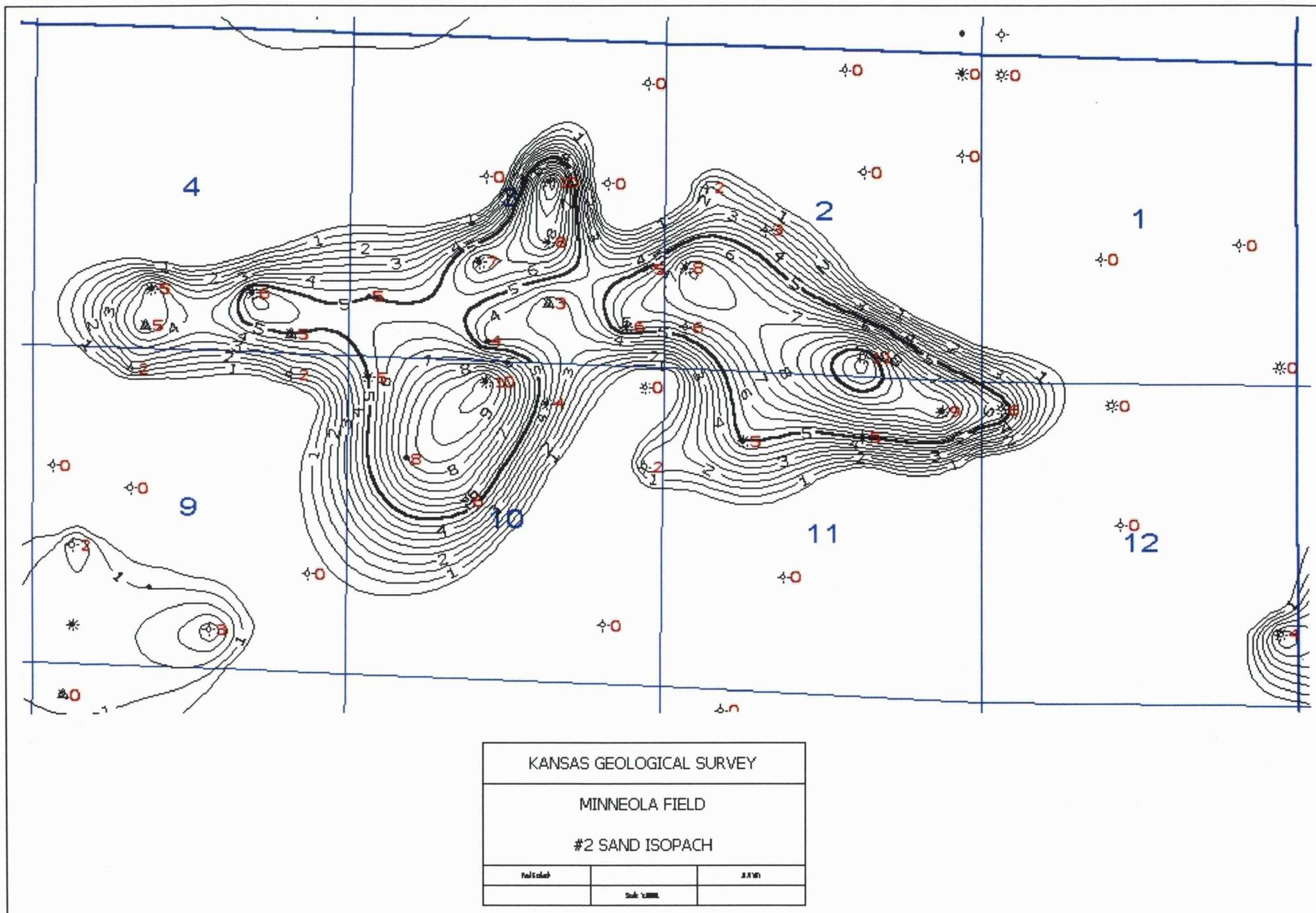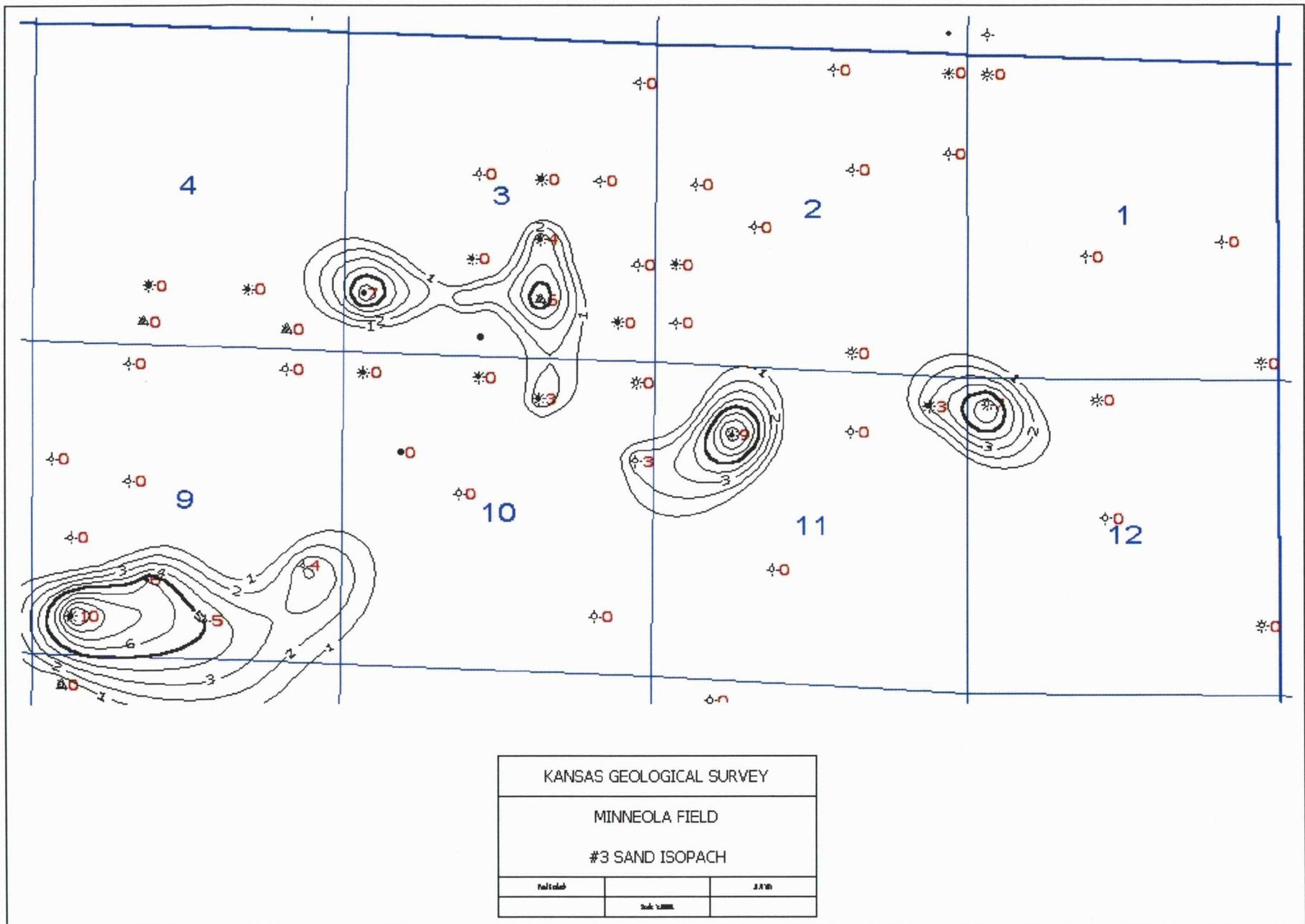
Figure: 4

Figure: 5

Figure: 6

KANSAS GEOLOGICAL SURVEY

MINNEOLA FIELD

#3 SAND porosity
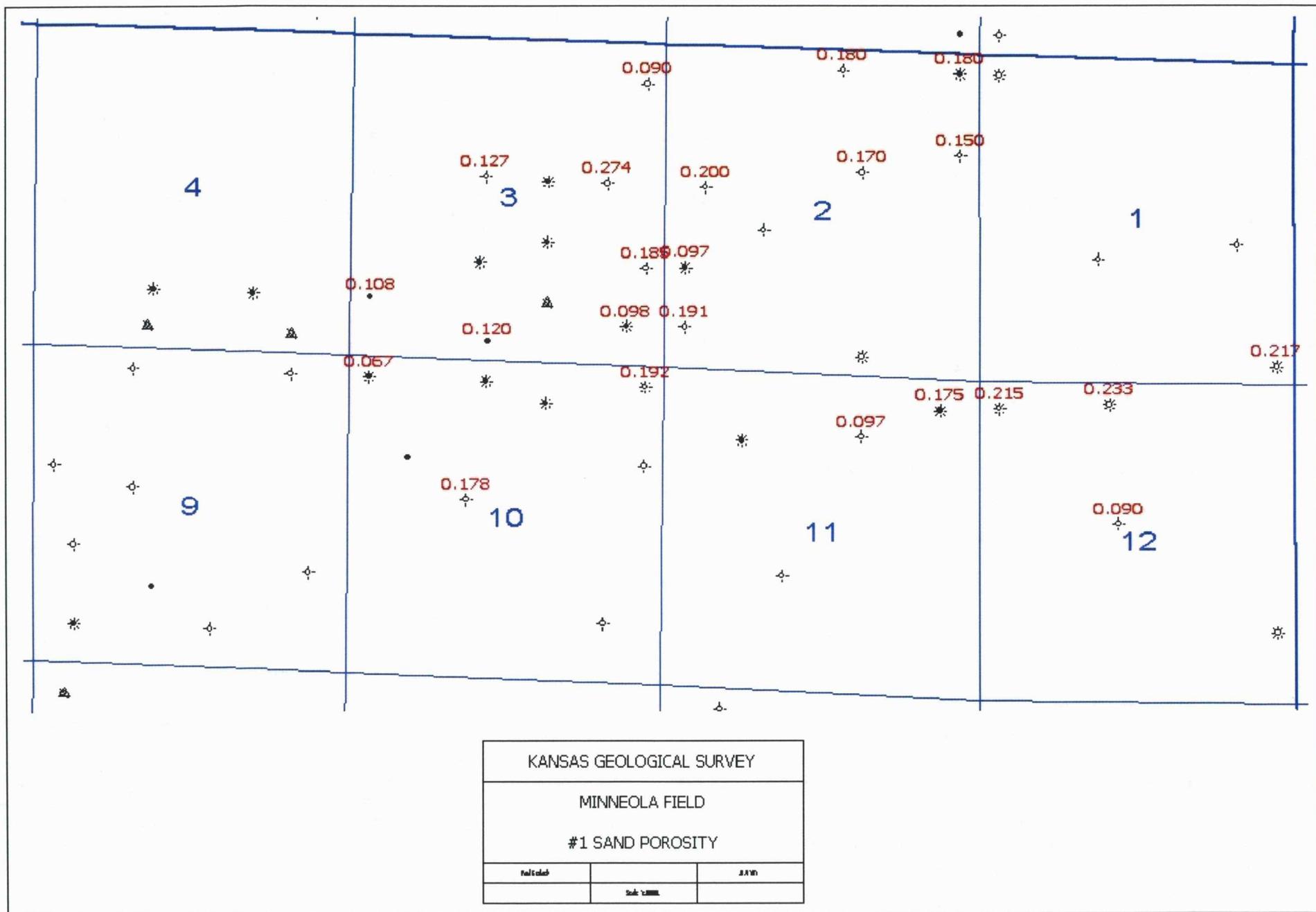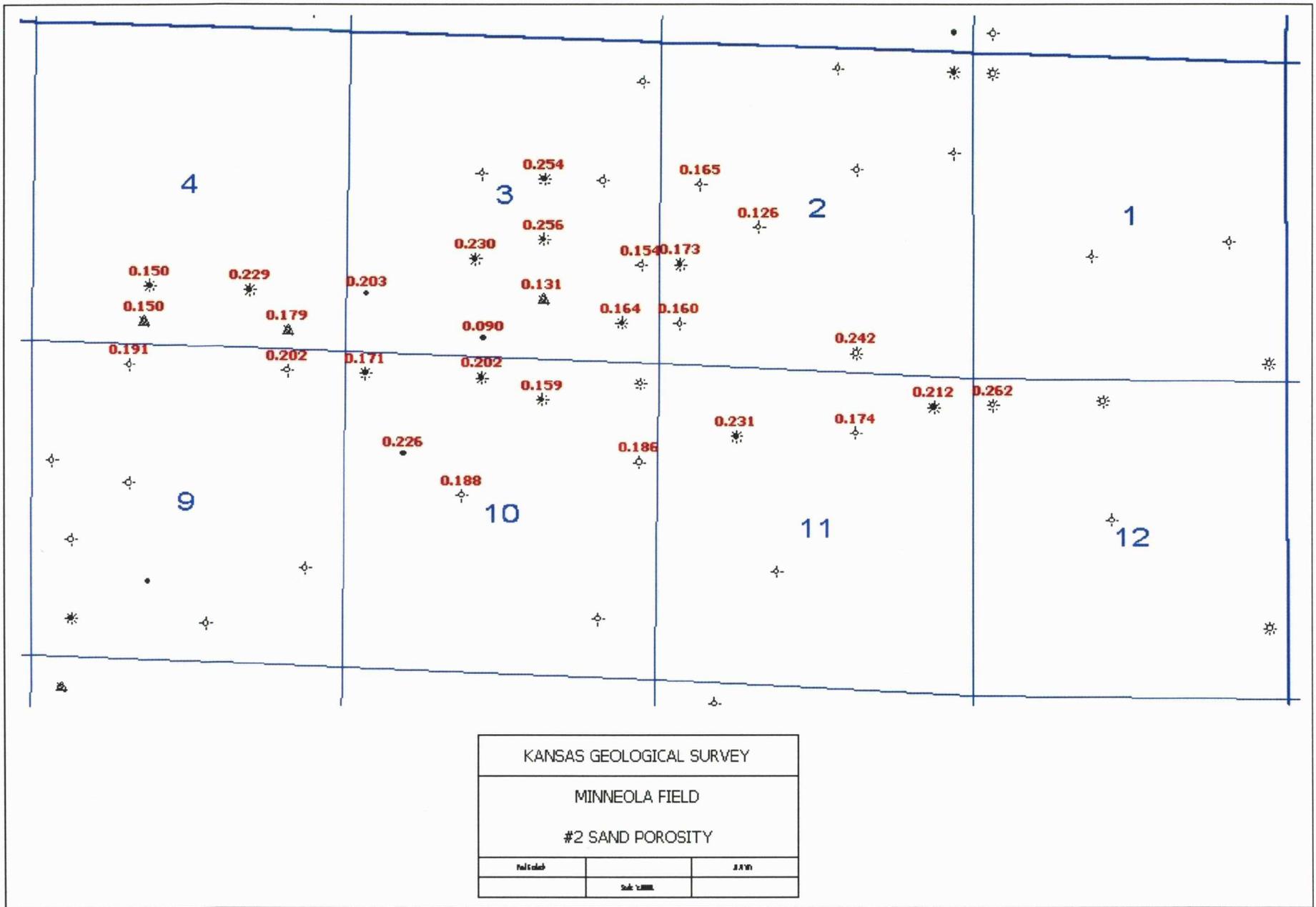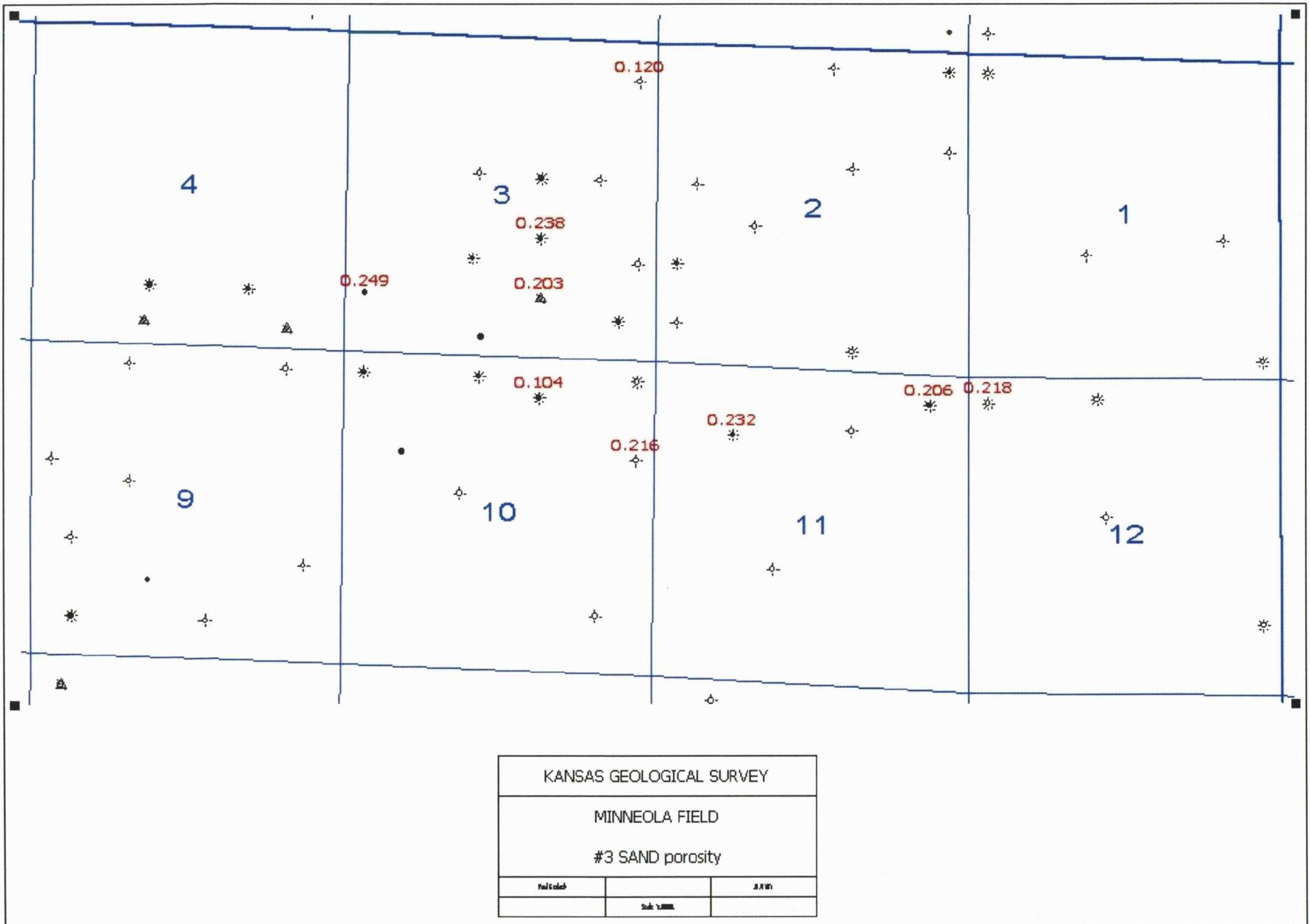
Figure: 7

Figure: 8

Figure: 9

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MINNEOLA FIELD

#3 SAND Sw

Figure: 10

Figure: 11

KANSAS GEOLOGICAL SURVEY

MINNEOLA FIELD

#1 SAND PERM

Figure: 12
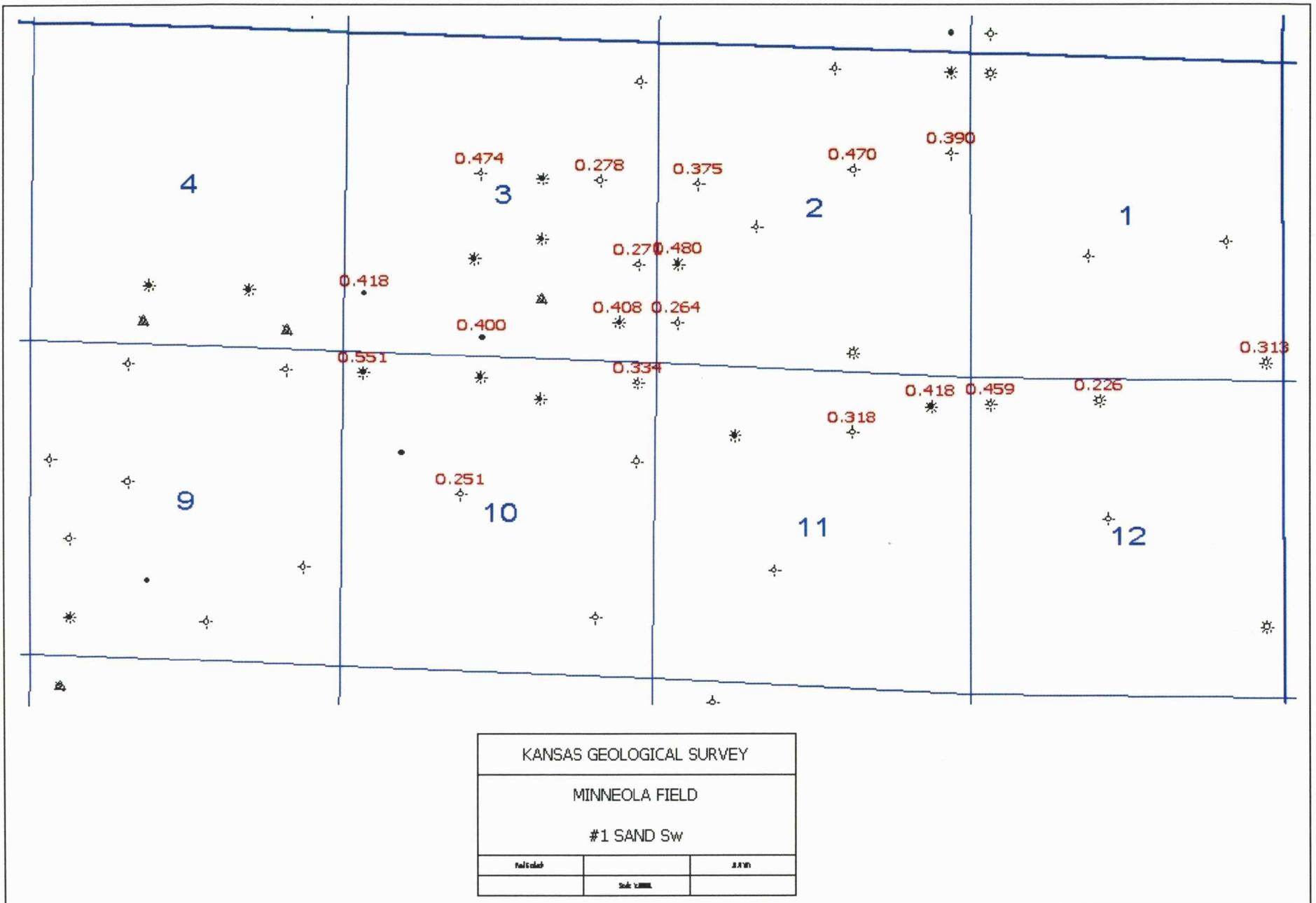
KANSAS GEOLOGICAL SURVEY
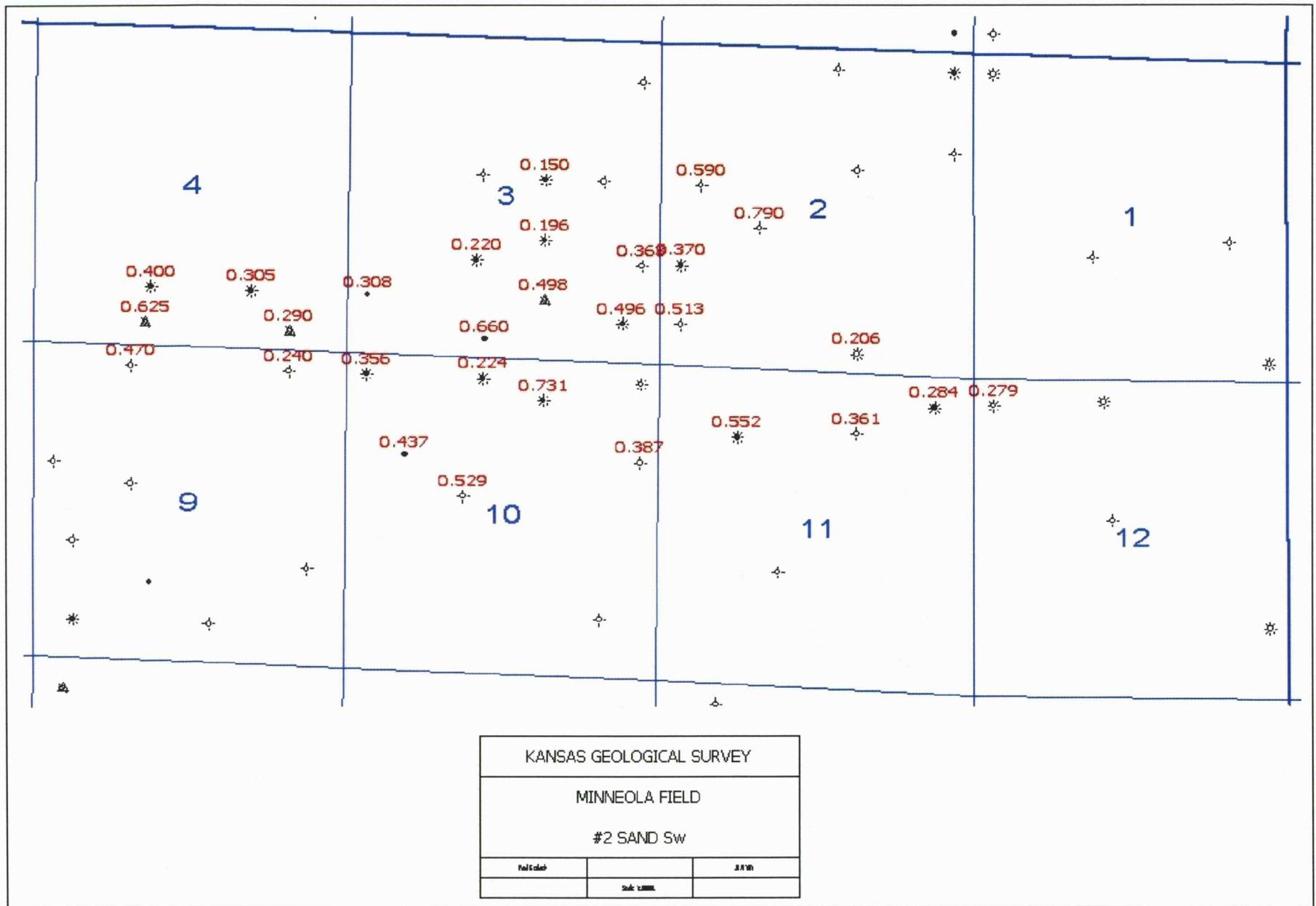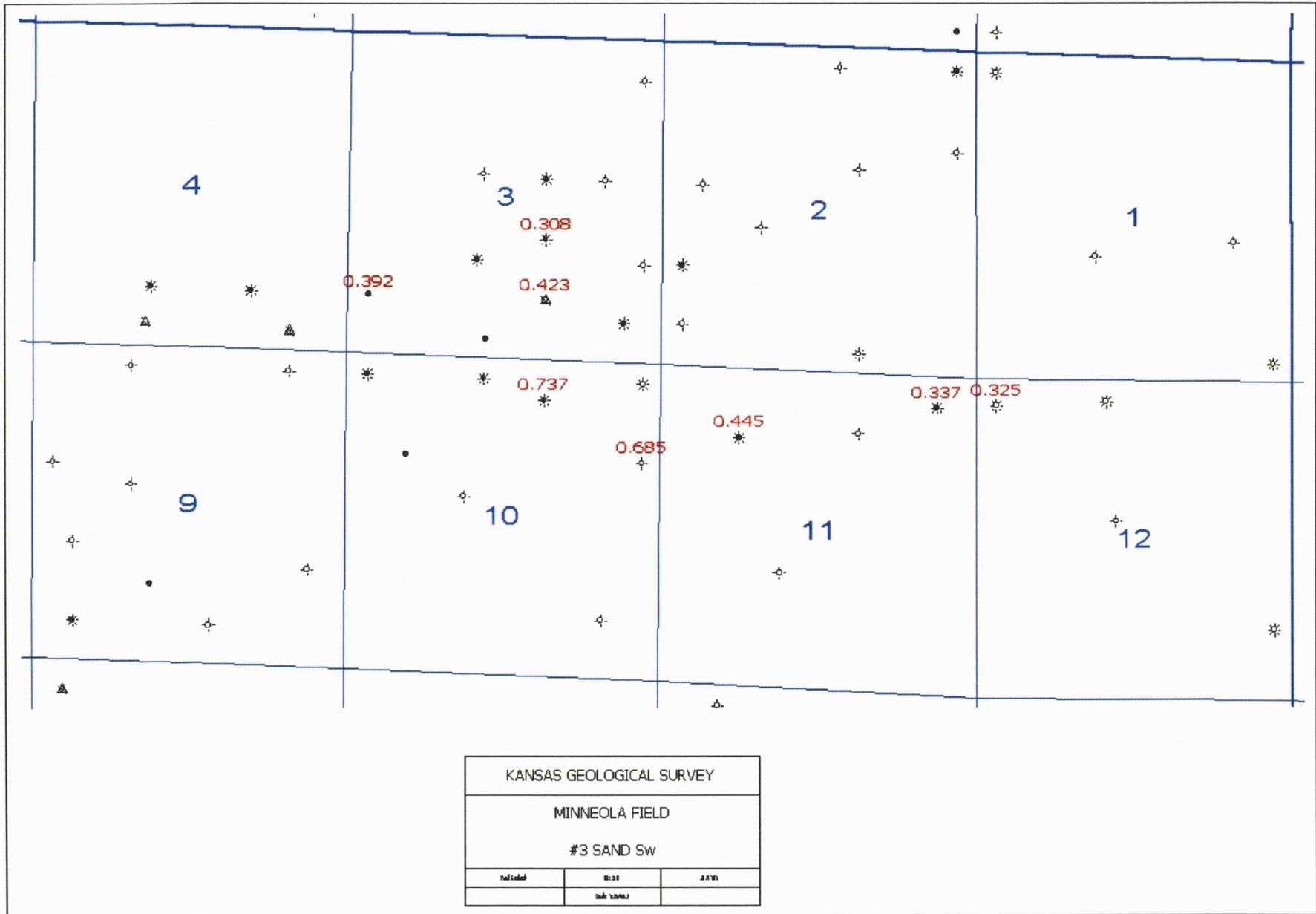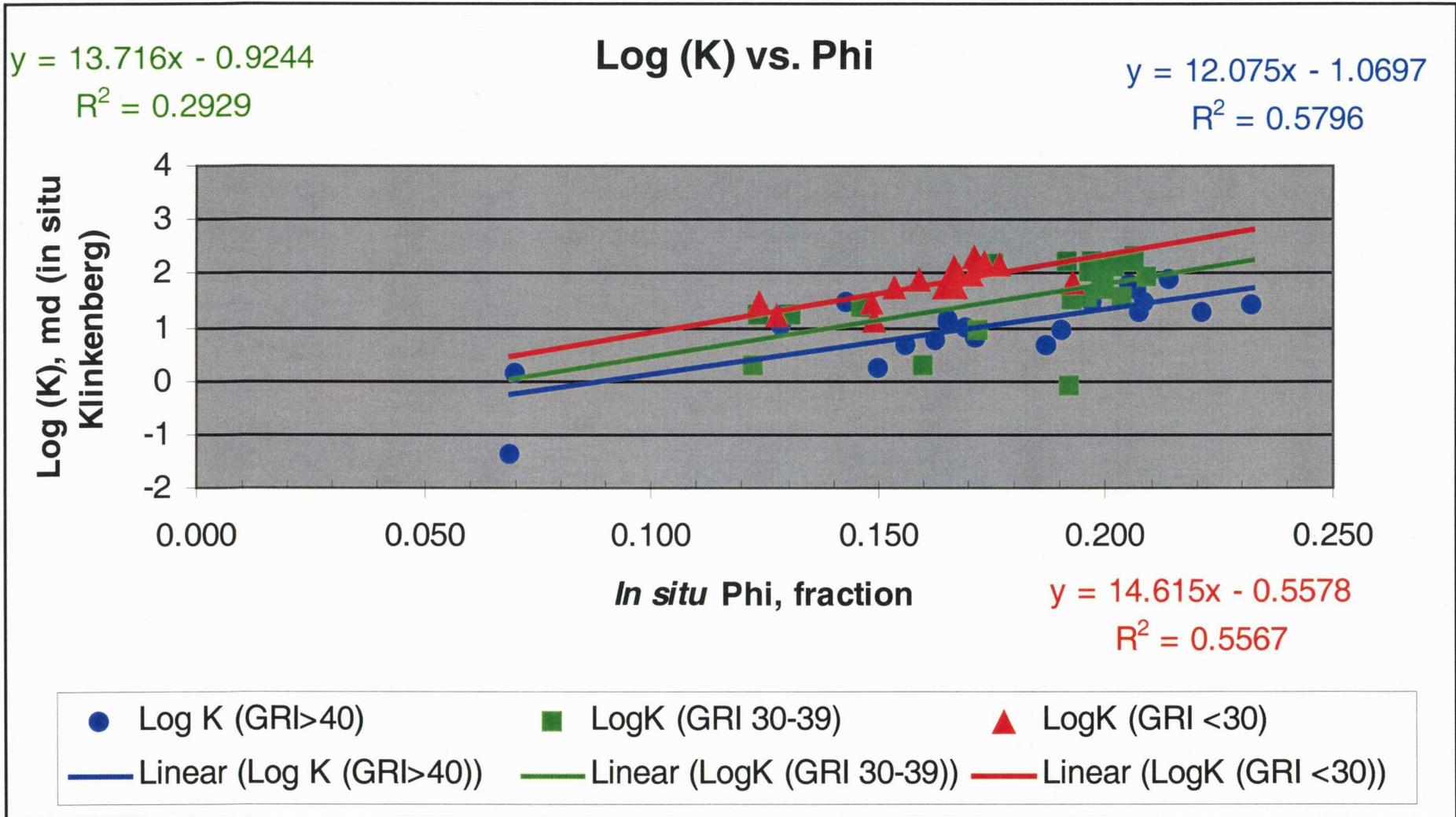
MINNEOLA FIELD
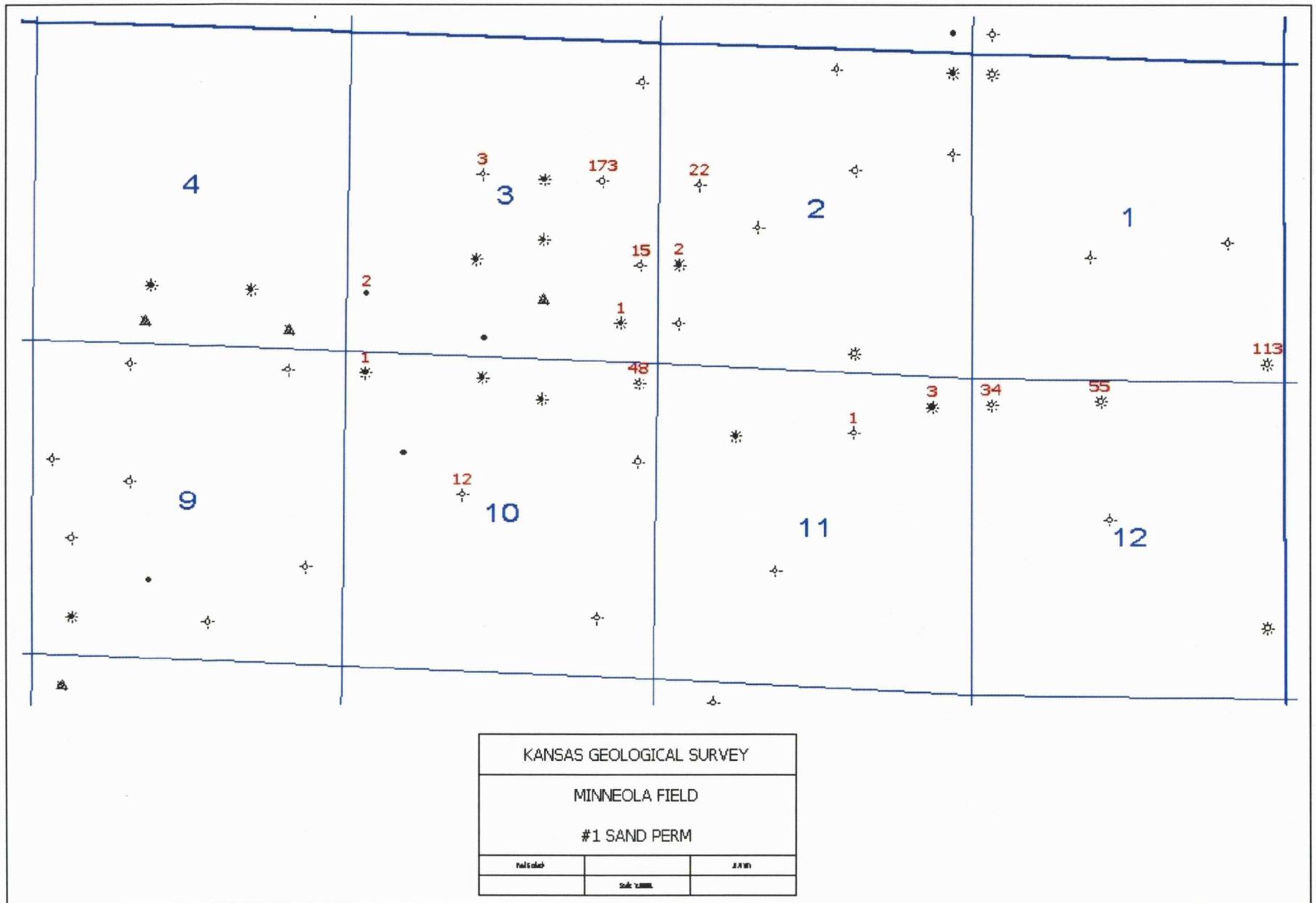
#2 SAND PERM
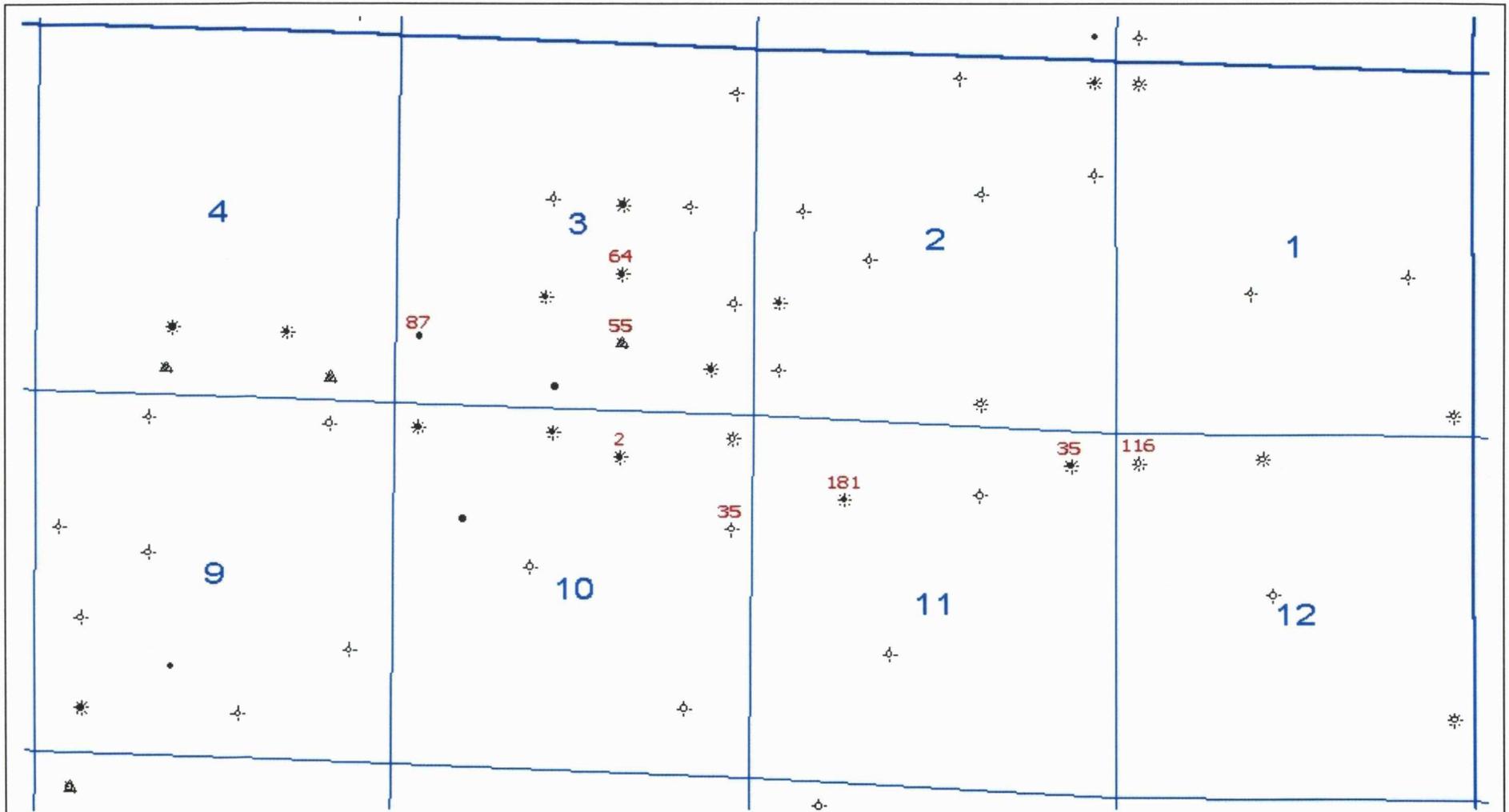
Figure 13

Figure 14

| KANSAS GEOLOGICAL SURVEY |
| MINNEOLA FIELD |
| #3 SAND PERM |

Figure: 15

**Height Above Free Water Level
Murfin Statton 2-12 5324.7 ft**

Approximate Gas-Brine Height Above Free Water Level (ft)

Wetting Phase Saturation (%)
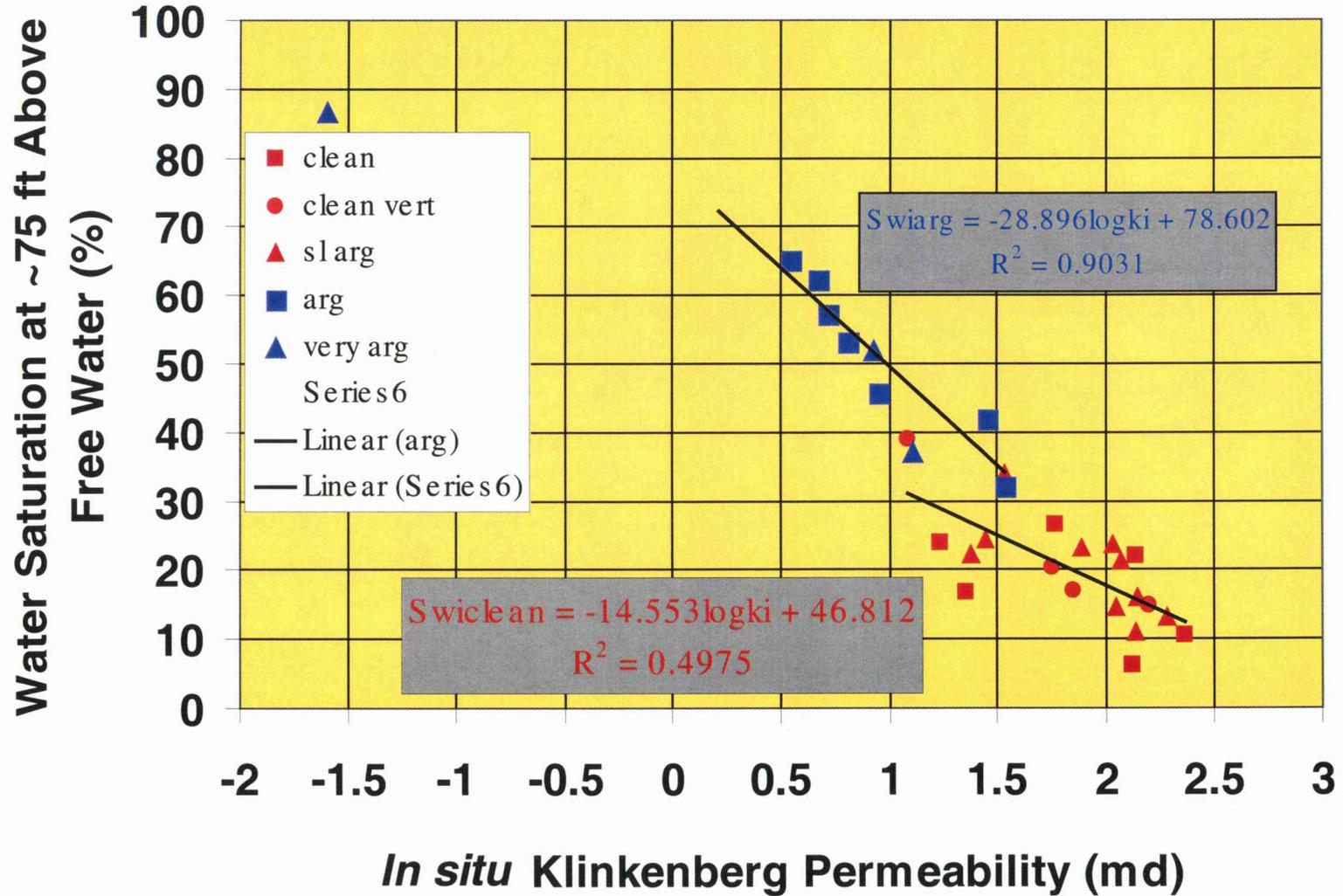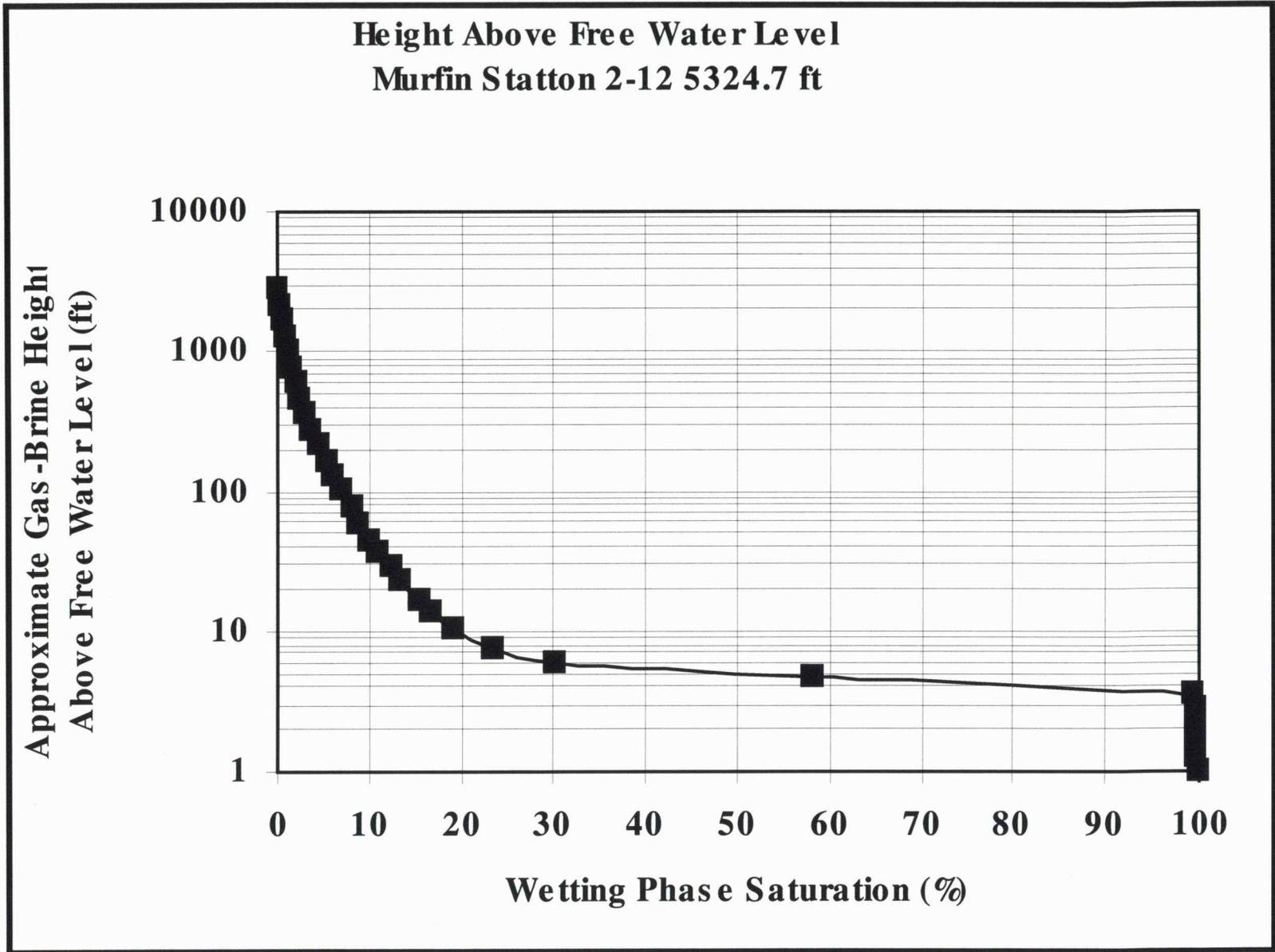
Figure: 16

Height Above Free Water Level
Murfin Statton #2-12 5319.9 ft
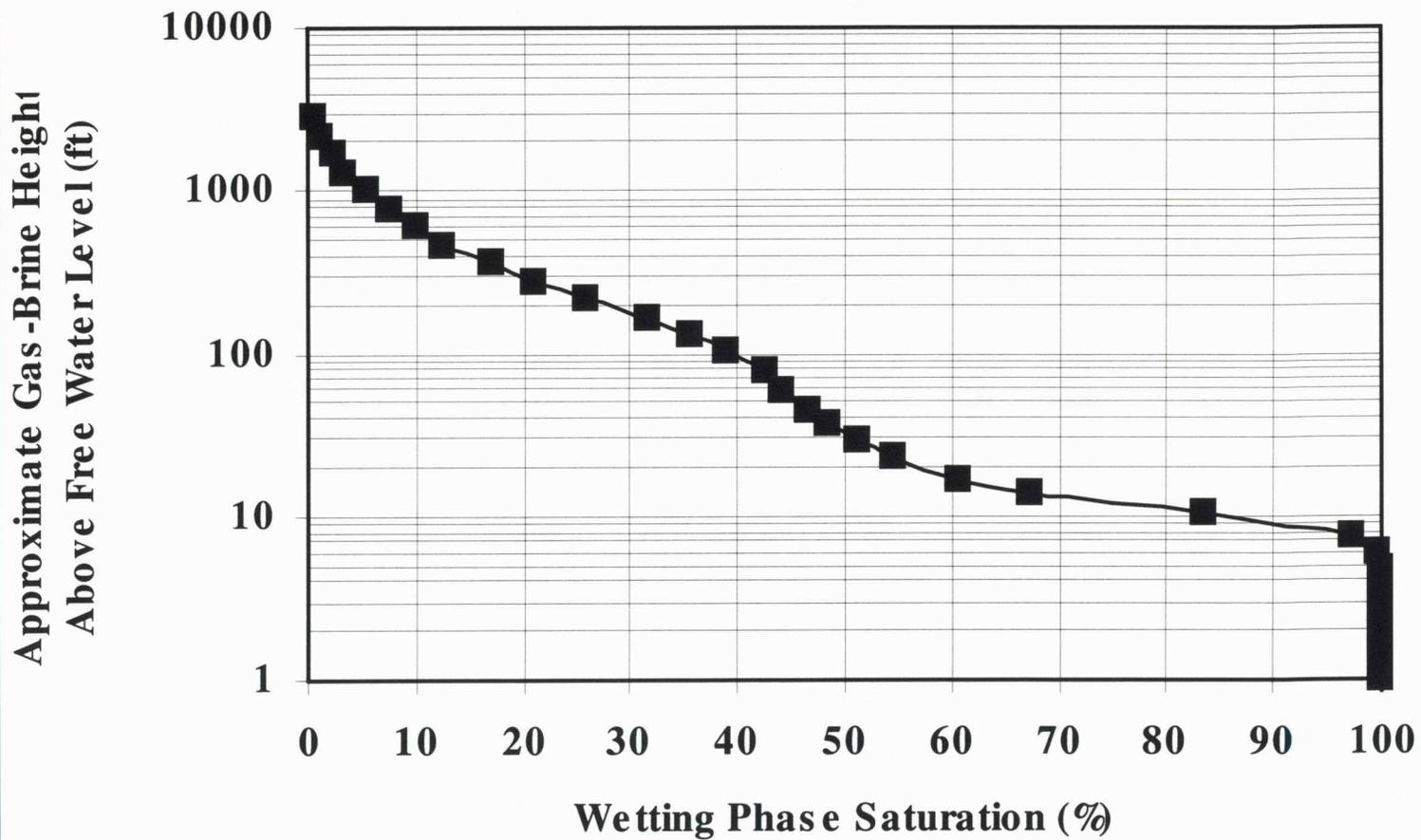
Figure: 17
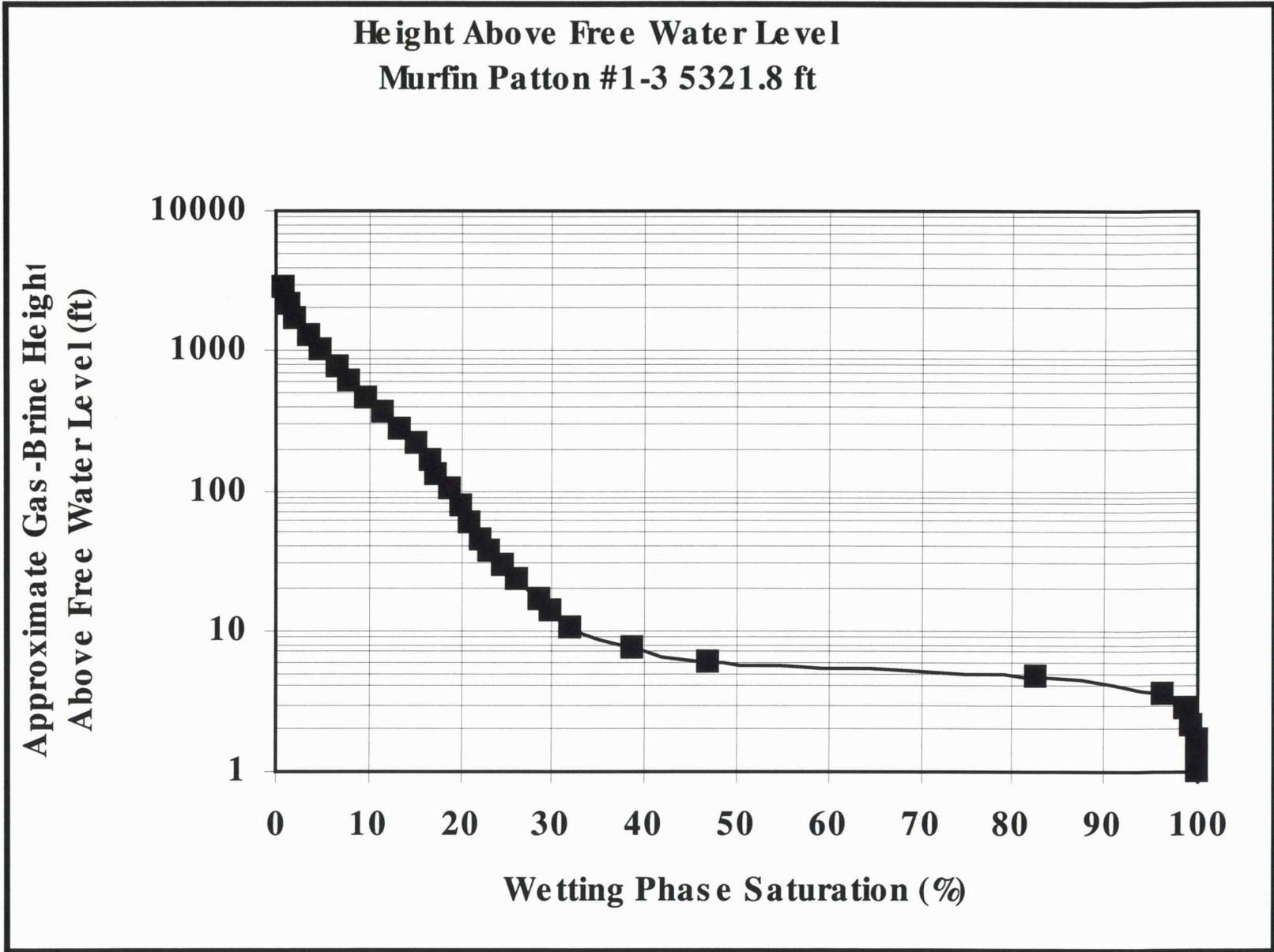
Height Above Free Water Level
Murfin Patton #1-3 5321.8 ft

Figure: 18

Figure: 19

Height Above Free Water Level
Murfin Patton #1-3 5319.4 ft
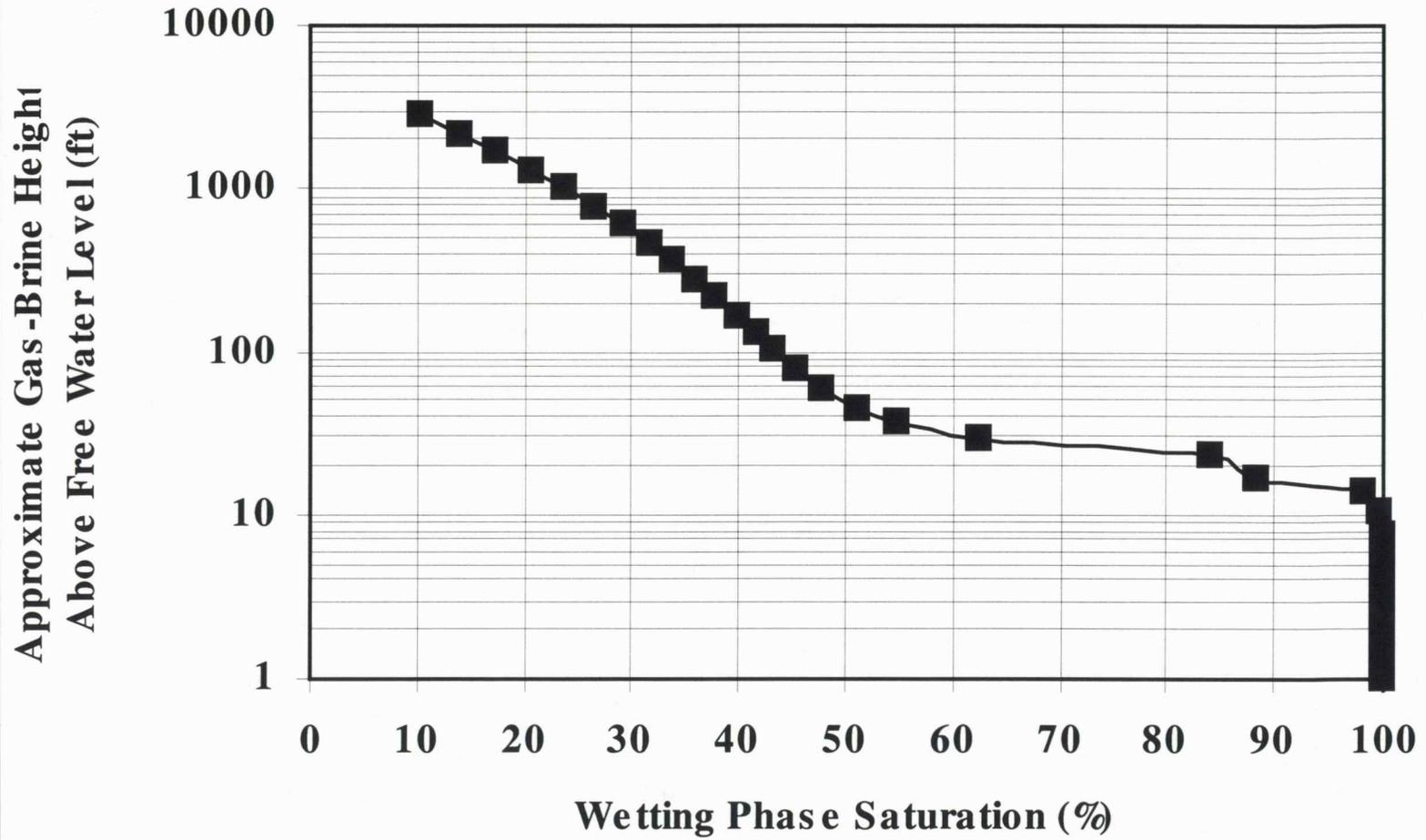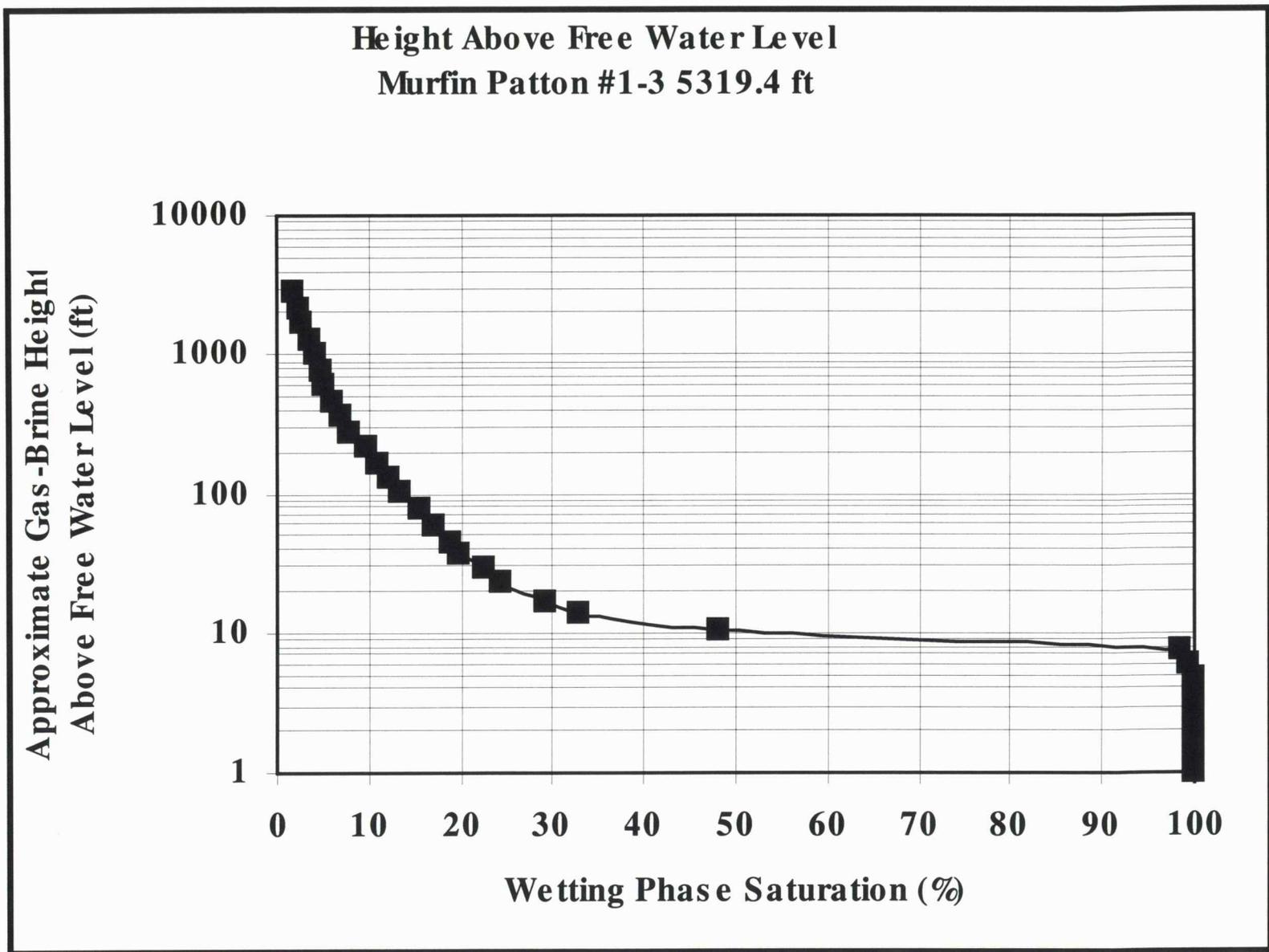
Figure: 20

MINNEOLA FIELD SIMULATION AREA
Field Production decline
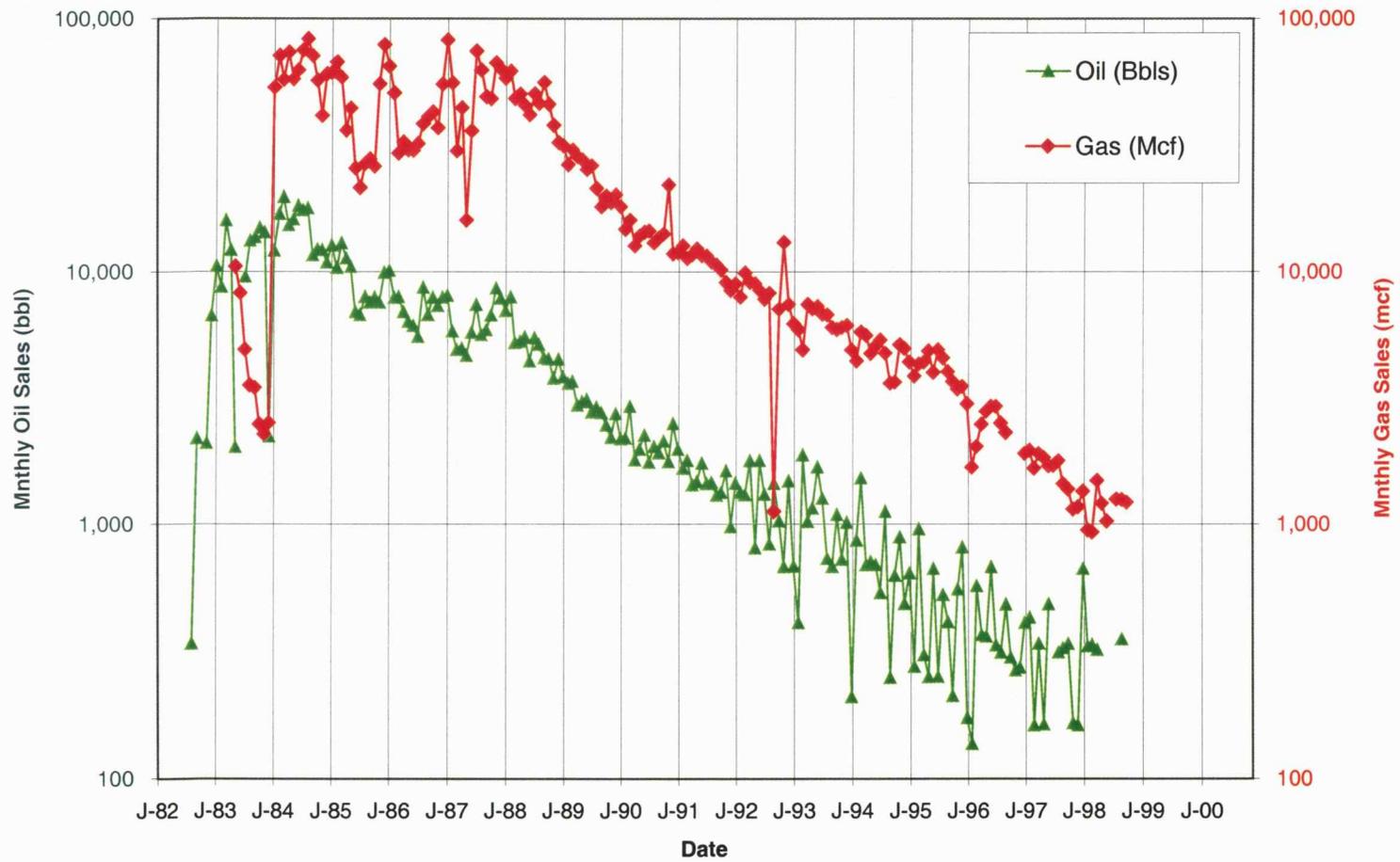
Figure: 21

Appendix A

Super-Pickett Plots

Input Parameters for Reservoir Simulation Study – Minneola Field, Clark County, Kansas

MCGEE #1-1 (Murfin, 20886)
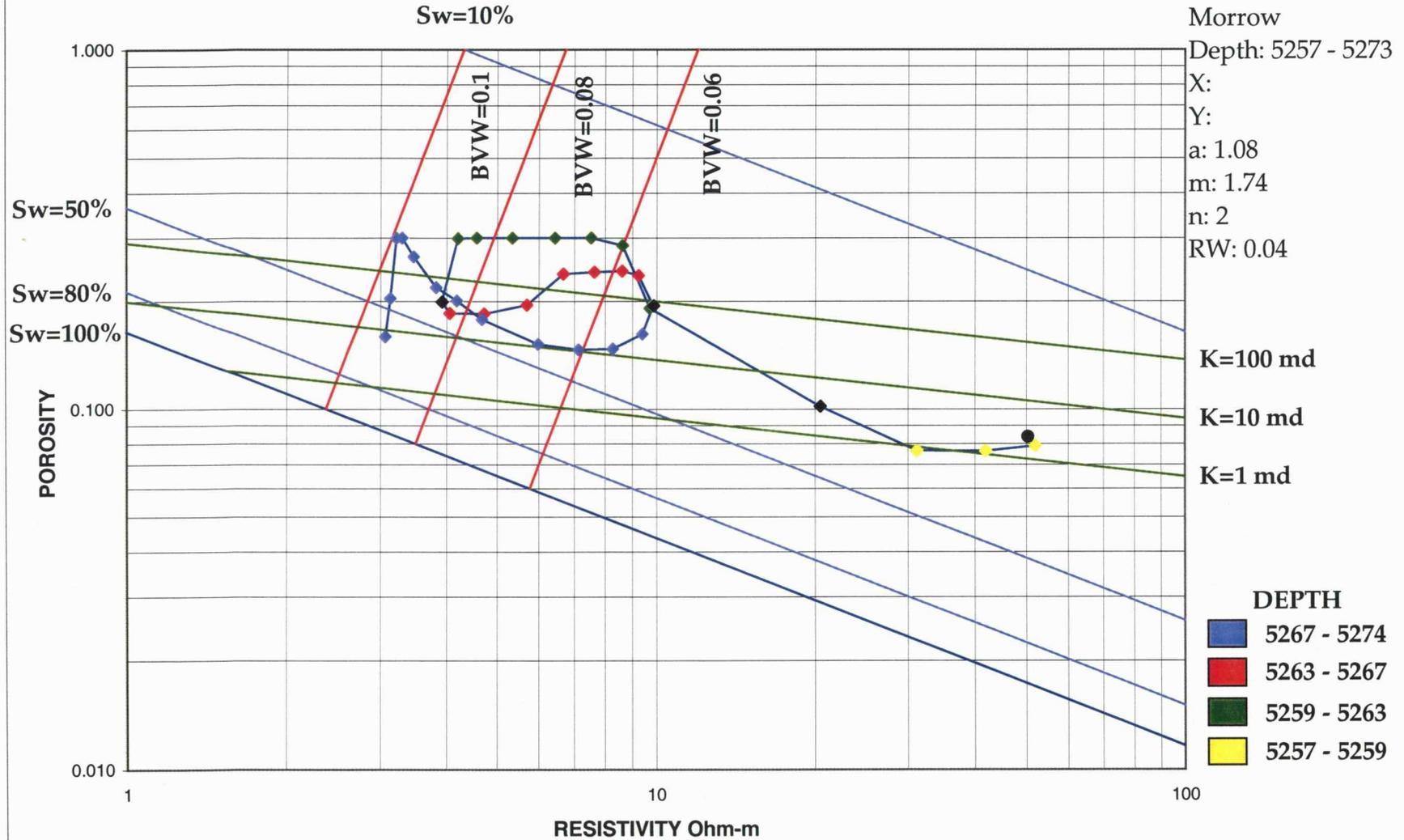
Sand #1 5262-68. DST 5259-74: 90' GCM. Perf 5263-67. IP n/a

MCGEE #1-1 (Murfin, 20886)

Sw=10%

Morrow
Depth: 5257 - 5273
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

Sw=50%

Sw=80%

Sw=100%

BVW=0.1

BVW=0.08

BVW=0.06

K=100 md

K=10 md

K=1 md

POROSITY

1.000

0.100

0.010

1   10   100

RESISTIVITY Ohm-m

GR .GAPI

🟥	75 - 125
🟩	40 - 75
🟦	30 - 40
🟨	0 - 30
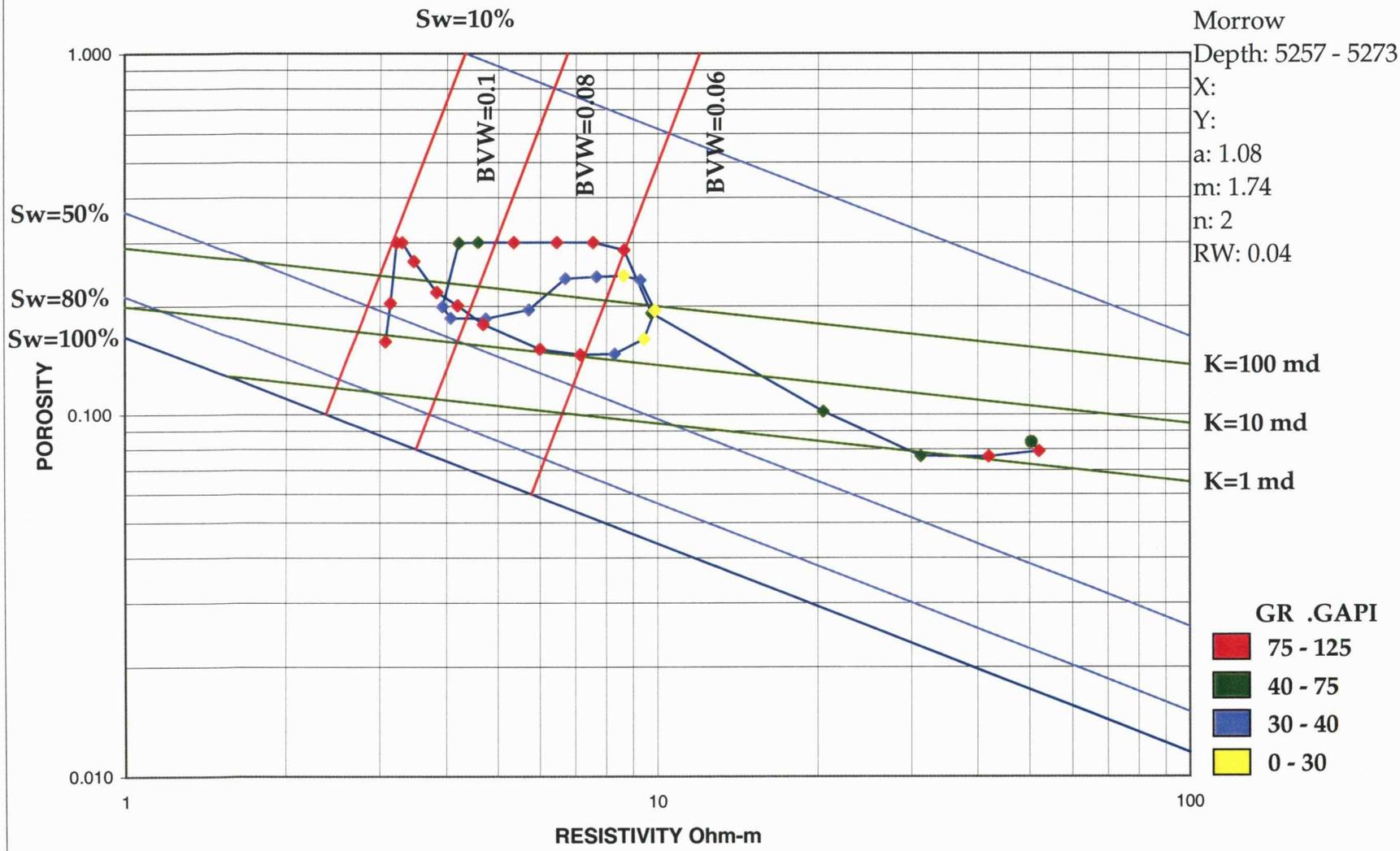
Sand #1 5262-68. DST 5259-74: 90' GCM. Perf 5263-67. IP n/a

ROONEY #B-1-2 (Murfin, 20917)

ROONEY #B-1-2 (Murfin, 20917)
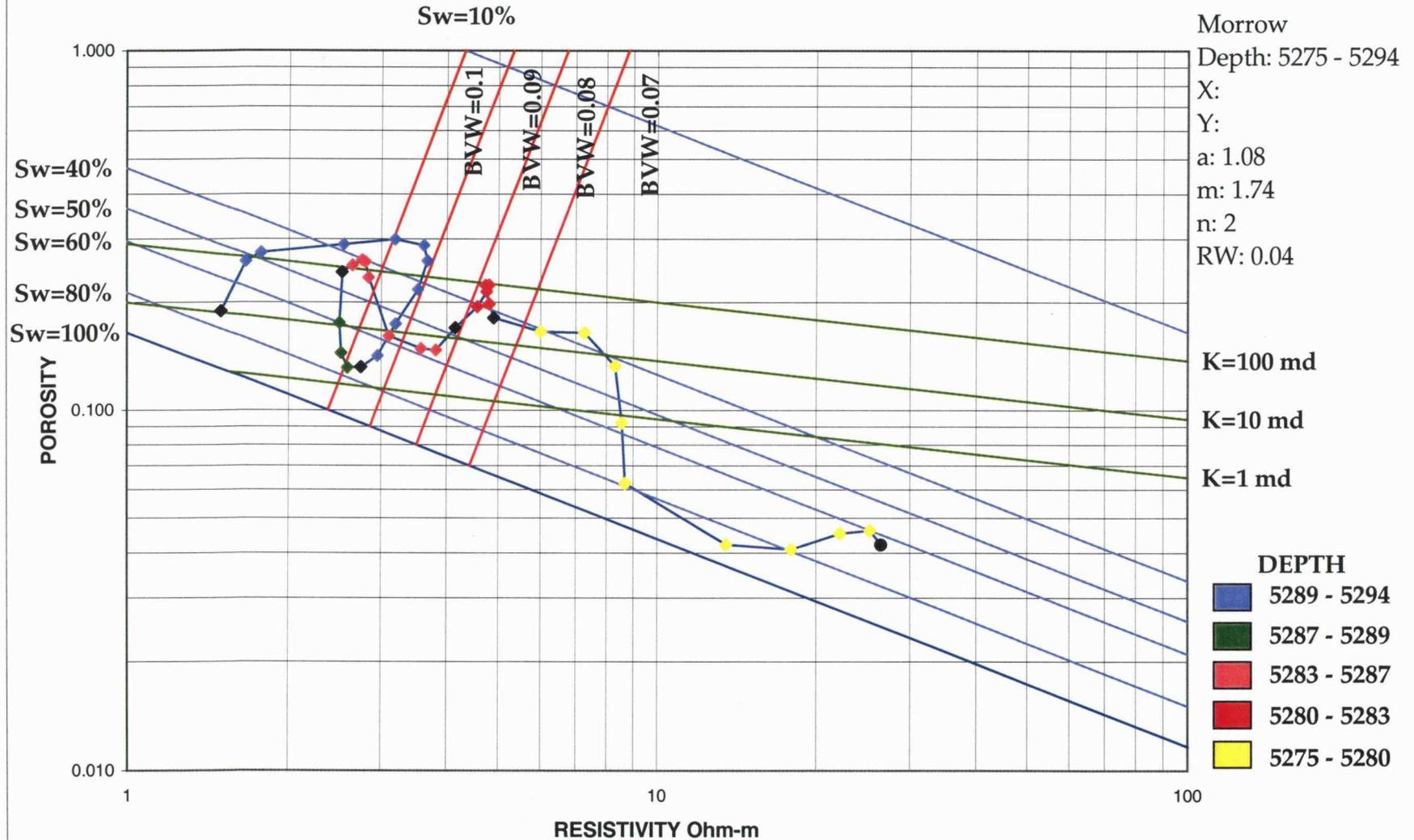
Sand 1: 5280-83. Sand 2: 5287-89. D&A

HALL #2-2 (Murfin, 20838)
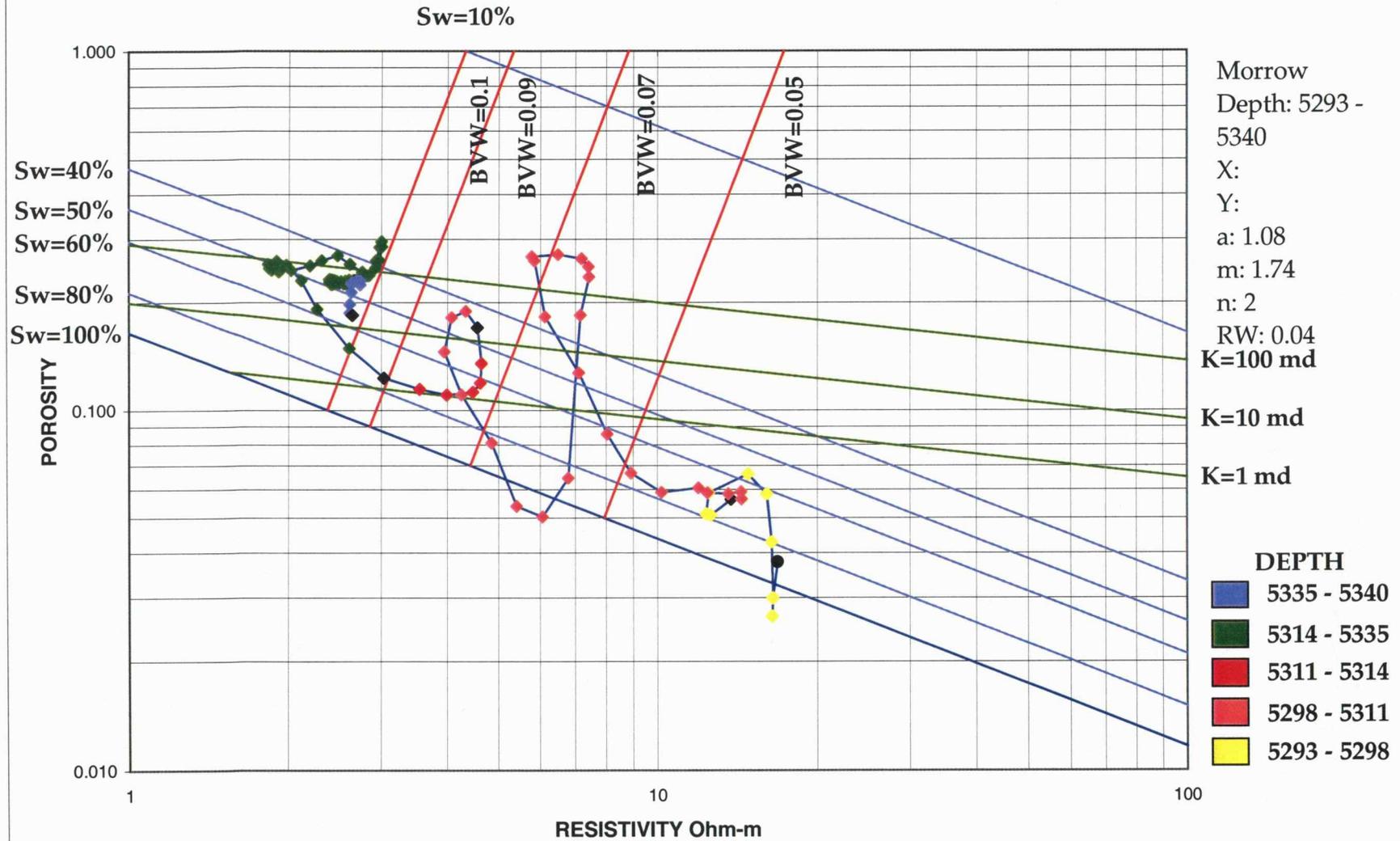
Sand 2: 5311-5314. D&A

HALL #2-2 (Murfin, 20838)
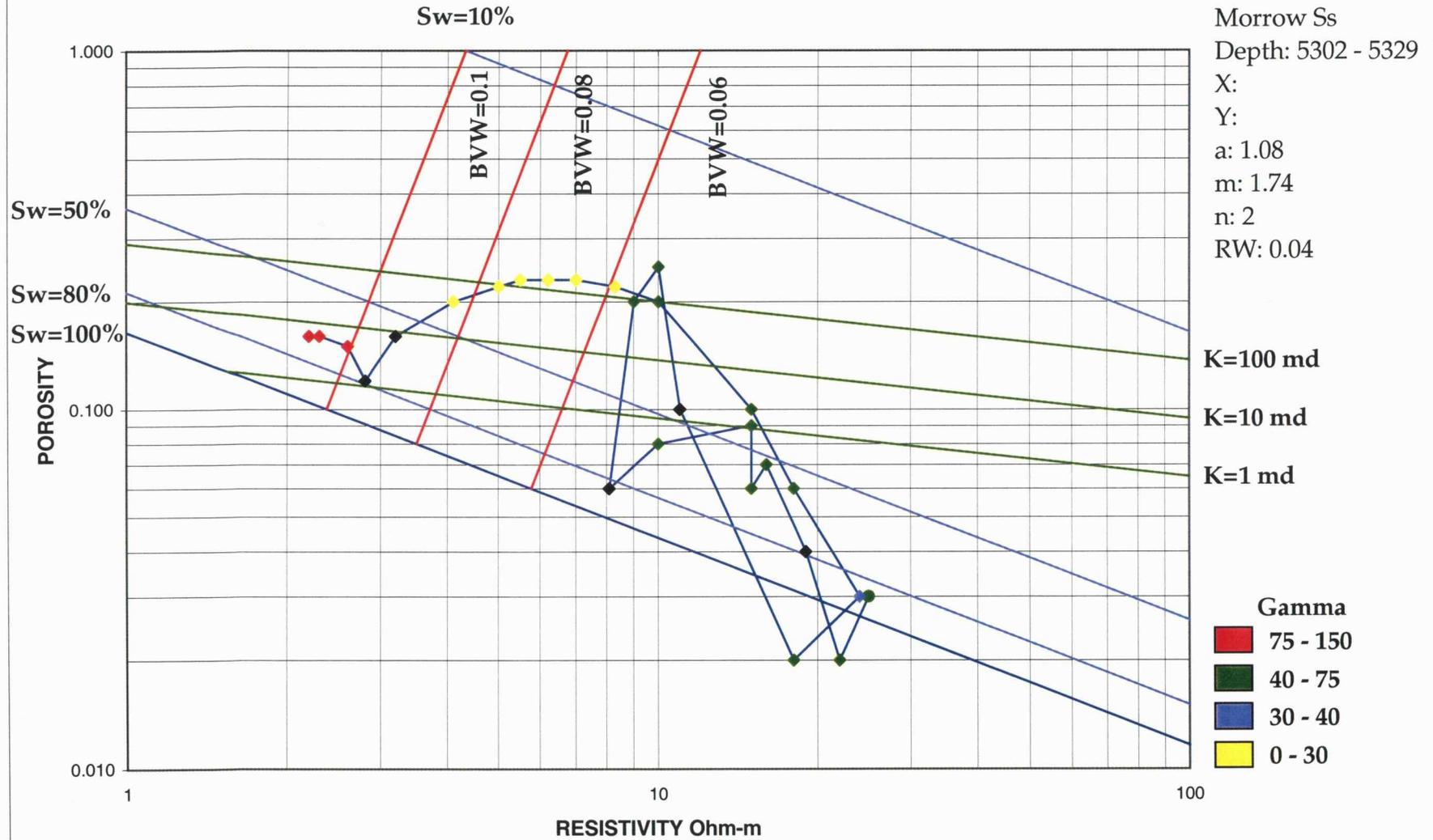
Sw=10%

Sw=40%
Sw=50%
Sw=60%
Sw=80%
Sw=100%

BVW=0.1
BVW=0.09
BVW=0.07
BVW=0.05

POROSITY

1.000

0.100

0.010

1   10   100

RESISTIVITY Ohm-m

Morrow
Depth: 5293 -
5340
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

K=100 md

K=10 md

K=1 md

GR .GAPI

🟥	75 - 135
🟩	40 - 75
🟦	30 - 40
🟨	0 - 30
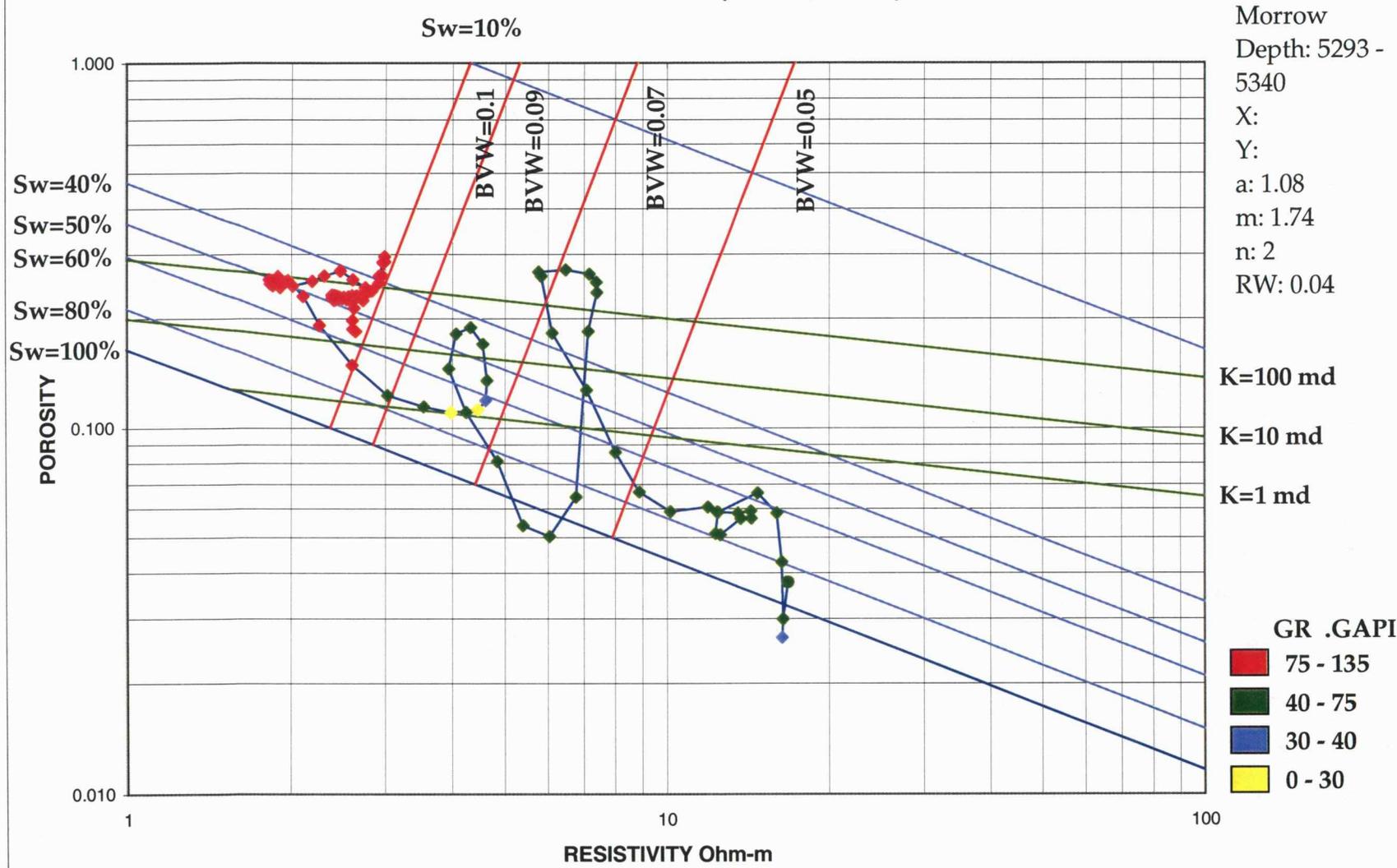
Sand 2: 5311-5314. D&A

Hall #1-2 (15-025-20785)

Sw=10%

Sw=50%

Sw=80%

Sw=100%

POROSITY

BVW=0.1

BVW=0.08

BVW=0.06

Morrow Ss
Depth: 5302 - 5329
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

K=100 md

K=10 md

K=1 md

DEPTH
- 5324 - 5329
- 5316 - 5324
- 5310 - 5316
- 5307 - 5310
- 5302 - 5307

1.000

0.100

0.010

1   10   100

RESISTIVITY Ohm-m
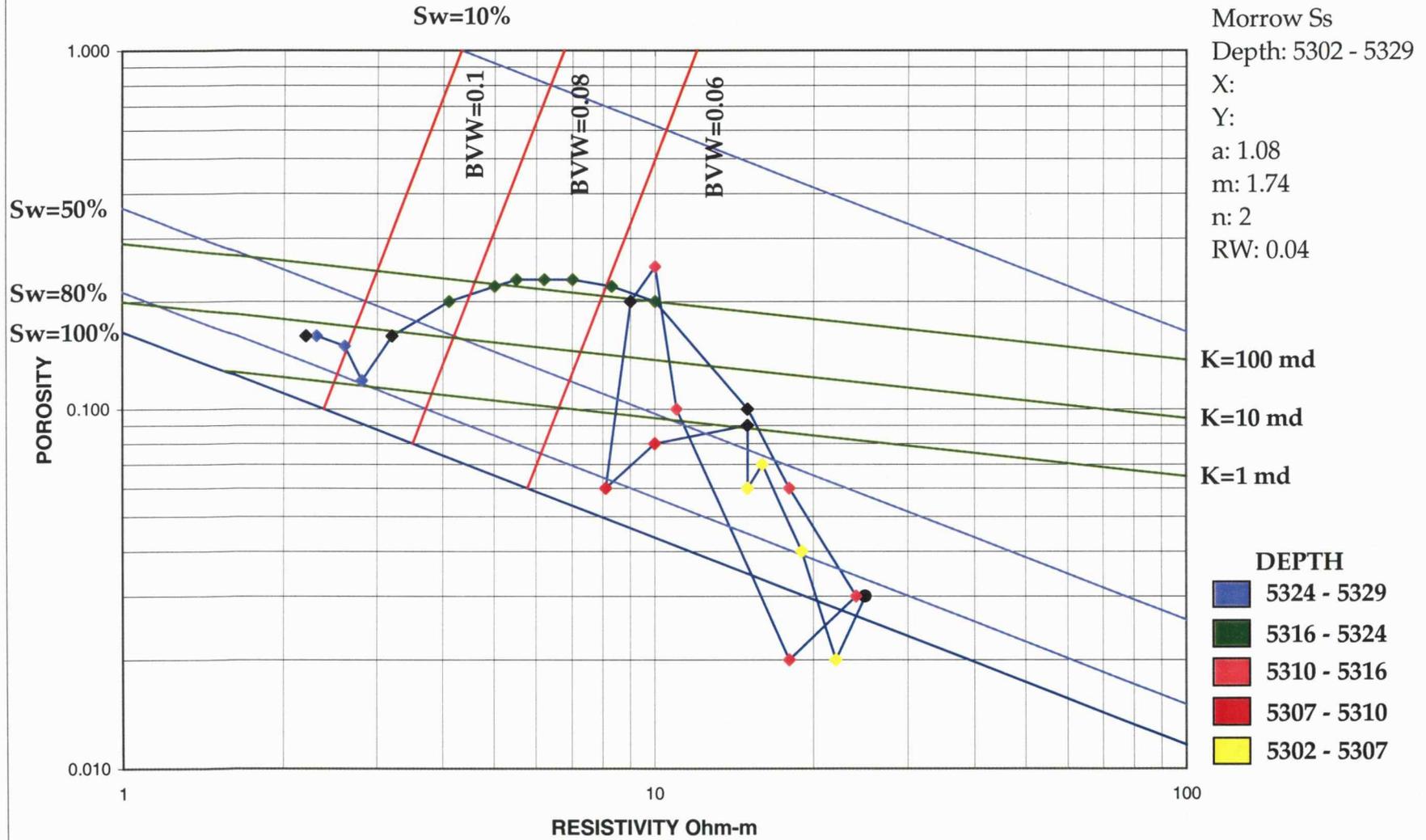
Sand 1: 5307-10. Sand 2: 5316-24. Perf 5317-23. IP: 134 bopd & 153 mcfd

Hall #1-2 (15-025-20785)

Hall B #1-2 (Murfin, 20919)

Sw=10%

Sw=30%

Sw=50%
Sw=60%

Sw=80%

Sw=100%

BVW=0.1   BVW=0.08   BVW=0.06

Morrow Ss
Depth: 5273 - 5290
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

K=100 md

K=10 md

K=1 md

POROSITY

1.000

0.100

0.010

RESISTIVITY Ohm-m

1   10   100

DEPTH
5283 - 5290
5281 - 5283
5278 - 5281
5273 - 5278
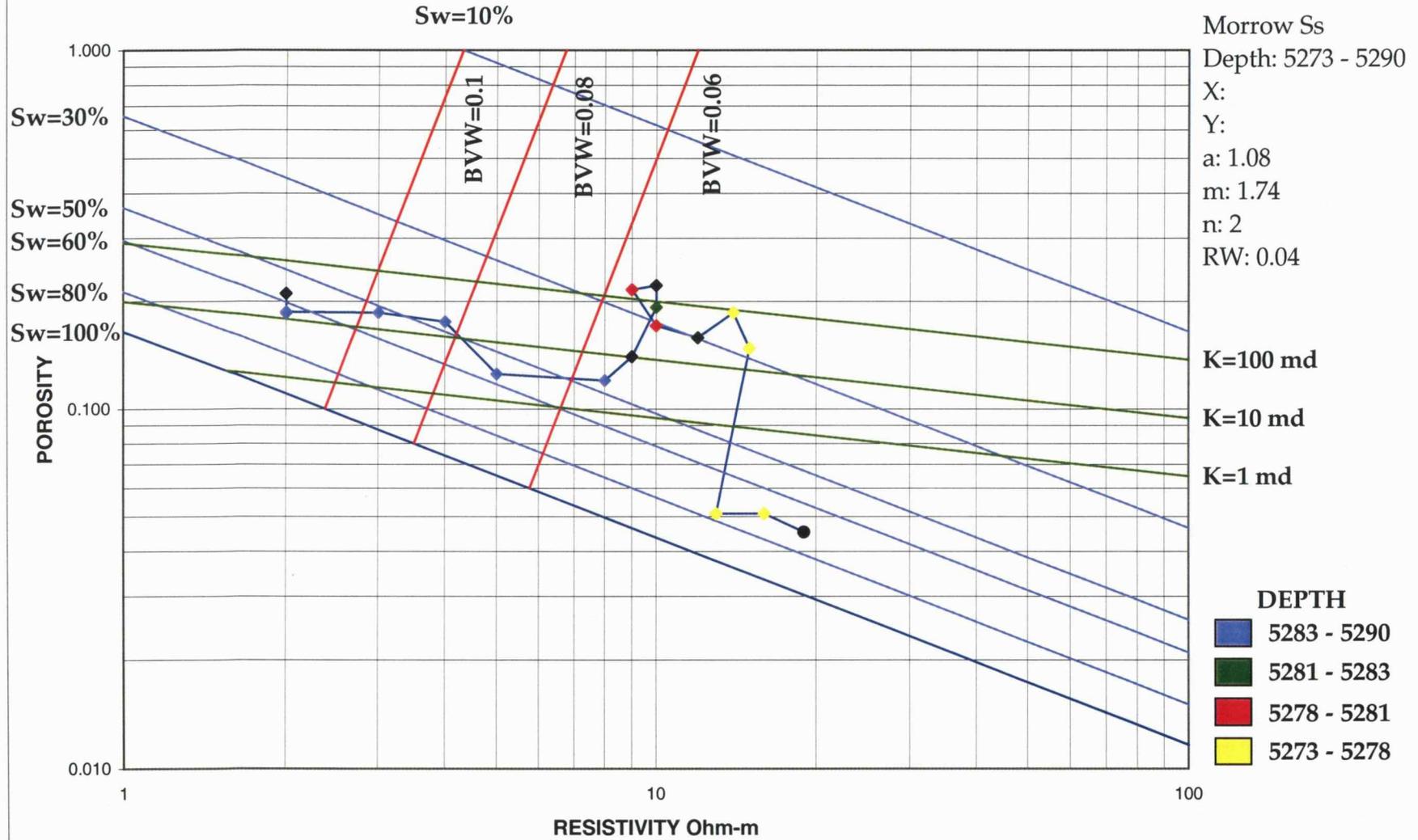
SD#1: 5278-81, SD#2: 5283-89. DST: 5276-00. Results N/A. D&A

Hall B #1-2 (Murfin, 20919)

Morrow Ss
Depth: 5273 - 5290
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04
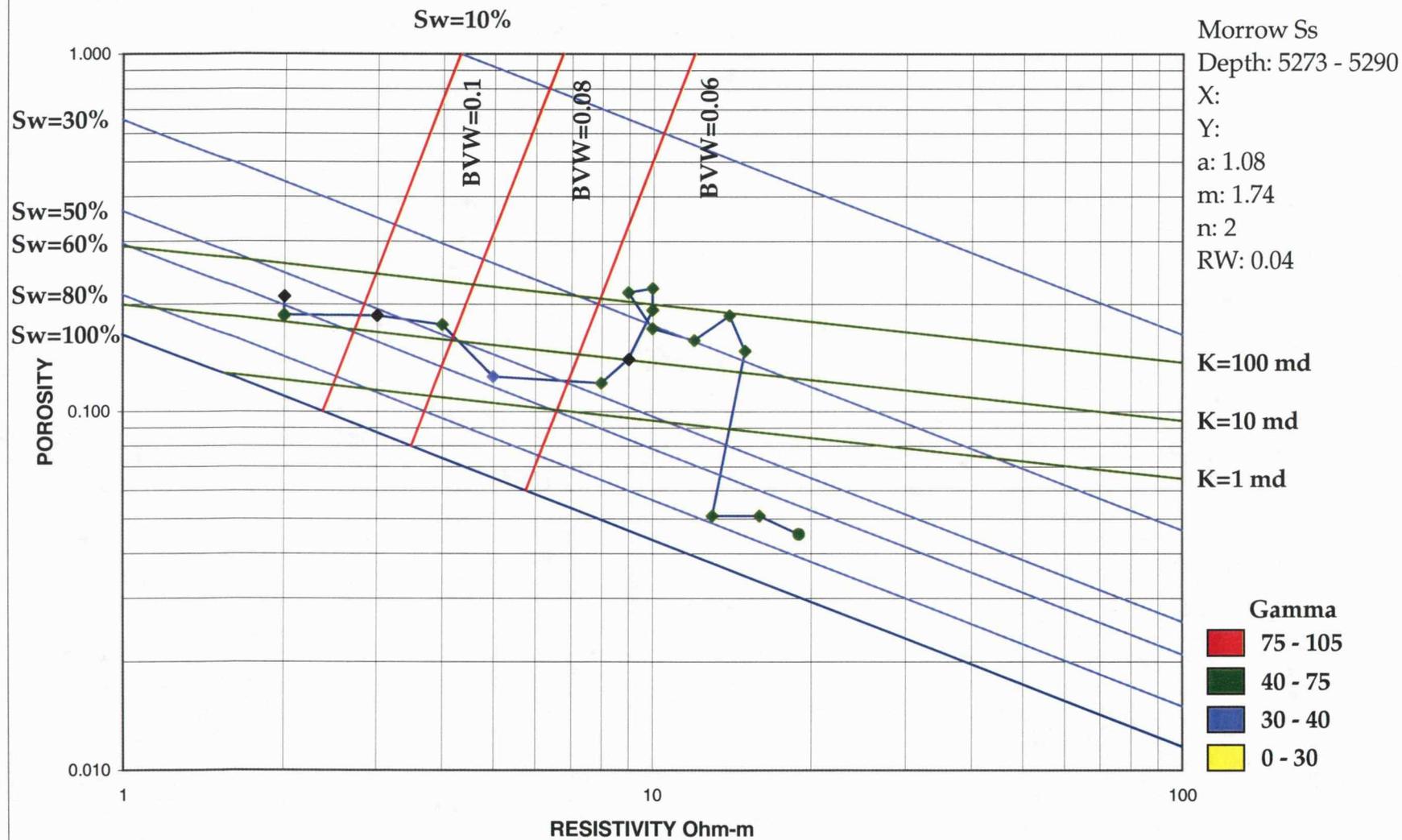
SD#1: 5278-81, SD#2: 5283-89. DST: 5276-00. Results N/A. D&A

SCHLICHTING #1-2 (Ladd, 15-025-20703)
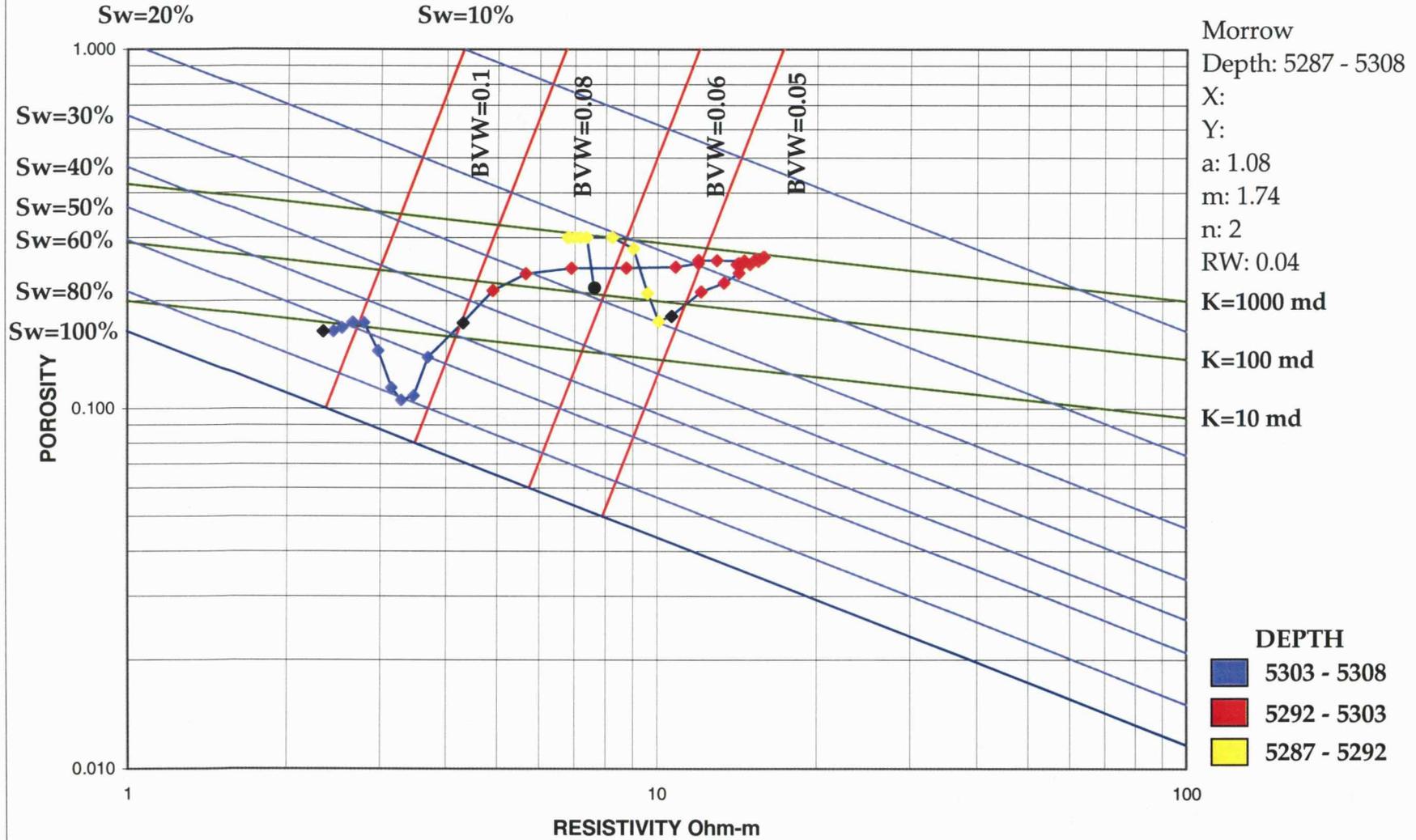
Sand 2: 5292-5303. Perf. 5293-5302. IP: 13543 mcfd, OBW

SCHLICHTING #1-2 (Ladd, 15-025-20703)
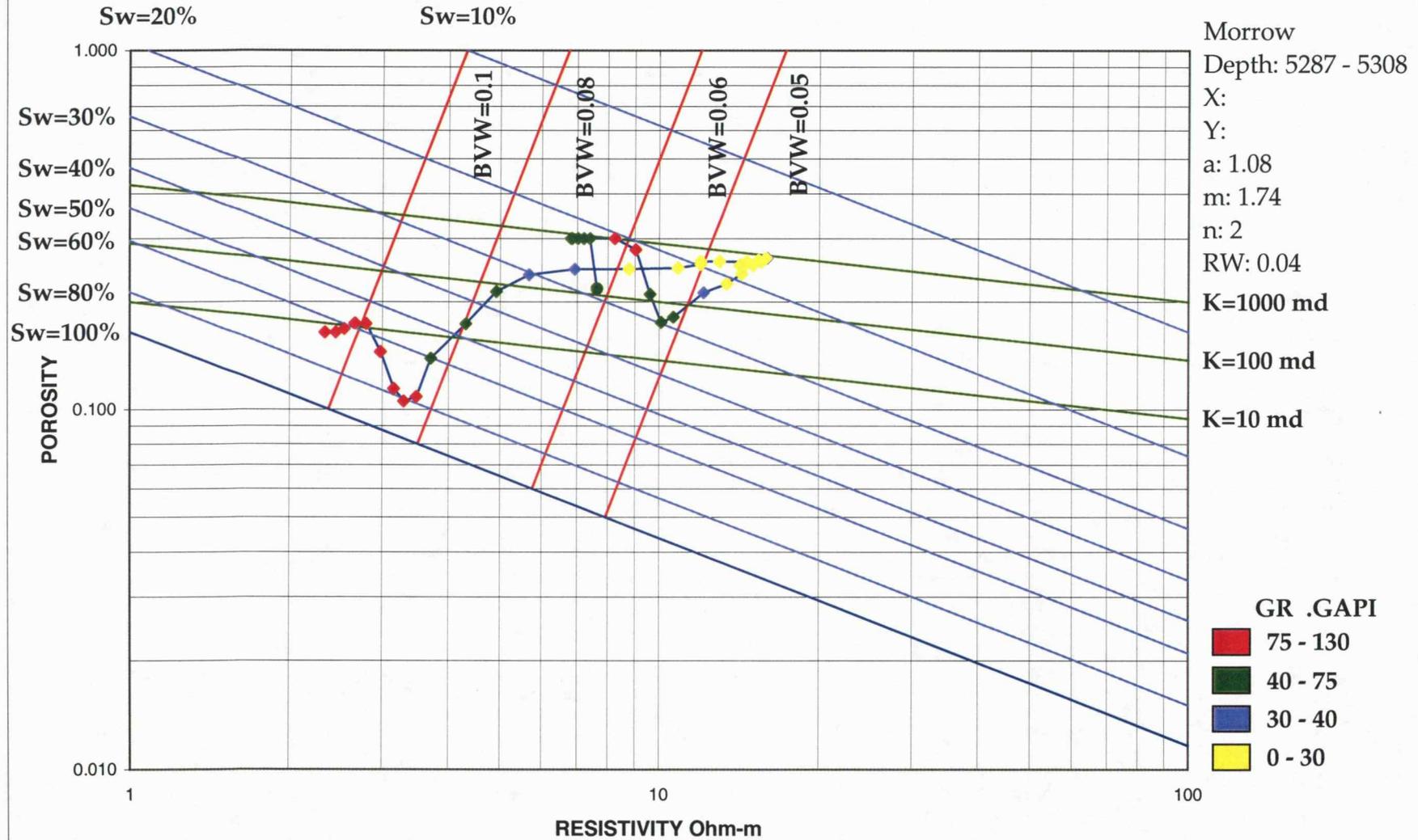
Sand 2: 5292-5303. Perf. 5293-5302. IP: 13543 mcfd, OBW

LENA D. BOUCHER #1-3A (Ladd, 15-025-20695)

Sw=10%

Morrow
Depth: 5286 - 5295
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04
Sonic

K=100 md

K=10 md

K=1 md

BVW=0.1

BVW=0.08

BVW=0.06
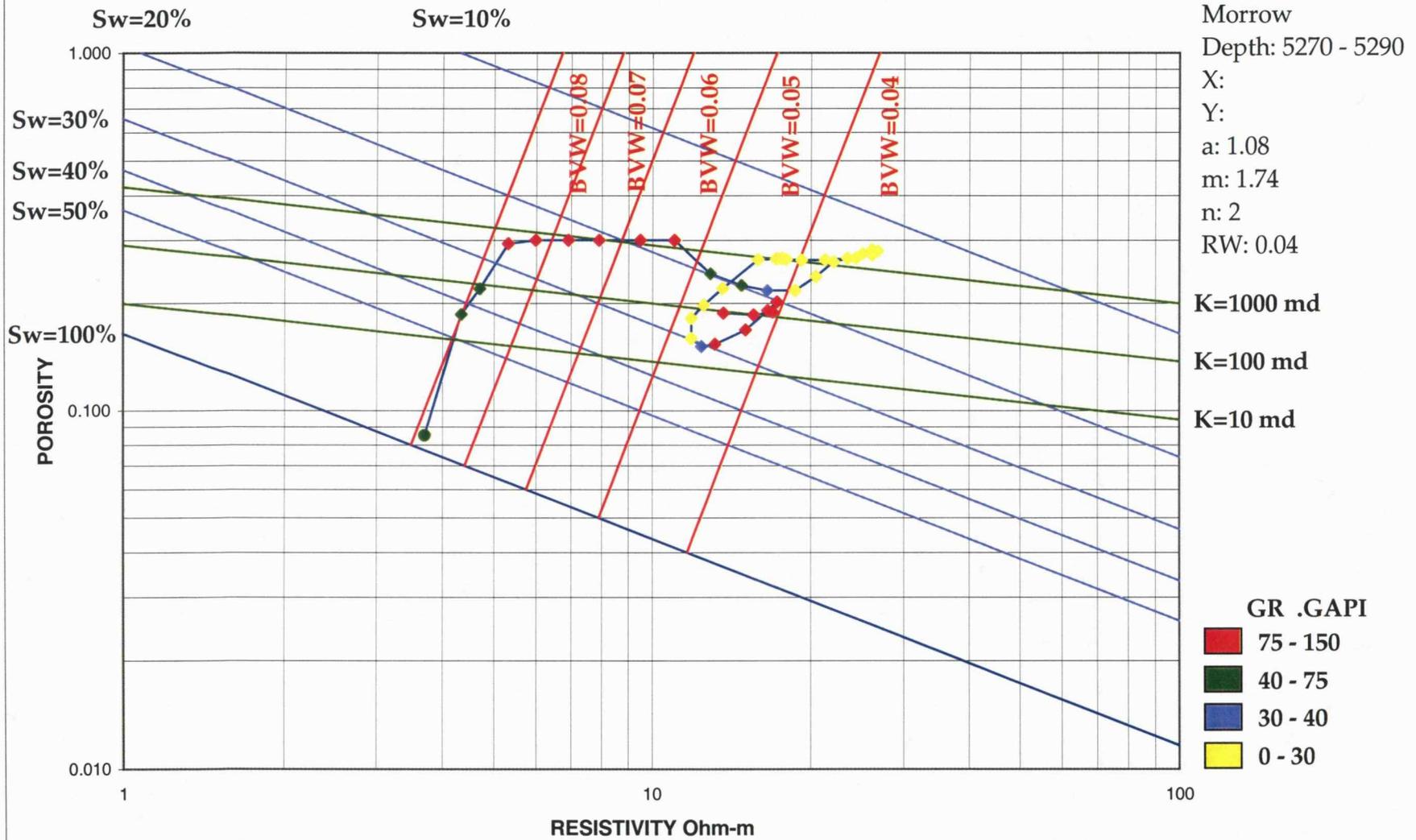
Sw=50%
Sw=60%
Sw=80%
Sw=100%

POROSITY

RESISTIVITY Ohm-m
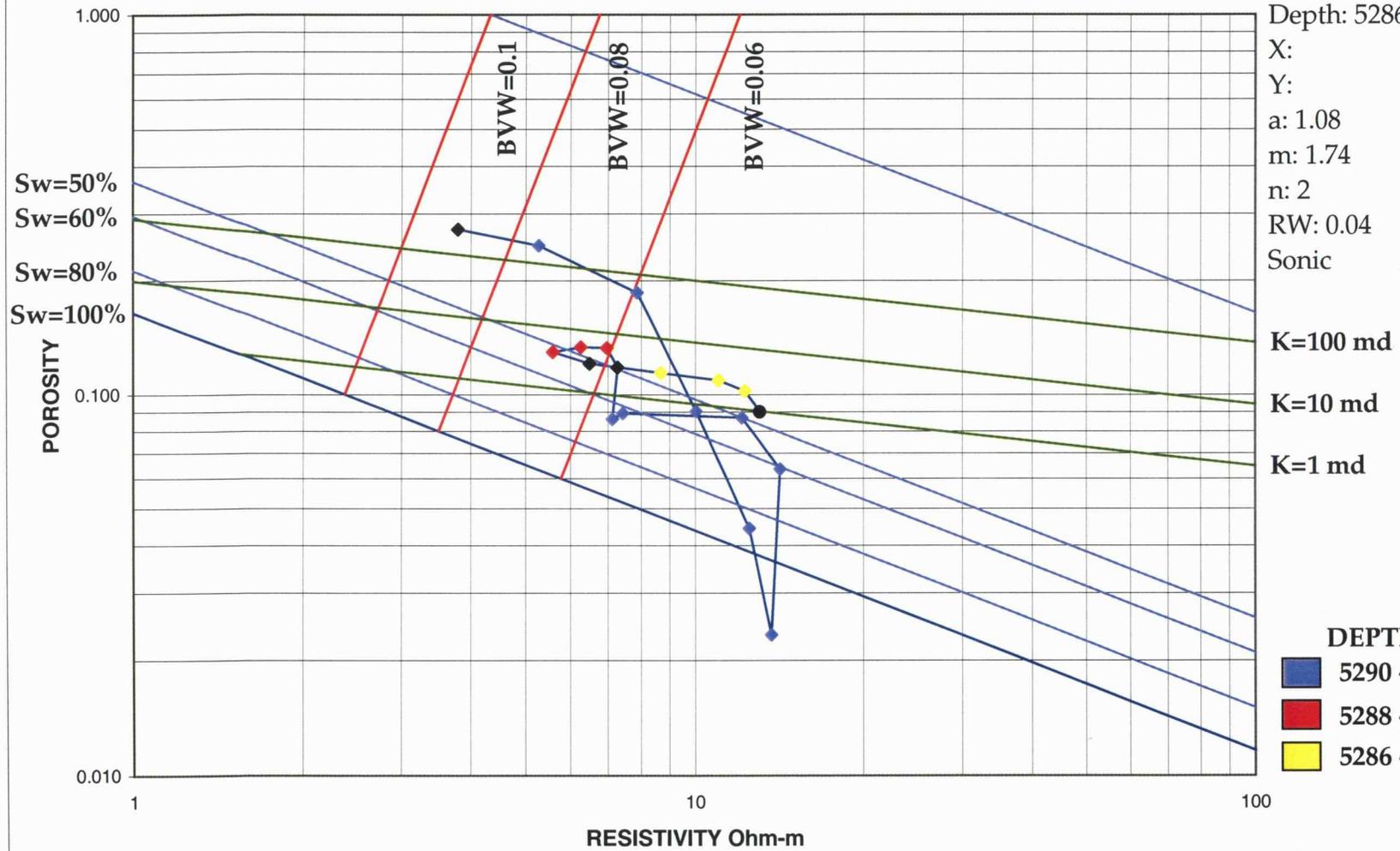
DEPTH

■ (blue)	5290 - 5295
■ (red)	5288 - 5290
■ (yellow)	5286 - 5288

Sand 1: 5288-90. D&A

LENA D. BOUCHER #1-3A (Ladd, 15-025-20695)

Sw=10%

Morrow
Depth: 5286 - 5295
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04
Sonic

BVW=0.1
BVW=0.08
BVW=0.06

Sw=50%
Sw=60%
Sw=80%
Sw=100%

POROSITY

K=100 md

K=10 md

K=1 md

RESISTIVITY Ohm-m
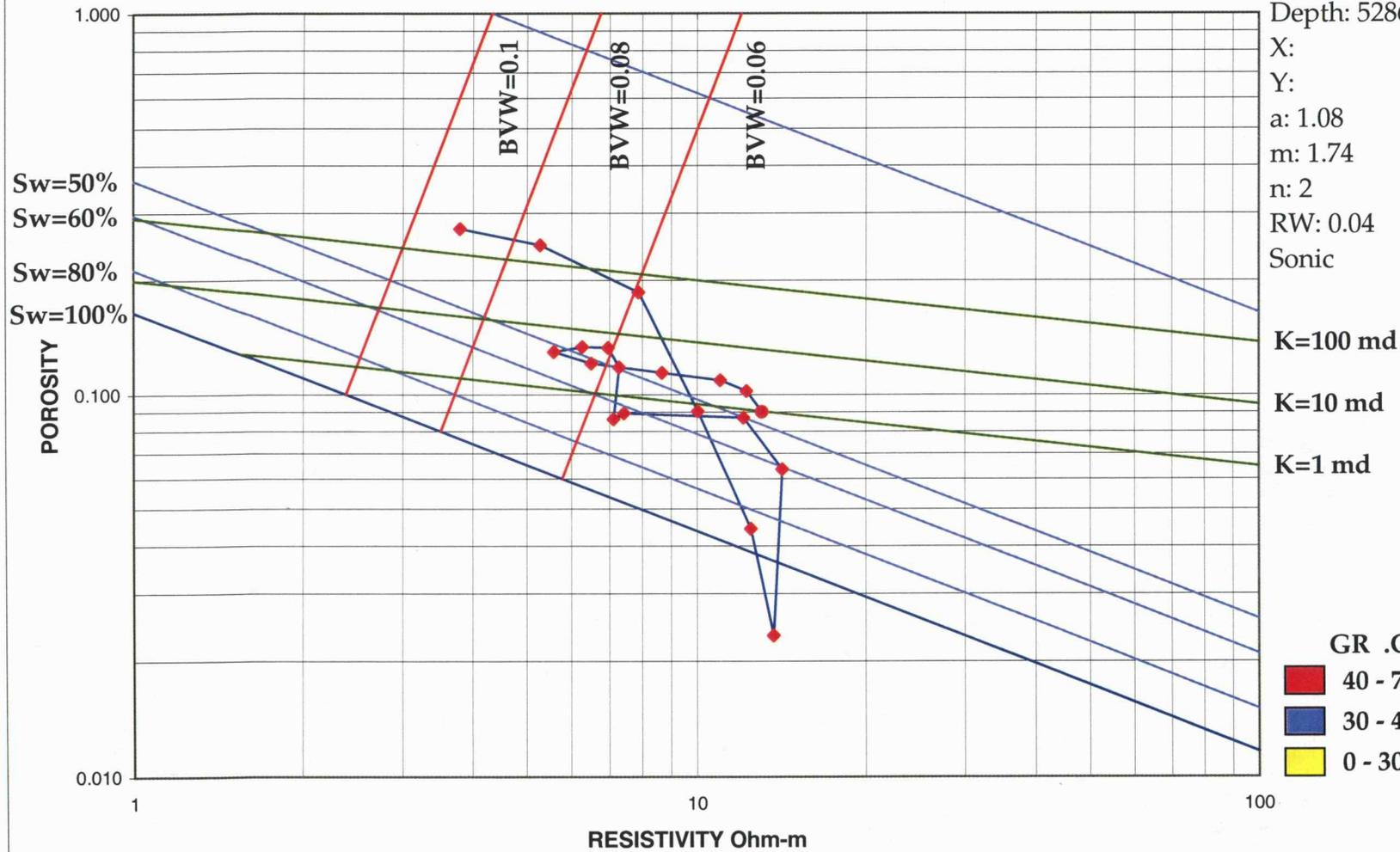
GR .GAPI

40 - 75
30 - 40
0 - 30

Sand 1: 5288-90. D&A

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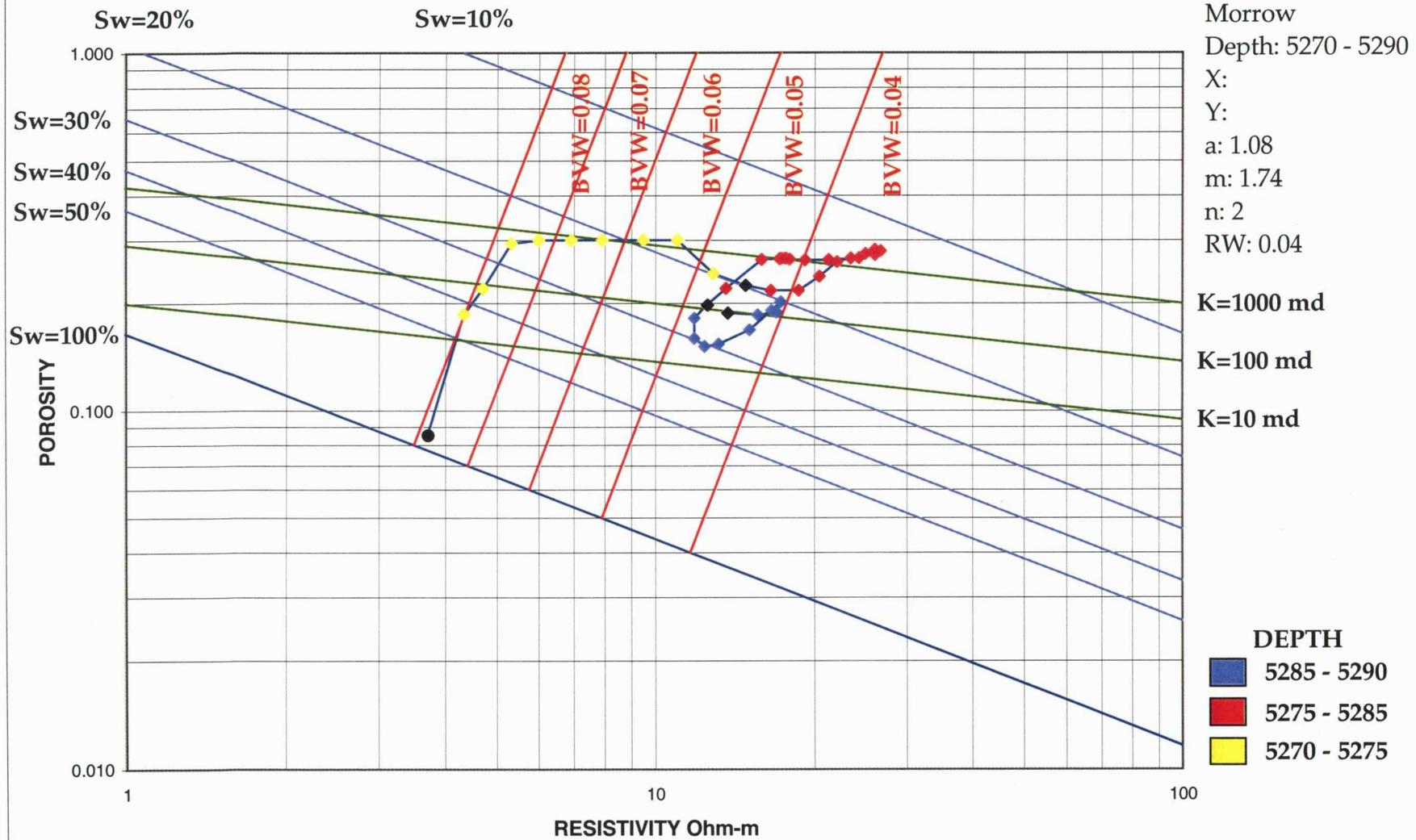
Sand 1: 5275-85. Perf. Atoka. Interval NA. Status - oil well
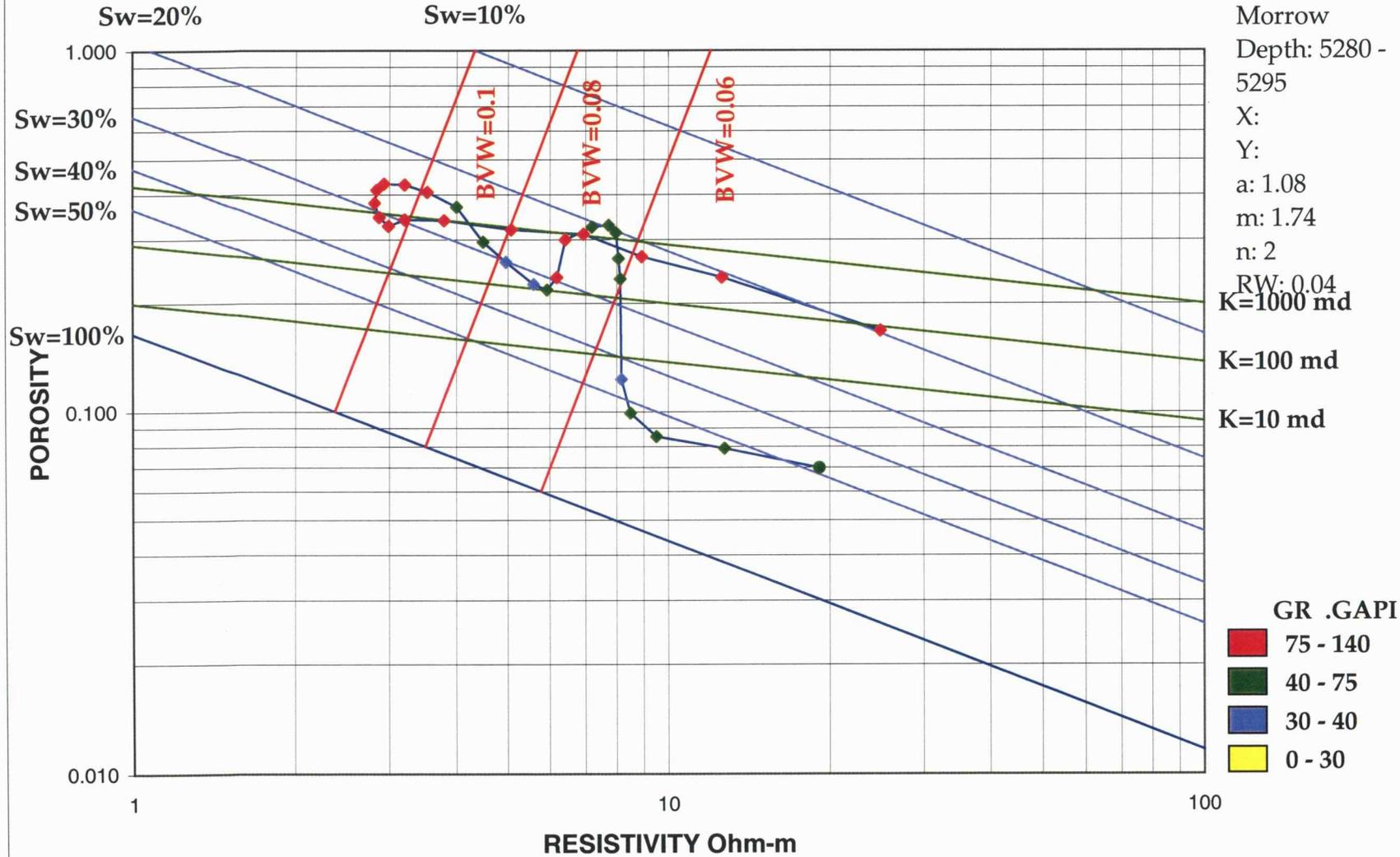
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Morrow
Depth: 5270 - 5290
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

Sw=20%   Sw=10%

Sw=30%
Sw=40%
Sw=50%

Sw=100%

POROSITY

BVW=0.08   BVW=0.07   BVW=0.06   BVW=0.05   BVW=0.04

K=1000 md
K=100 md
K=10 md

RESISTIVITY Ohm-m

1.000
0.100
0.010

1   10   100

GR .GAPI

🟥	75 - 150
🟩	40 - 75
🟦	30 - 40
🟨	0 - 30

Sand 1: 5275-85. Perf. Atoka. Interval NA. Status - oil well

FAGER #1-3 (Murfin, 15-025-20696)

Morrow
Depth: 5280 - 5295
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04
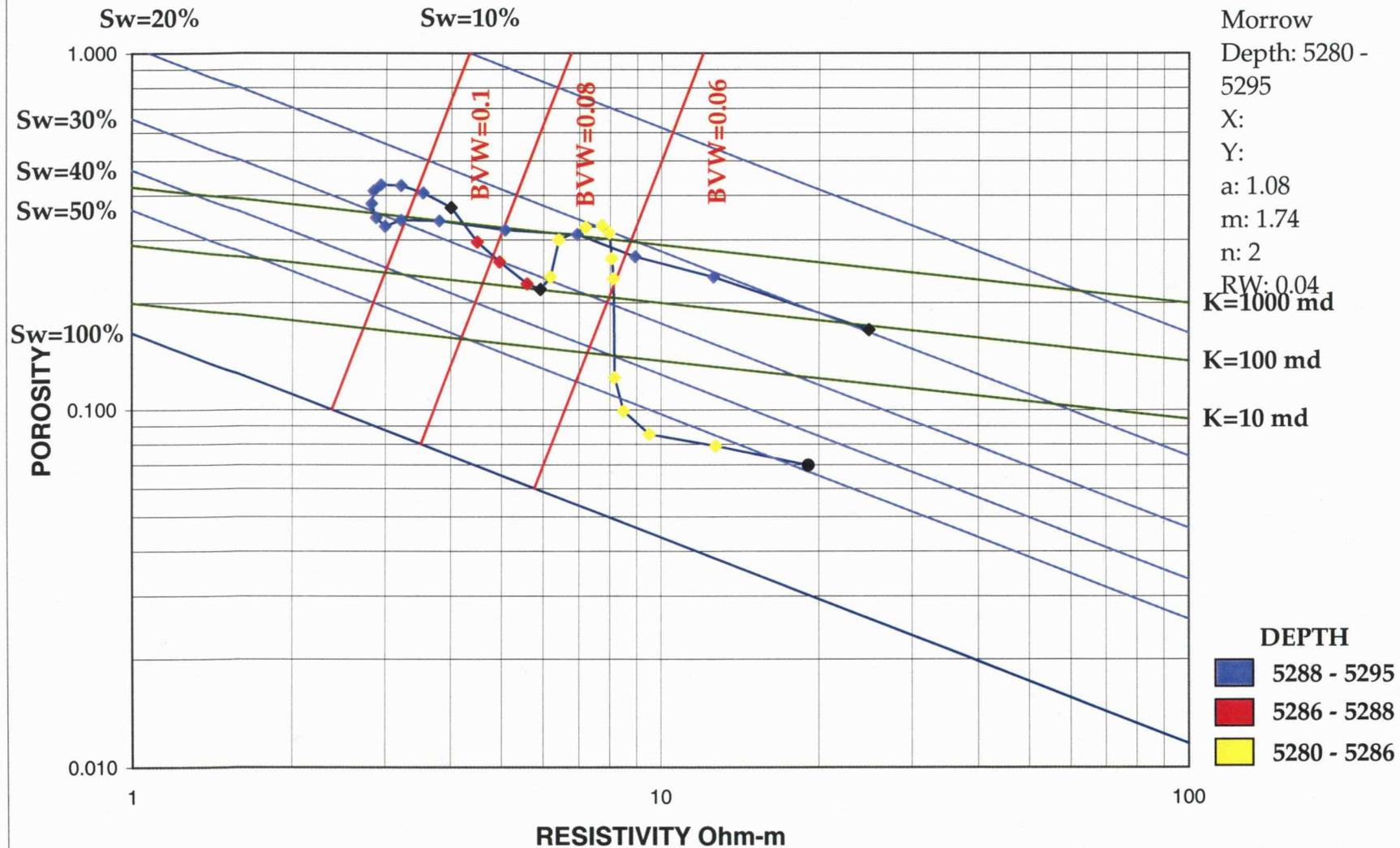
Sand 1: 5286-88. D&A
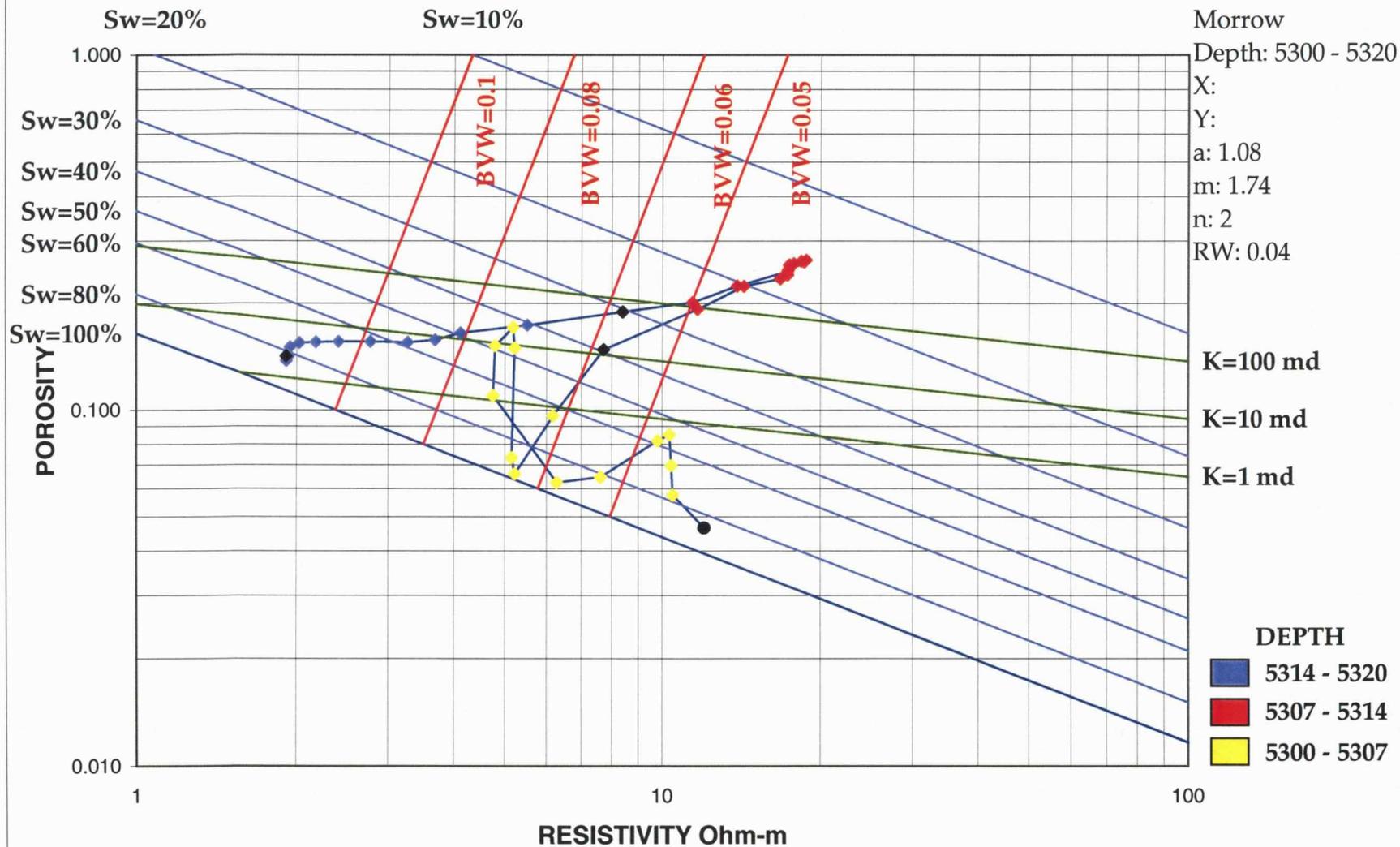
FAGER #1-3 (Murfin, 15-025-20696)

HINDMAN #1-3 (#1, Ladd, 15-025-20635)

Sand 2: 5307-14. Perf 5306-15: IP 159 bopd & 655 mcfd, OBW
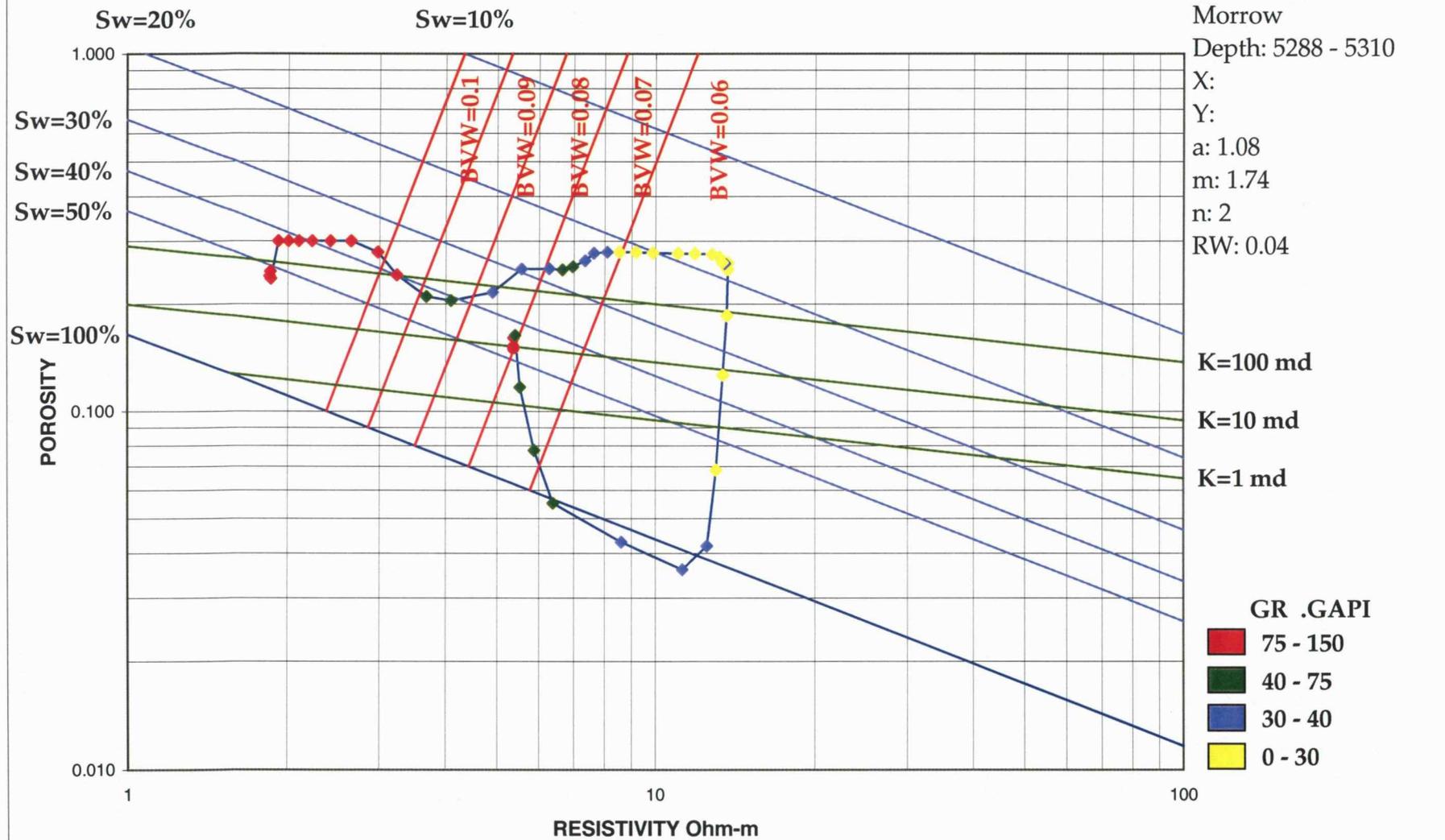
HINDMAN #1-3 (#1, Ladd, 15-025-20635)
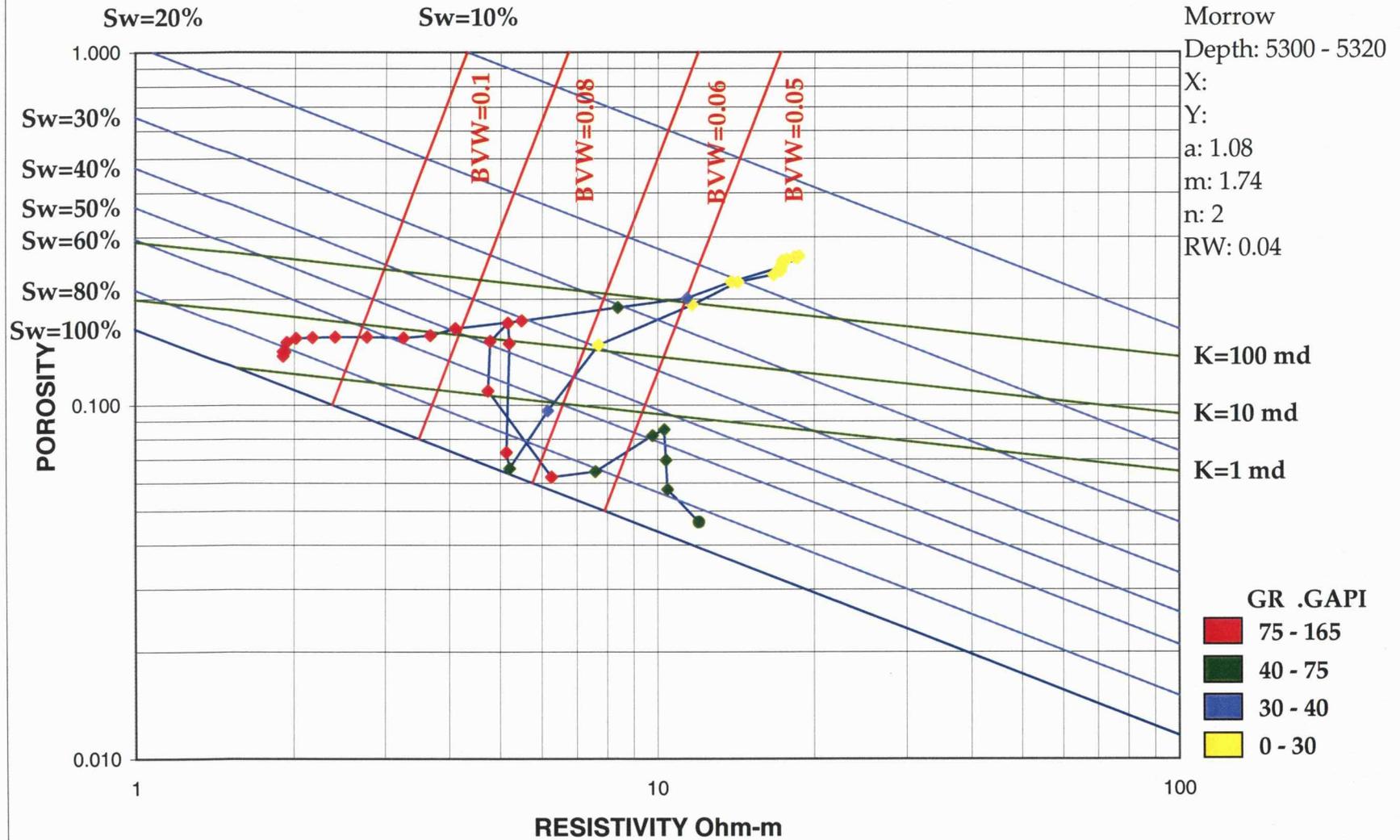
Sand 2: 5307-14. Perf 5306-15: IP 159 bopd & 655 mcfd, OBW

PATTON #2-3 (Murfin, 15-025-20685)
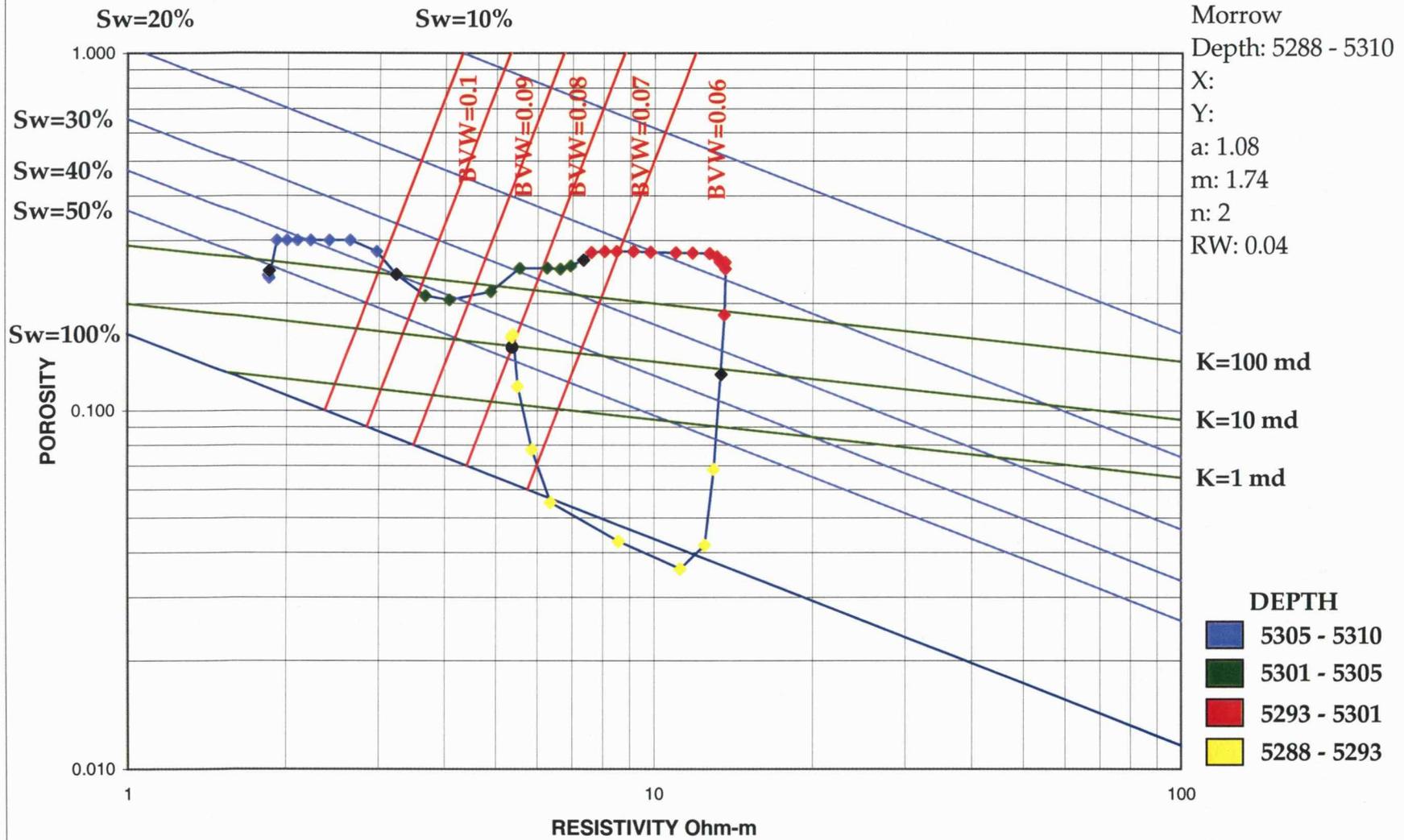
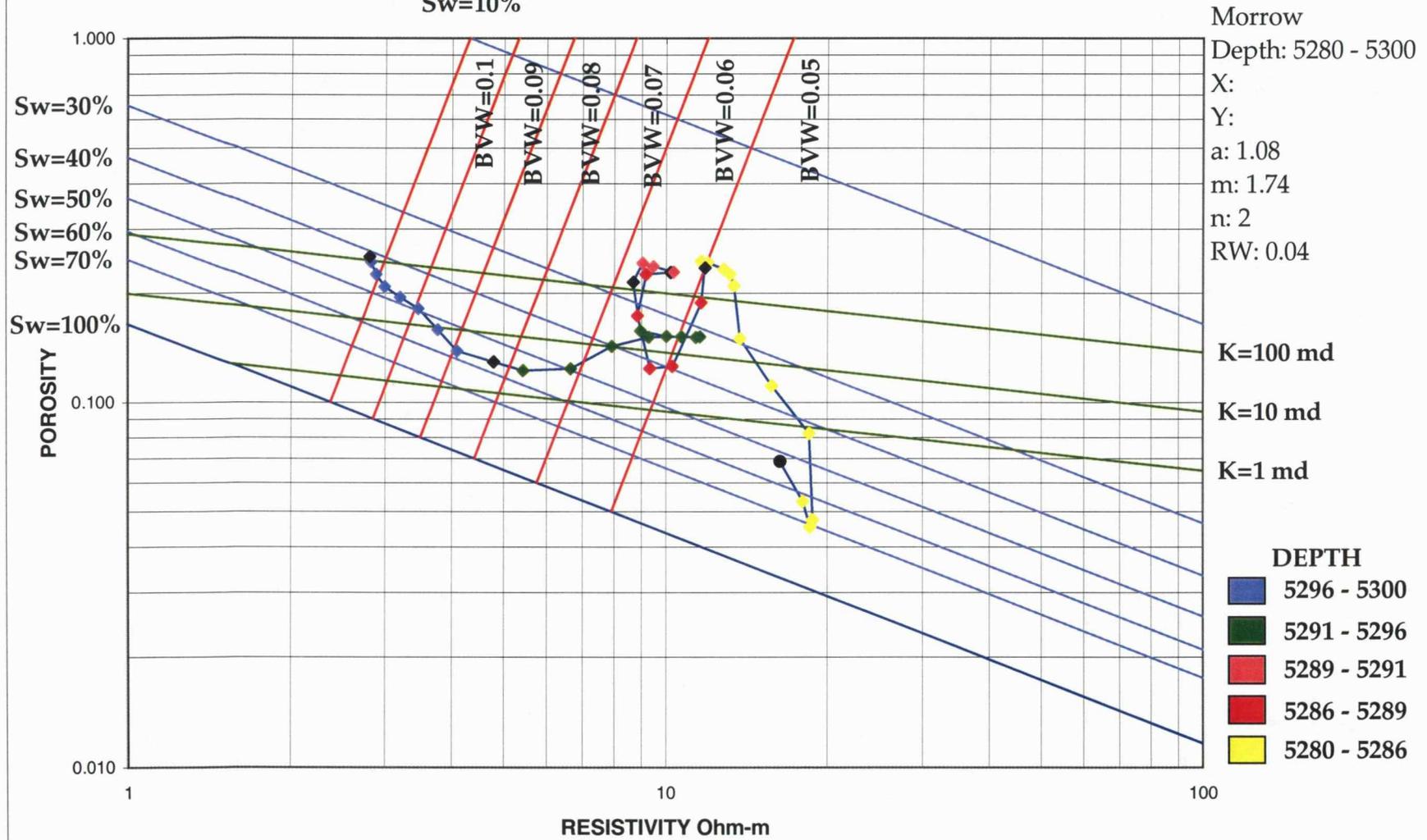Sand 2: 5293-5301. Sand 3: 5301-05. Perf interval and IP - na.

PATTON #2-3 (Murfin, 15-025-20685)

Sand 2: 5293-5301. Sand 3: 5301-05. Perf interval and IP - na.

PATTON #2-3 (Ladd, 15-025-20859)

Sand 1: 5286-89. Sand #2: 5291-96. D&A.

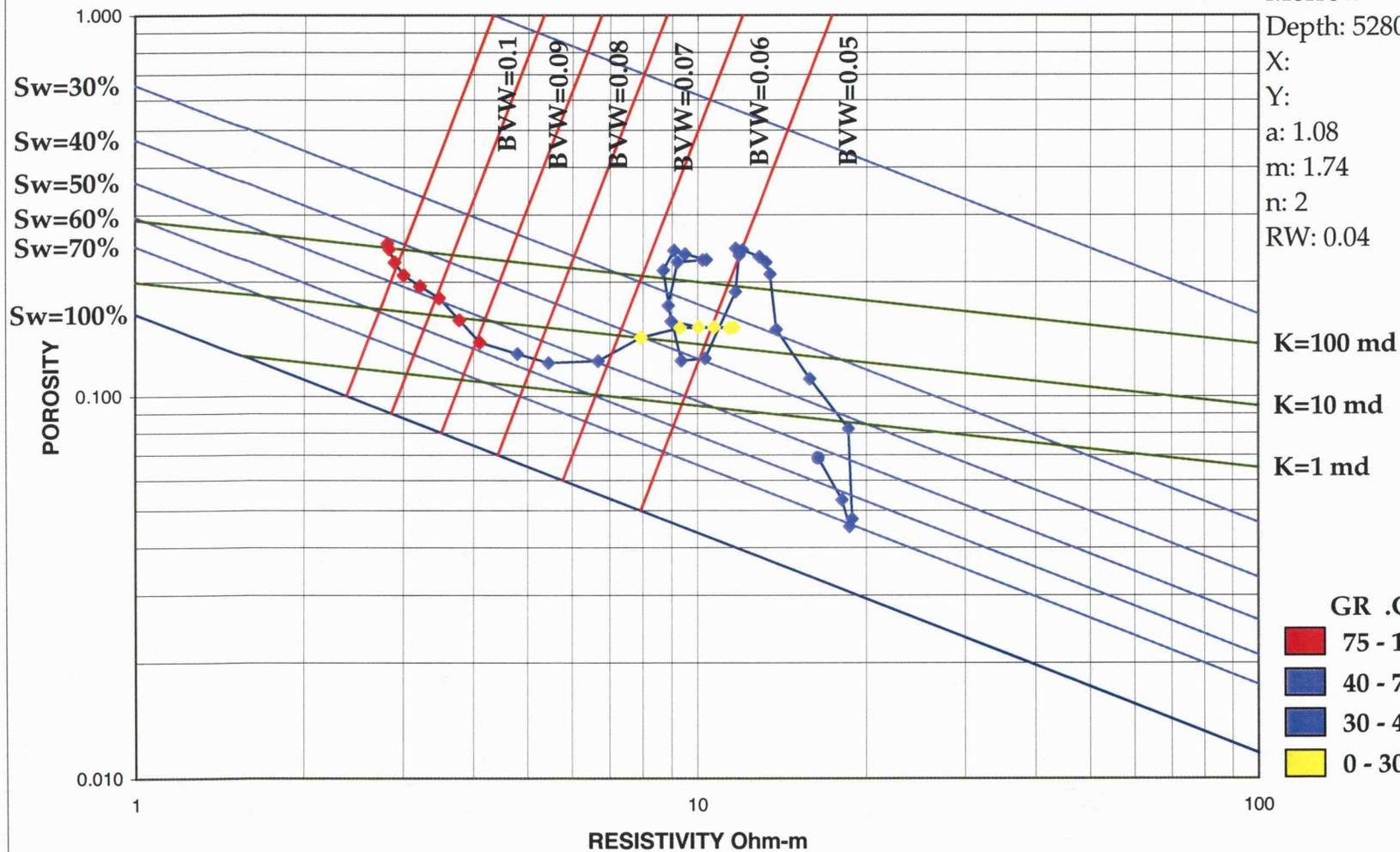# PATTON #2-3 (Ladd, 15-025-20859)

Sw=10%

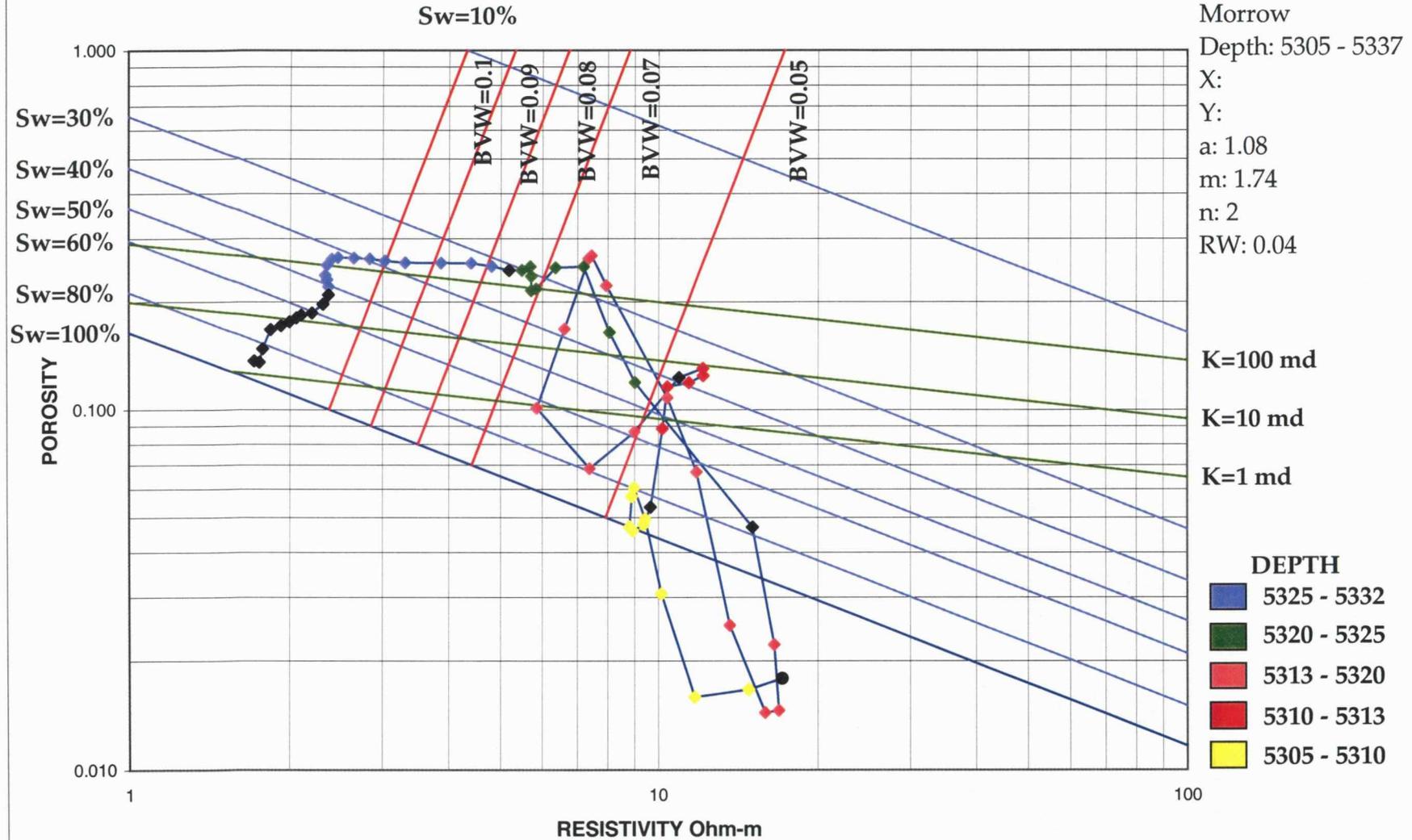Morrow
Depth: 5280 - 5300
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

Sw=30%
Sw=40%
Sw=50%
Sw=60%
Sw=70%

Sw=100%

BVW=0.1
BVW=0.09
BVW=0.08
BVW=0.07
BVW=0.06
BVW=0.05

POROSITY

1.000

0.100

0.010

K=100 md

K=10 md

K=1 md

RESISTIVITY Ohm-m

1

10

100

GR .GAPI

	75 - 110
	40 - 75
	30 - 40
	0 - 30

Sand 1: 5286-89. Sand #2: 5291-96. D&A.

E.F. HARRIS #1-3 (Ladd, 15-025-20616)

Sand 1: 5310-13. Sand 2: 5320-25. Sand 3: 5325-32. Formation and perf interval na. IP: 80 bopd.

E.F. HARRIS #1-3 (Ladd, 15-025-20616)
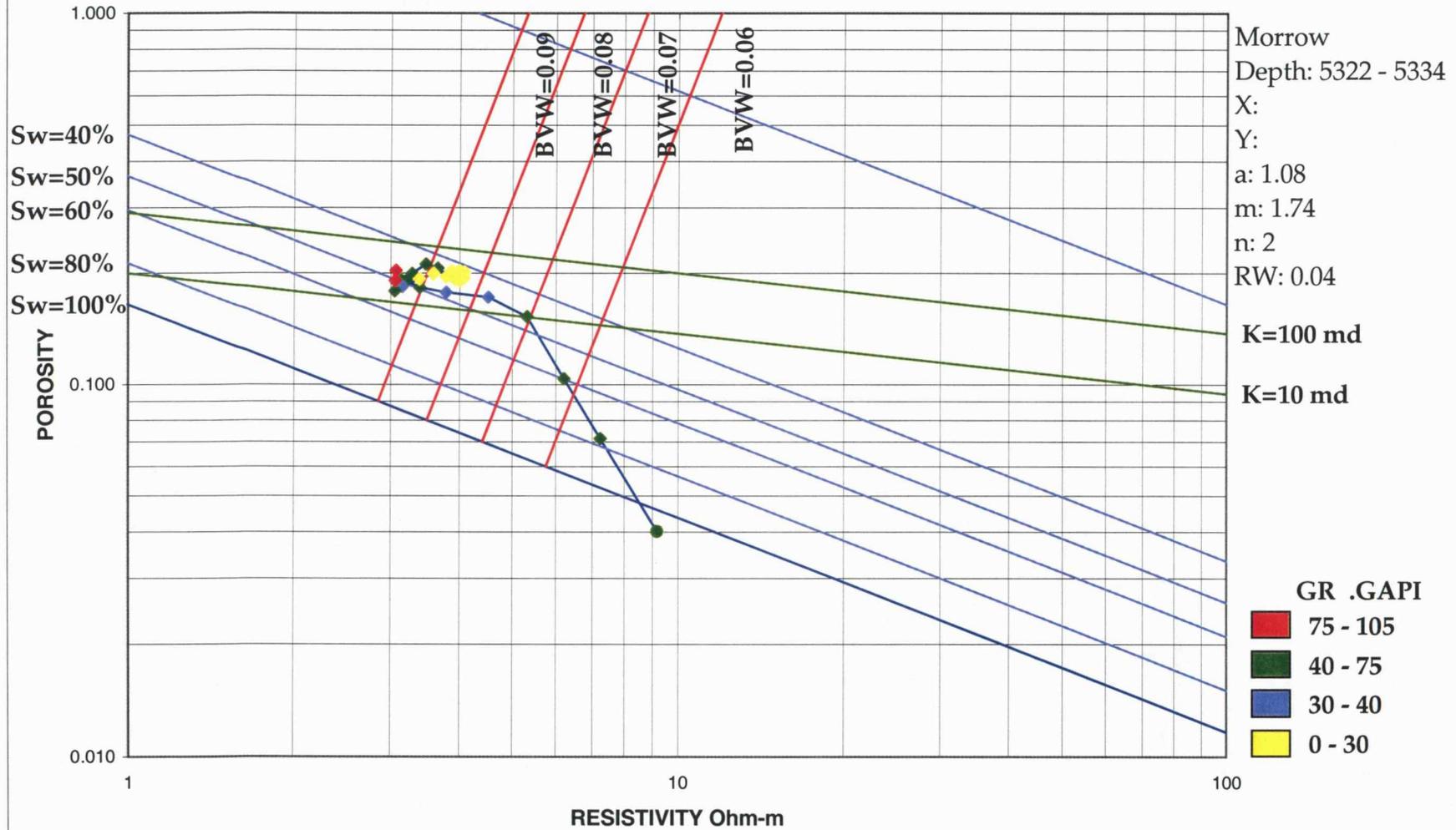
Sw=10%

Morrow
Depth: 5305 - 5337
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

Sw=30%
Sw=40%
Sw=50%
Sw=60%
Sw=80%
Sw=100%

BVW=0.1
BVW=0.09
BVW=0.08
BVW=0.07
BVW=0.05

POROSITY

1.000
0.100
0.010

K=100 md
K=10 md
K=1 md

RESISTIVITY Ohm-m

1
10
100

GR .GAPI

75 - 175	
50 - 75	
25 - 50	
0 - 25	
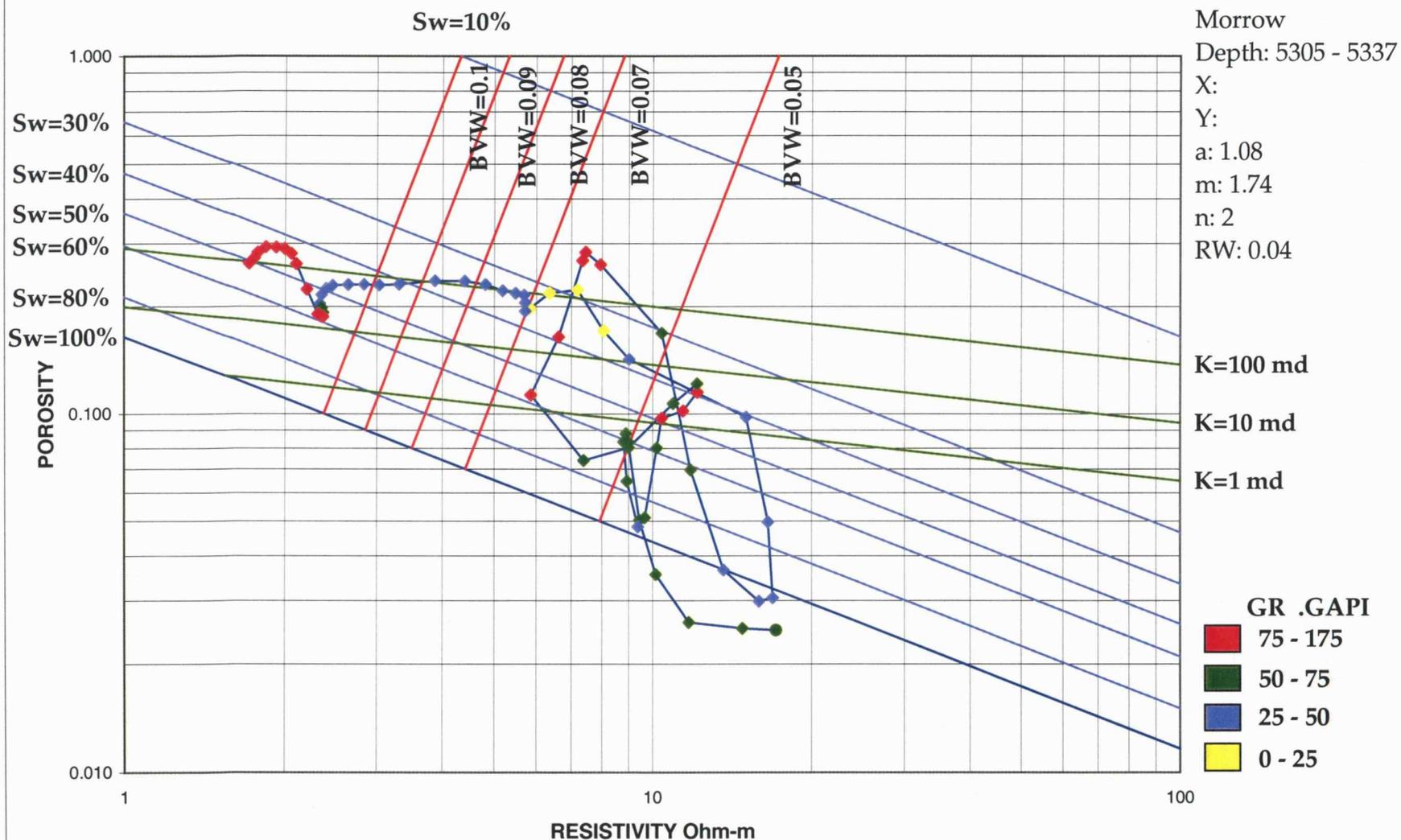
Sand 1: 5310-13. Sand 2: 5320-25. Sand 3: 5325-32. Formation and perf interval na. IP: 80 bopd.

PATTON #1-3 (Murfin, 20668)

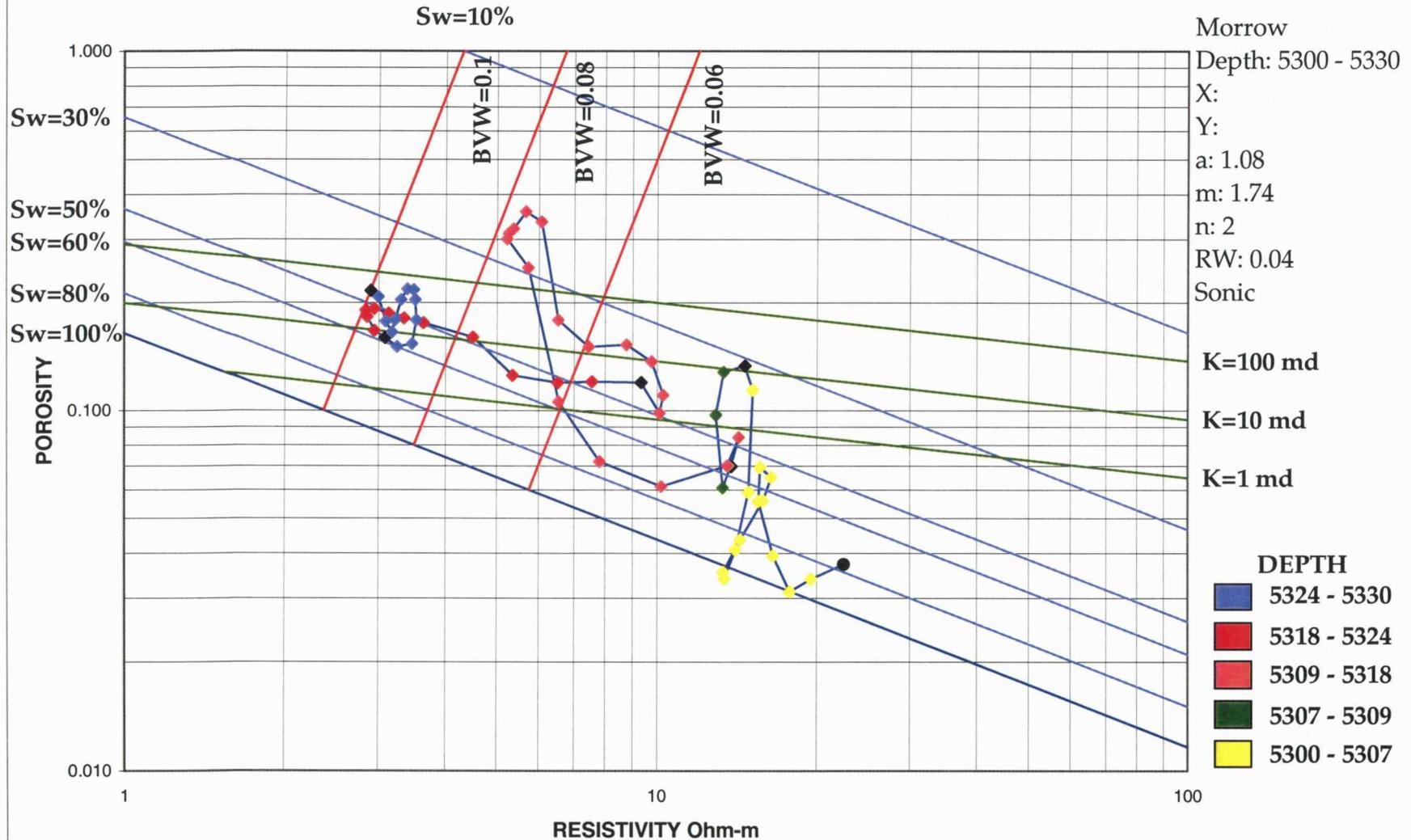**PATTON #1-3 (Murfin, 20668)**
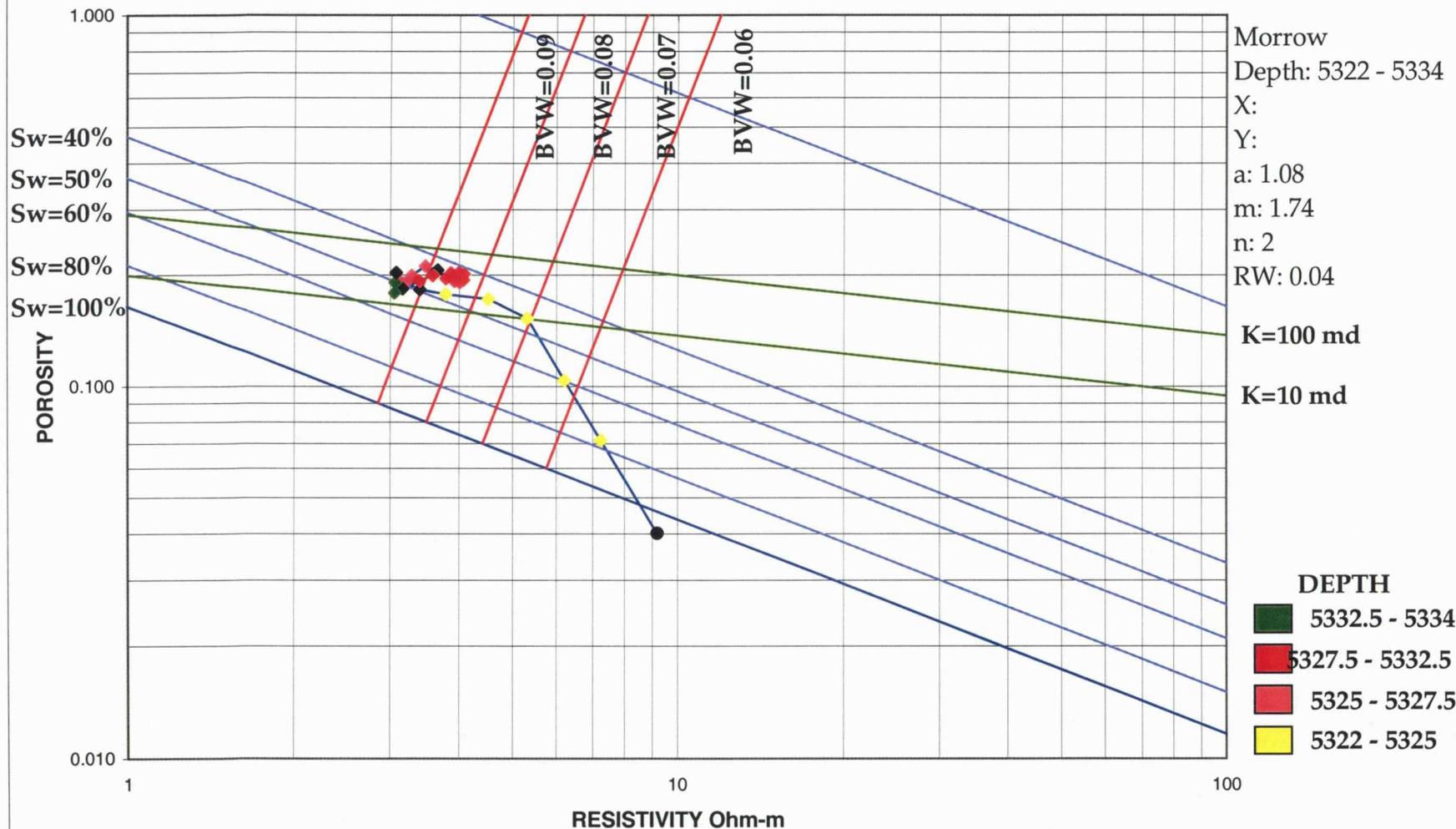
Sand 2: 5322-25. Sand 3: 5328-34. Perf. : 5327.5-32.5: IP 177 bopd, nw

PATTON #1 (Ladd, 15-025-20594)

Sw=10%

Sw=30%

Sw=50%
Sw=60%

Sw=80%

Sw=100%

POROSITY

BVW=0.1
BVW=0.08
BVW=0.06

Morrow
Depth: 5300 - 5330
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04
Sonic

K=100 md

K=10 md

K=1 md

1.000

0.100

0.010

1   10   100

RESISTIVITY Ohm-m

DEPTH
	5324 - 5330
	5318 - 5324
	5309 - 5318
	5307 - 5309
	5300 - 5307

Sand 1: 5307-09. Sand 2: 5318-24. Perf. 5318-24 & 5369-80: 110 bopd & 2700 mcfd & 21 bwpd

PATTON #1 (Ladd, 15-025-20594)
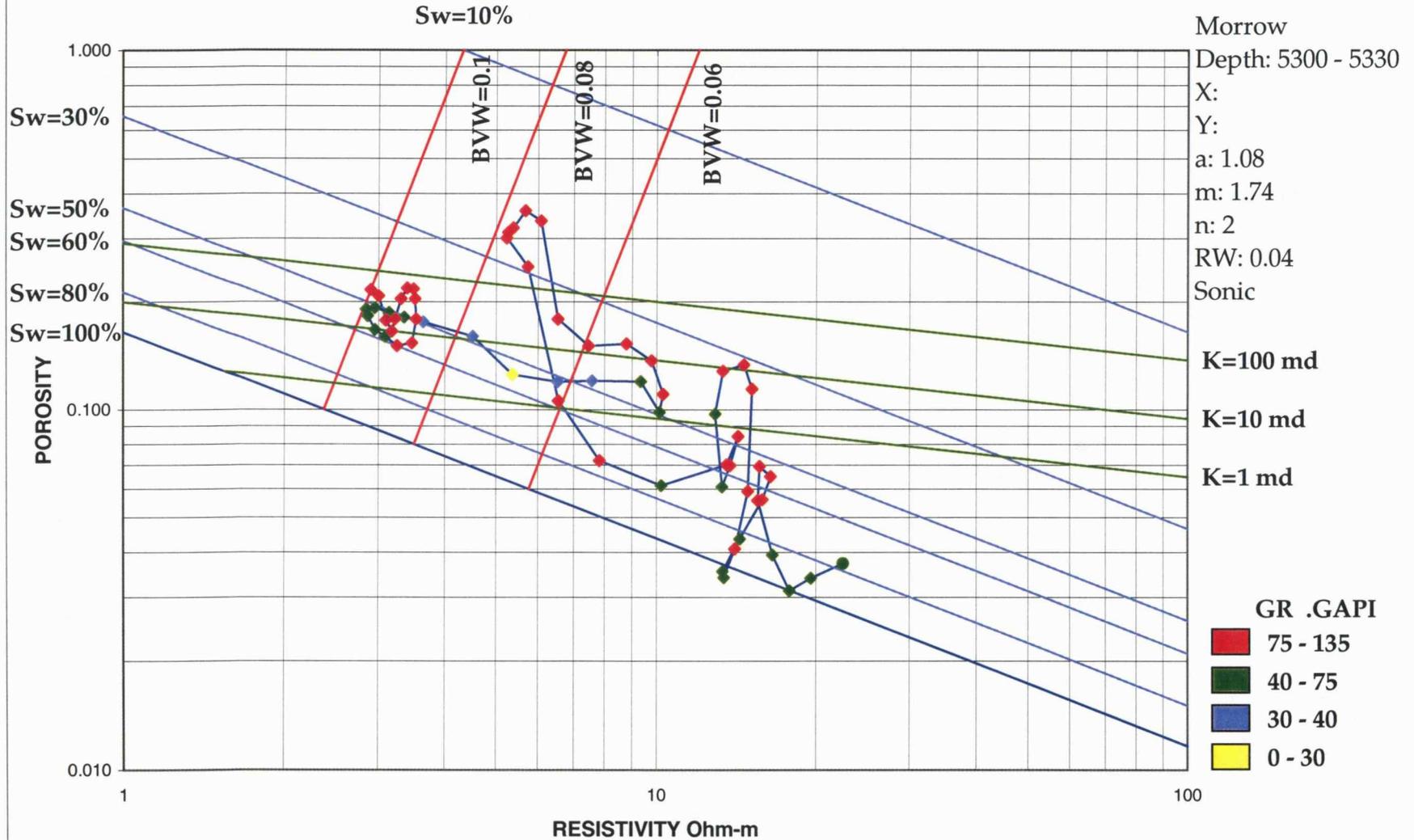
Sand 1: 5307-09. Sand 2: 5318-24. Perf. 5318-24 & 5369-80: 110 bopd & 2700 mcfd & 21 bwpd

GOELLER #1-4 (Murfin, 15-025-20858)

Sand 2: 5316-22. Perf. 5316-21: IP 90 bopd, 98 mcfd.

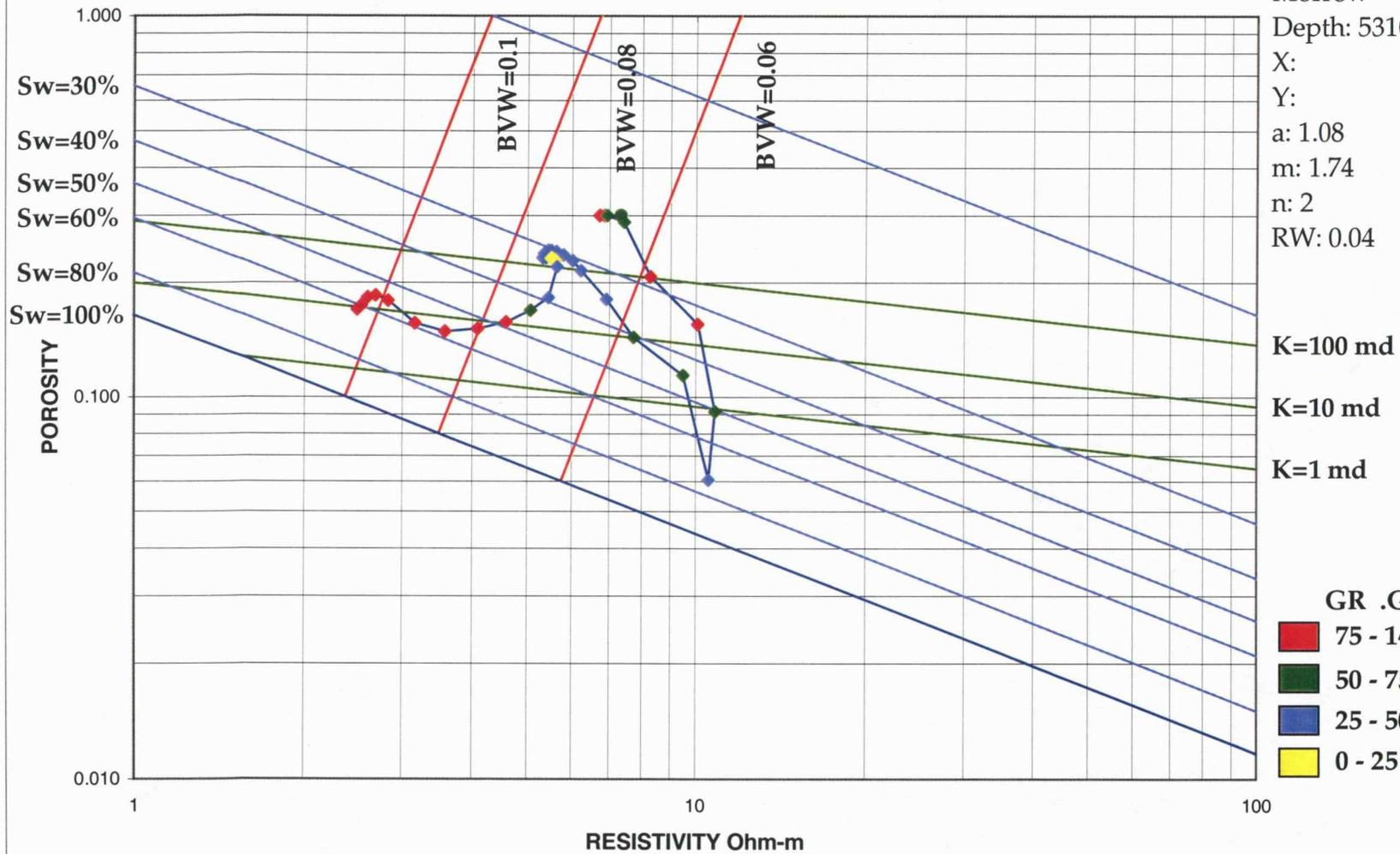GOELLER #1-4 (Murfin, 15-025-20858)
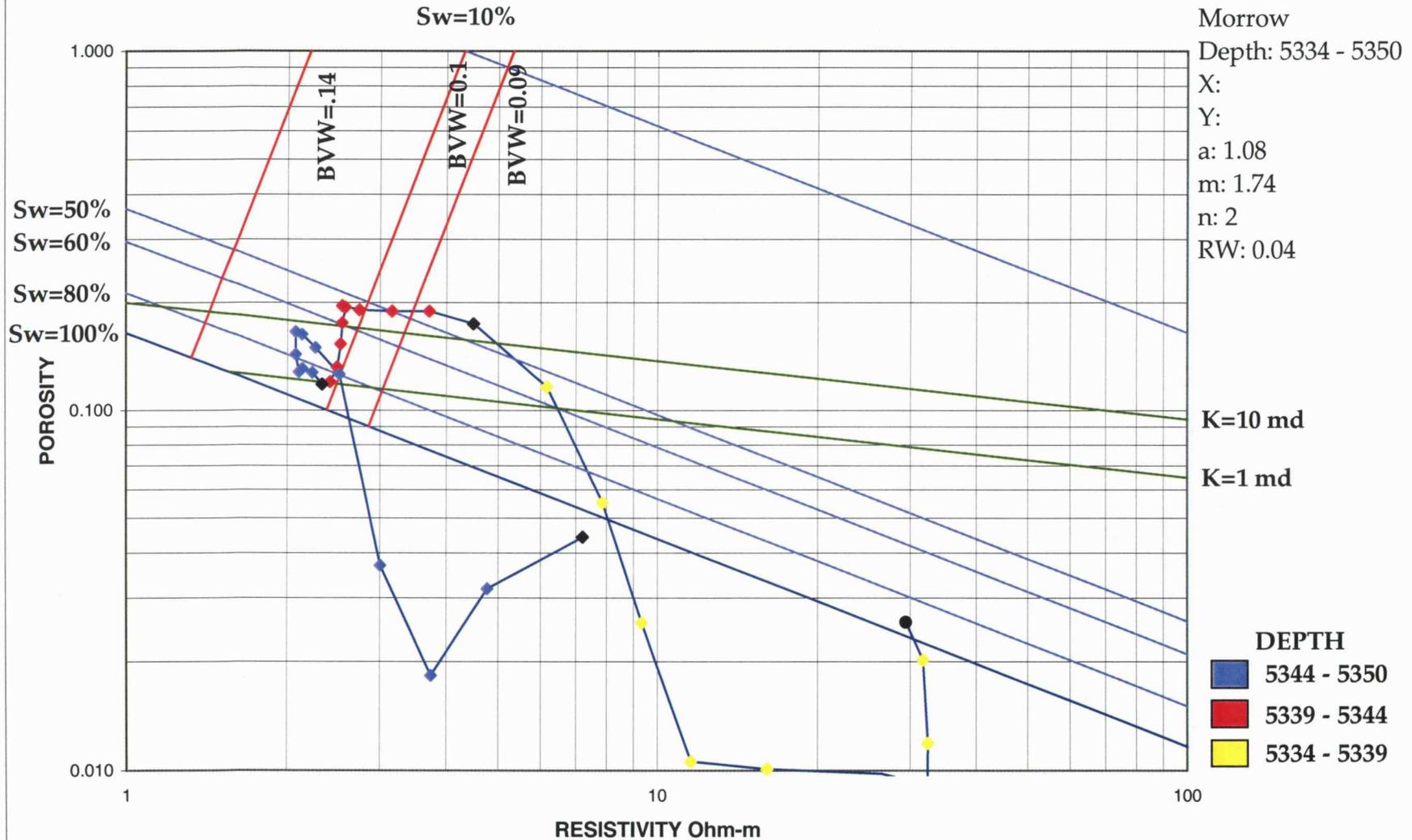
Sw=10%
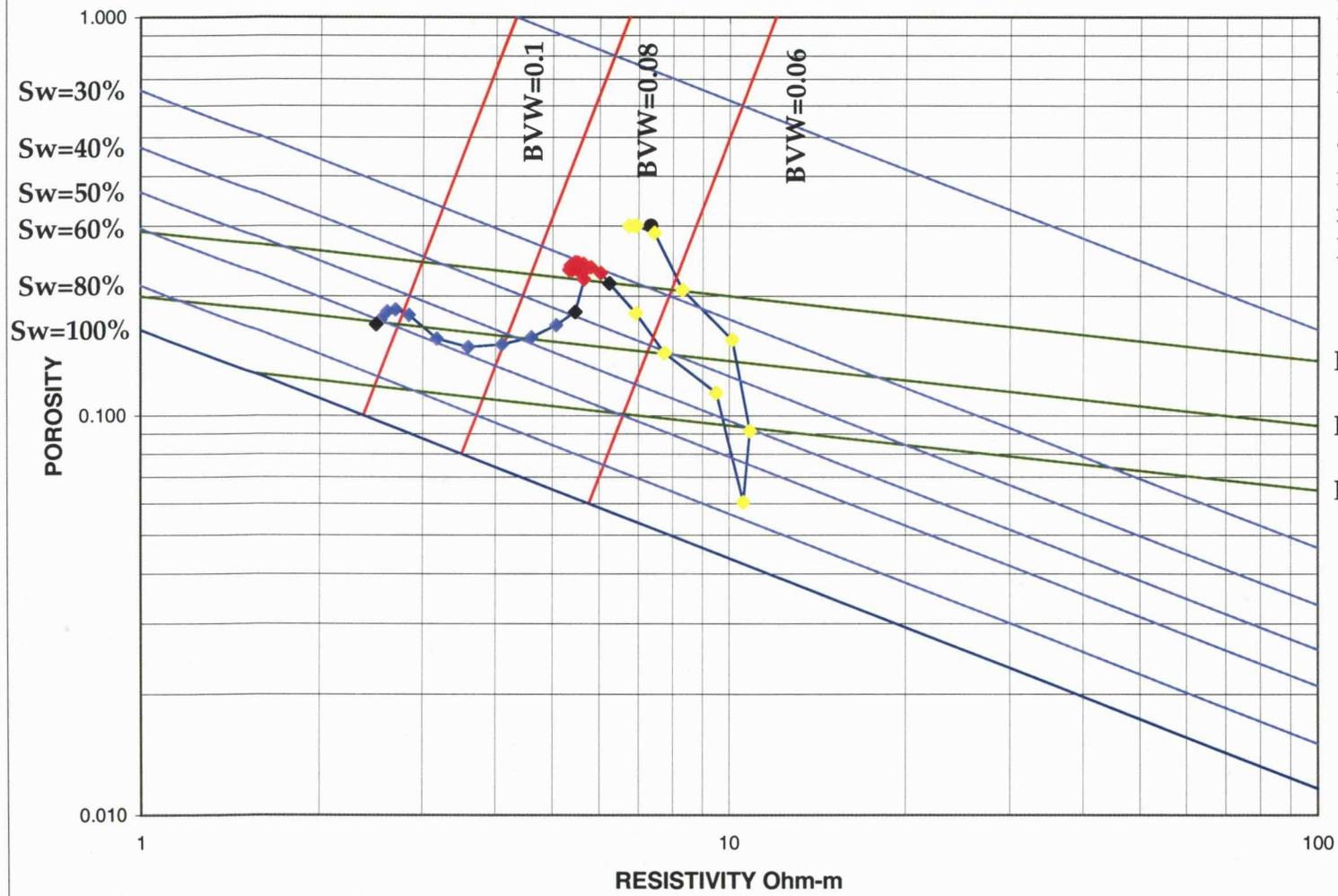
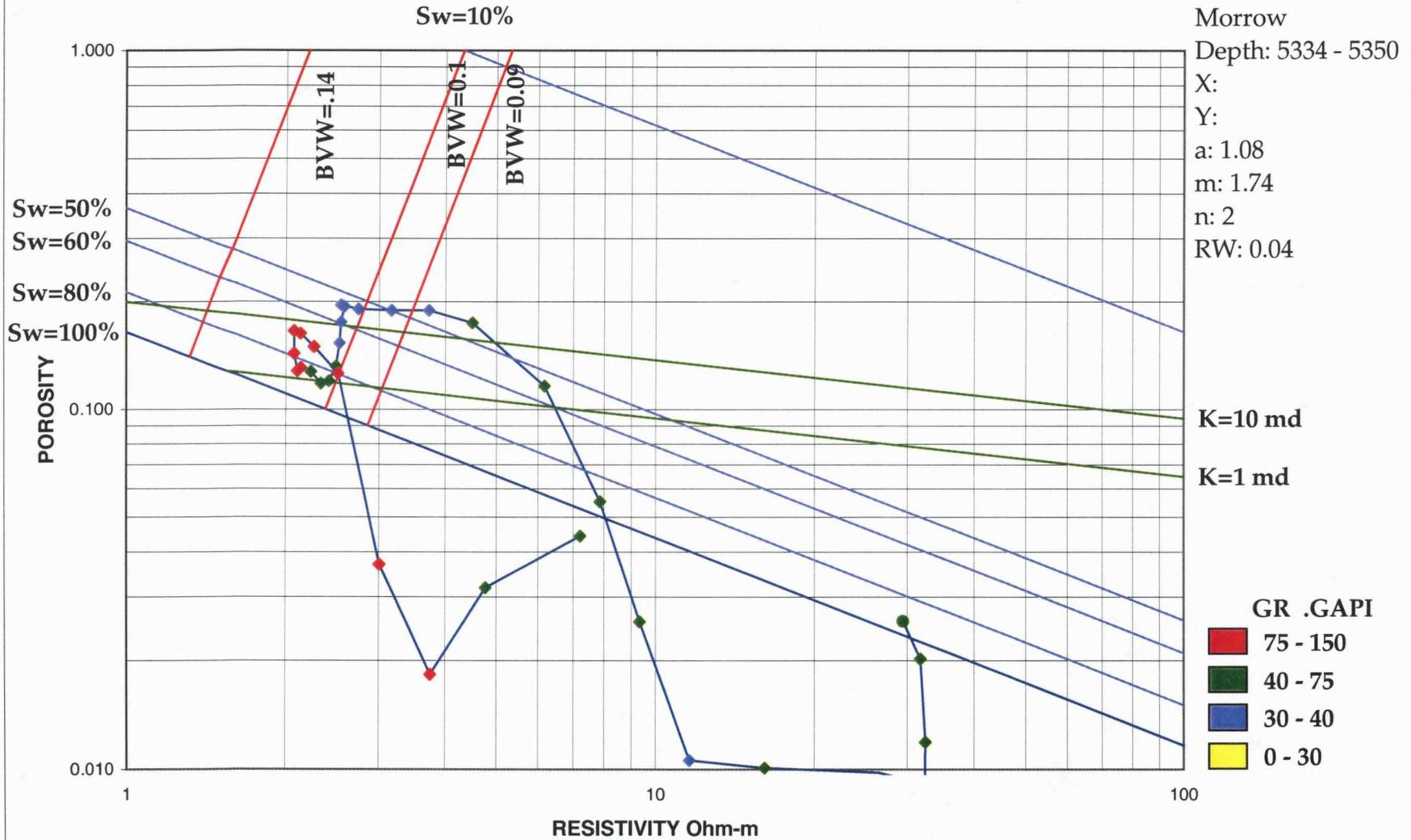Morrow
Depth: 5310 - 5327
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

Sw=30%
Sw=40%
Sw=50%
Sw=60%
Sw=80%
Sw=100%

BVW=0.1
BVW=0.08
BVW=0.06

POROSITY

K=100 md
K=10 md
K=1 md

1.000
0.100
0.010

1   10   100

RESISTIVITY Ohm-m

GR .GAPI
75 - 140
50 - 75
25 - 50
0 - 25

Sand 2: 5316-22. Perf. 5316-21: IP 90 bopd, 98 mcfd.

NORTON #E-1 (TXO Prod., 15-025-20837)

Sw=10%

Morrow
Depth: 5334 - 5350
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

Sw=50%
Sw=60%
Sw=80%
Sw=100%

BVW=.14
BVW=0.1
BVW=0.09

K=10 md
K=1 md

POROSITY

RESISTIVITY Ohm-m

DEPTH
- 5344 - 5350
- 5339 - 5344
- 5334 - 5339

Sand 2: 5339-44. Perf. 5339-44: IP not available. Shut in gas well. Converted to water injection well.
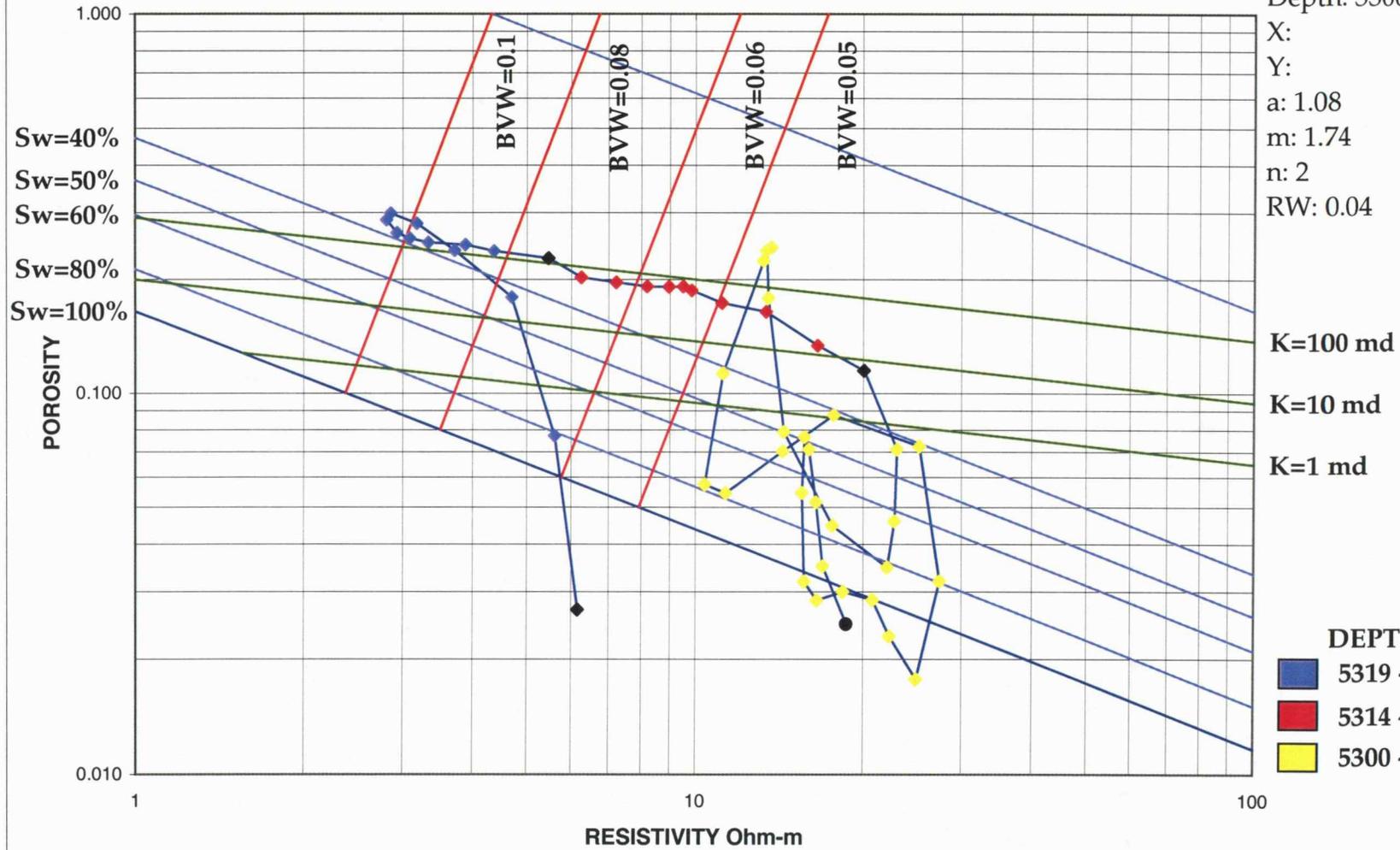
NORTON #E-1 (TXO Prod., 15-025-20837)

Sw=10%

Morrow
Depth: 5334 - 5350
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

BVW=.14   BVW=0.1   BVW=0.09

Sw=50%
Sw=60%
Sw=80%
Sw=100%

POROSITY

K=10 md

K=1 md

RESISTIVITY Ohm-m

GR .GAPI
- 75 - 150 (red)
- 40 - 75 (green)
- 30 - 40 (blue)
- 0 - 30 (yellow)

Sand 2: 5339-44. Perf. 5339-44: IP not available. Shut in gas well. Converted to water injection well.

GOELLER #1-4 (Ladd/Swift, 15-025-20615)

Sw=10%

Morrow
Depth: 5300 - 5325
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

Sw=40%
Sw=50%
Sw=60%
Sw=80%
Sw=100%

BVW=0.1
BVW=0.08
BVW=0.06
BVW=0.05

POROSITY

K=100 md
K=10 md
K=1 md

1.000
0.100
0.010

1
10
100

RESISTIVITY Ohm-m

DEPT.F
5319 - 5325
5314 - 5319
5300 - 5314

Sand 2: 5314-19. Well completed in Atokan as OIL well. Interval na.

GOELLER #1-4 (Ladd/Swift, 15-025-20615)
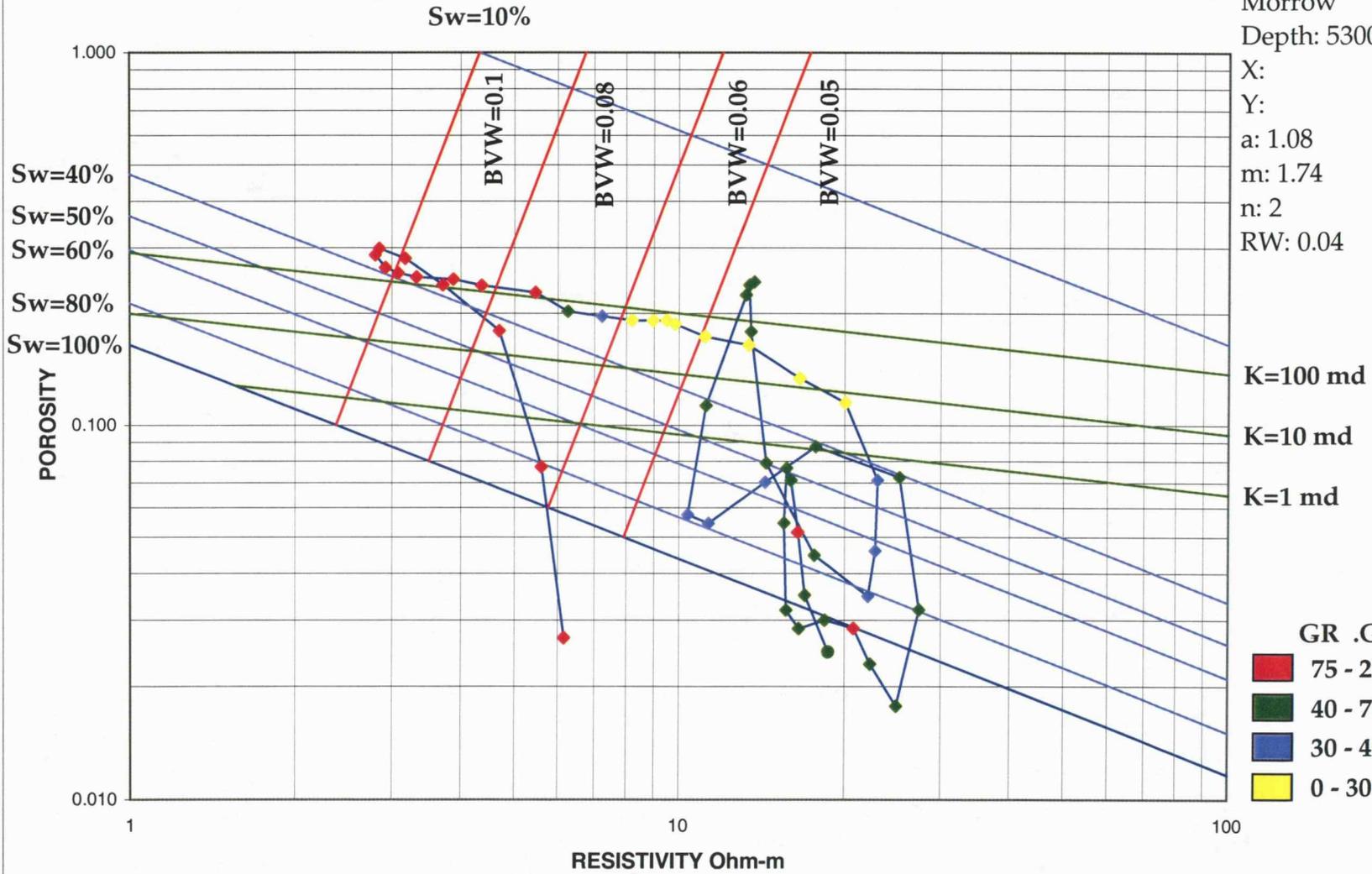
Sand 2: 5314-19. Well completed in Atokan as OIL well. Interval na.

ALLEY #1-9 (Murfin, 15-025-20911)
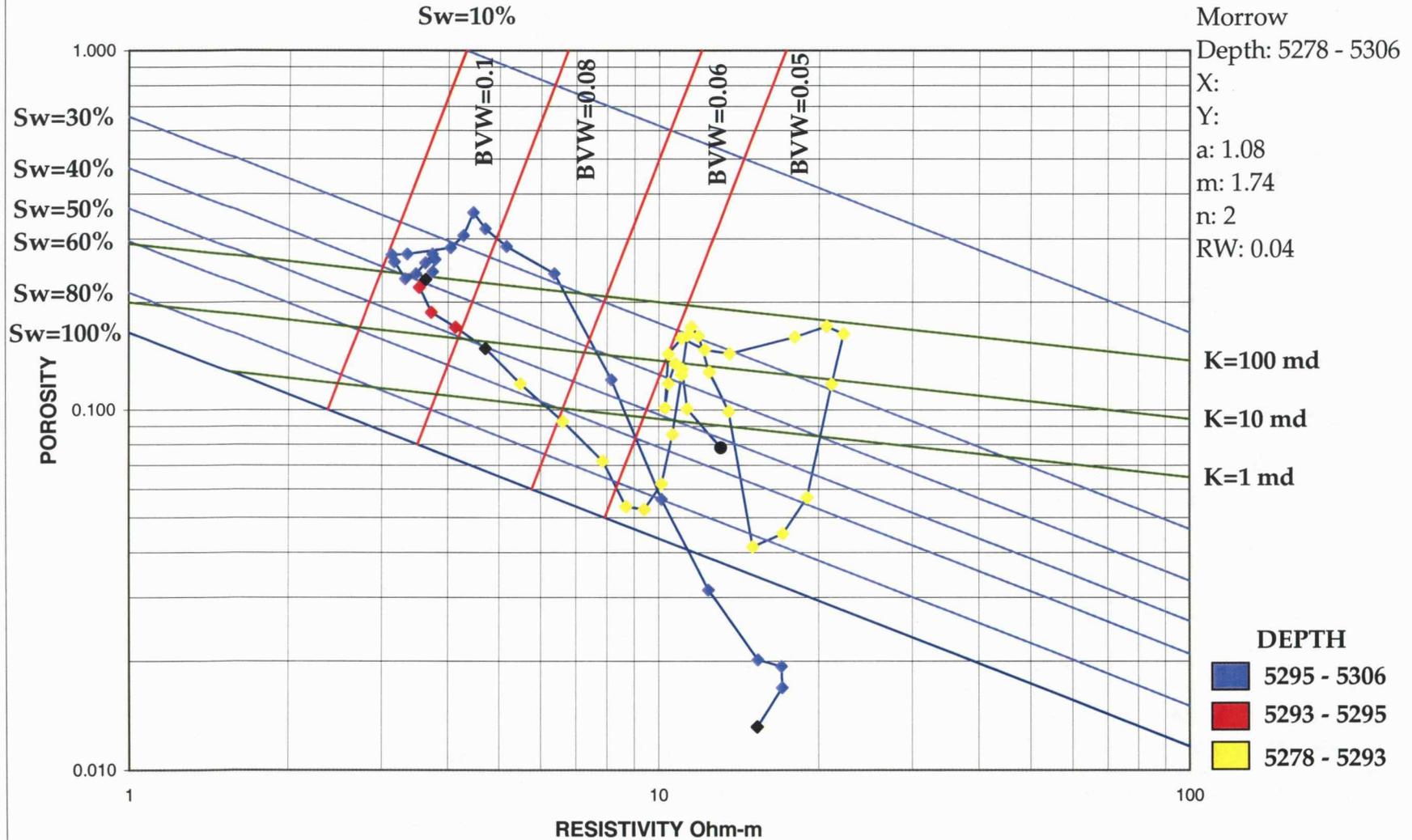
Sand 2: 5293-95. DST 5278-5306: Rec no reported. D&A

ALLEY #1-9 (Murfin, 15-025-20911)

Sw=10%

Sw=30%
Sw=40%
Sw=50%
Sw=60%
Sw=80%
Sw=100%

BVW=0.1
BVW=0.08
BVW=0.06
BVW=0.05

POROSITY

1.000

0.100

0.010

1

10

100

RESISTIVITY Ohm-m

Morrow
Depth: 5278 - 5306
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

K=100 md

K=10 md

K=1 md

GR .GAPI
70 - 210
40 - 70
30 - 40
0 - 30
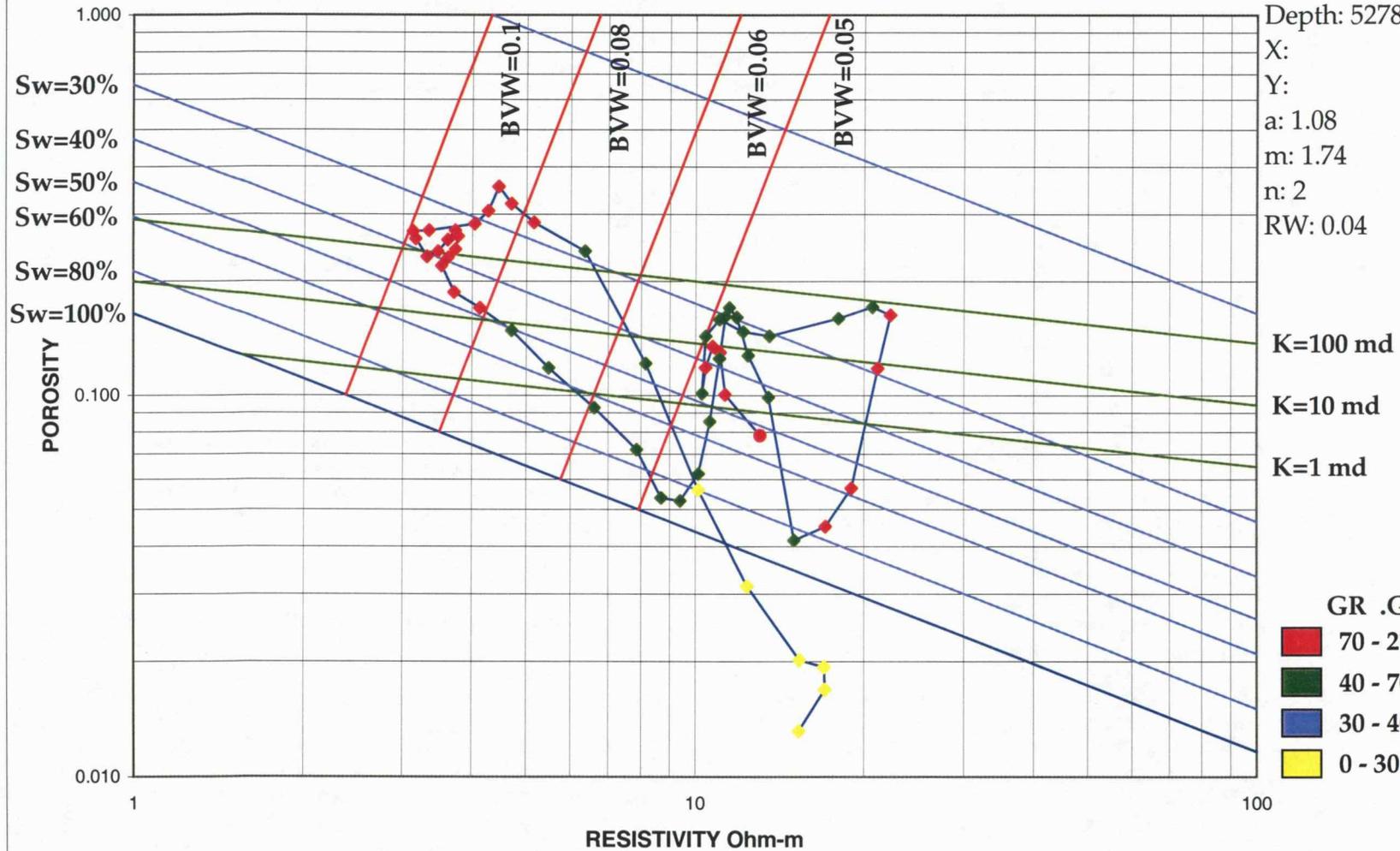
Sand 2: 5293-95. DST 5278-5306: Rec no reported. D&A

NORTON #B-1 (TXO Prod., 15-025-20672)

Sw=10%

Morrow
Depth: 5295 - 5310
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

Sw=30%

Sw=50%
Sw=60%

Sw=80%

Sw=100%

BVW=0.1

BVW=0.08

BVW=0.06

POROSITY

K=10 md

K=1 md

1.000

0.100

0.010

1   10   100

RESISTIVITY Ohm-m
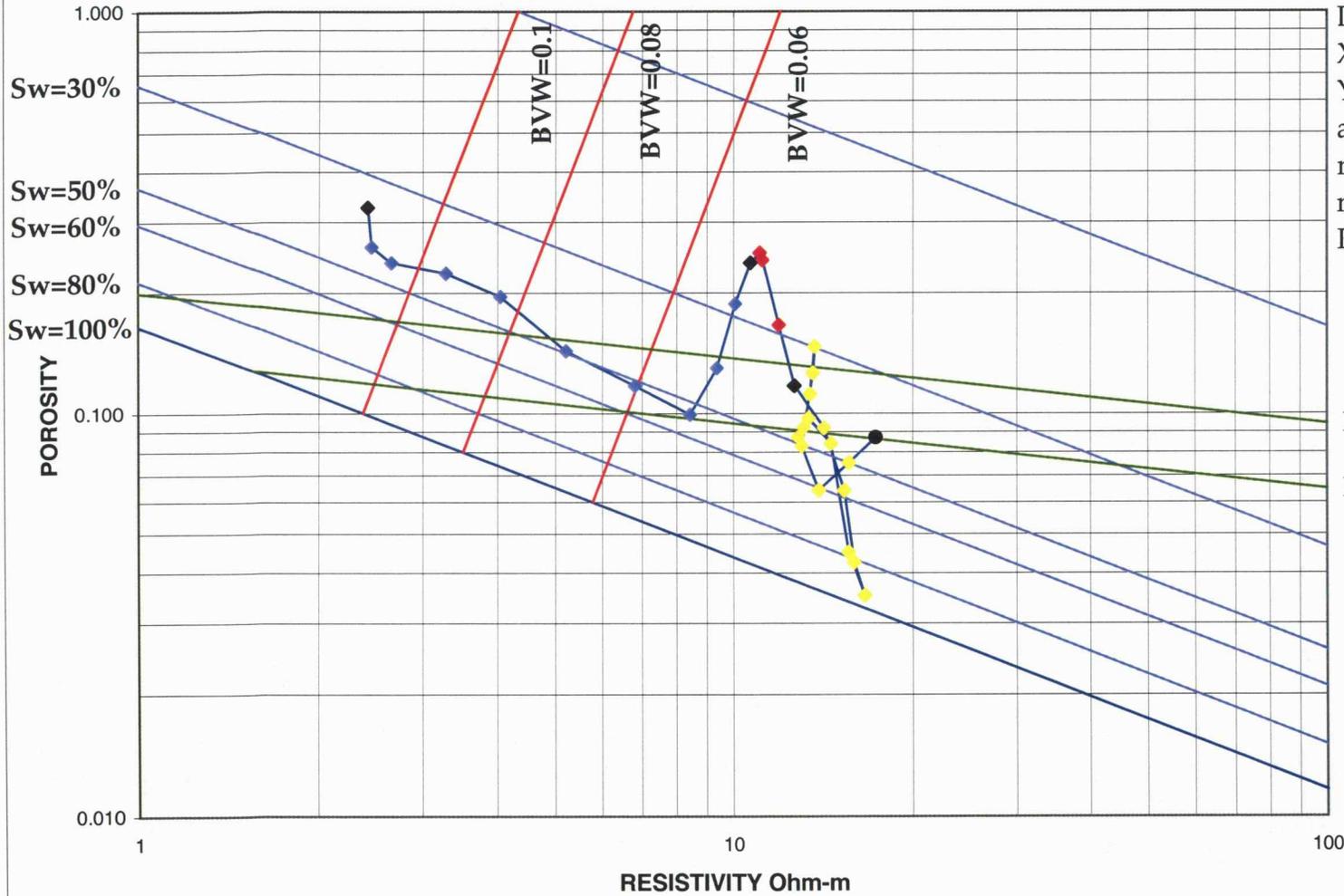
DEPTH

■ (blue)	**5305 - 5310**
■ (red)	**5303 - 5305**
■ (yellow)	**5295 - 5303**

Sand 2: 5303-05. D&A

NORTON #B-1 (TXO Prod., 15-025-20672)
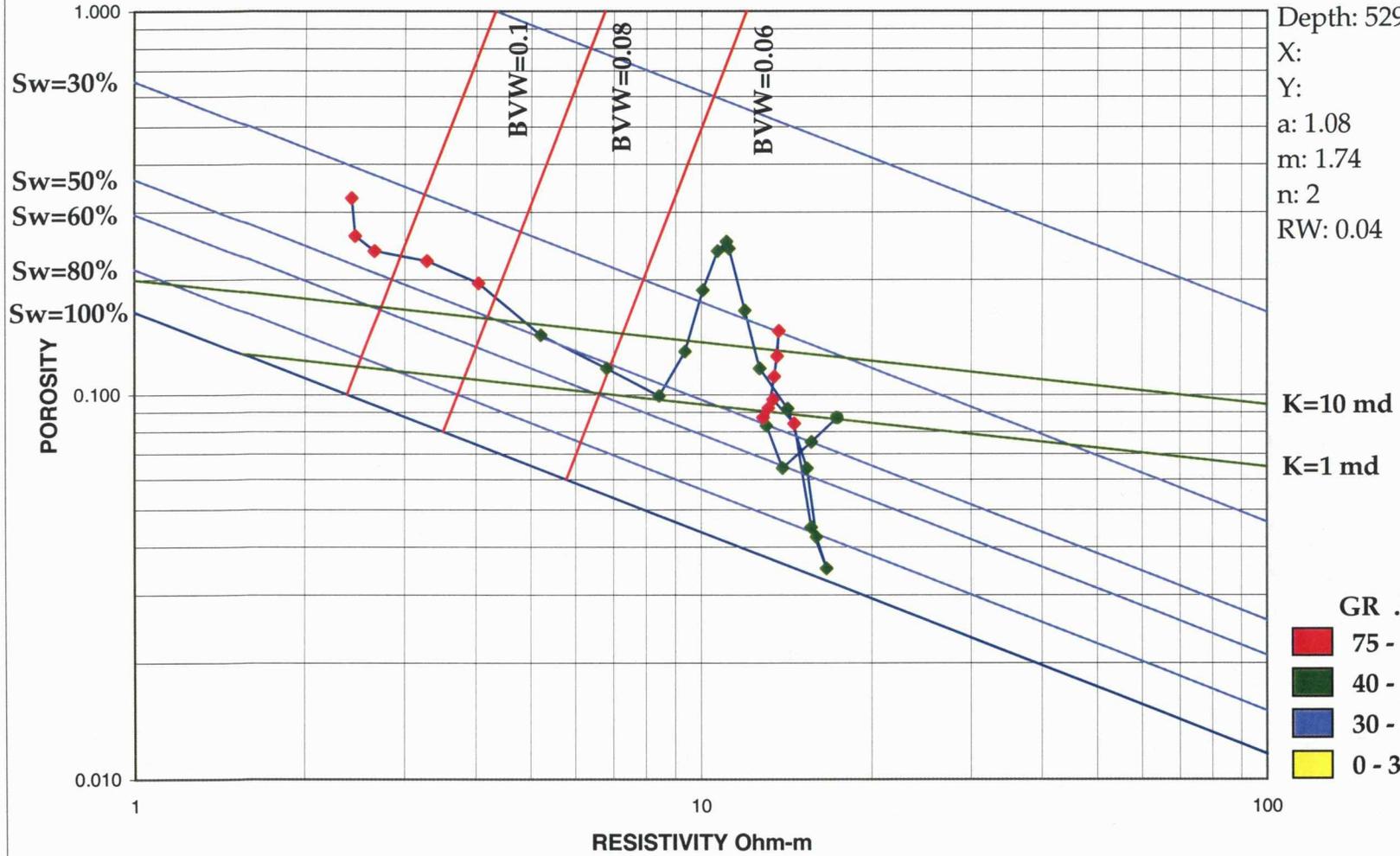
Sand 2: 5303-05. D&A

TEDFORD #1 (Ladd, 15-025-20416)
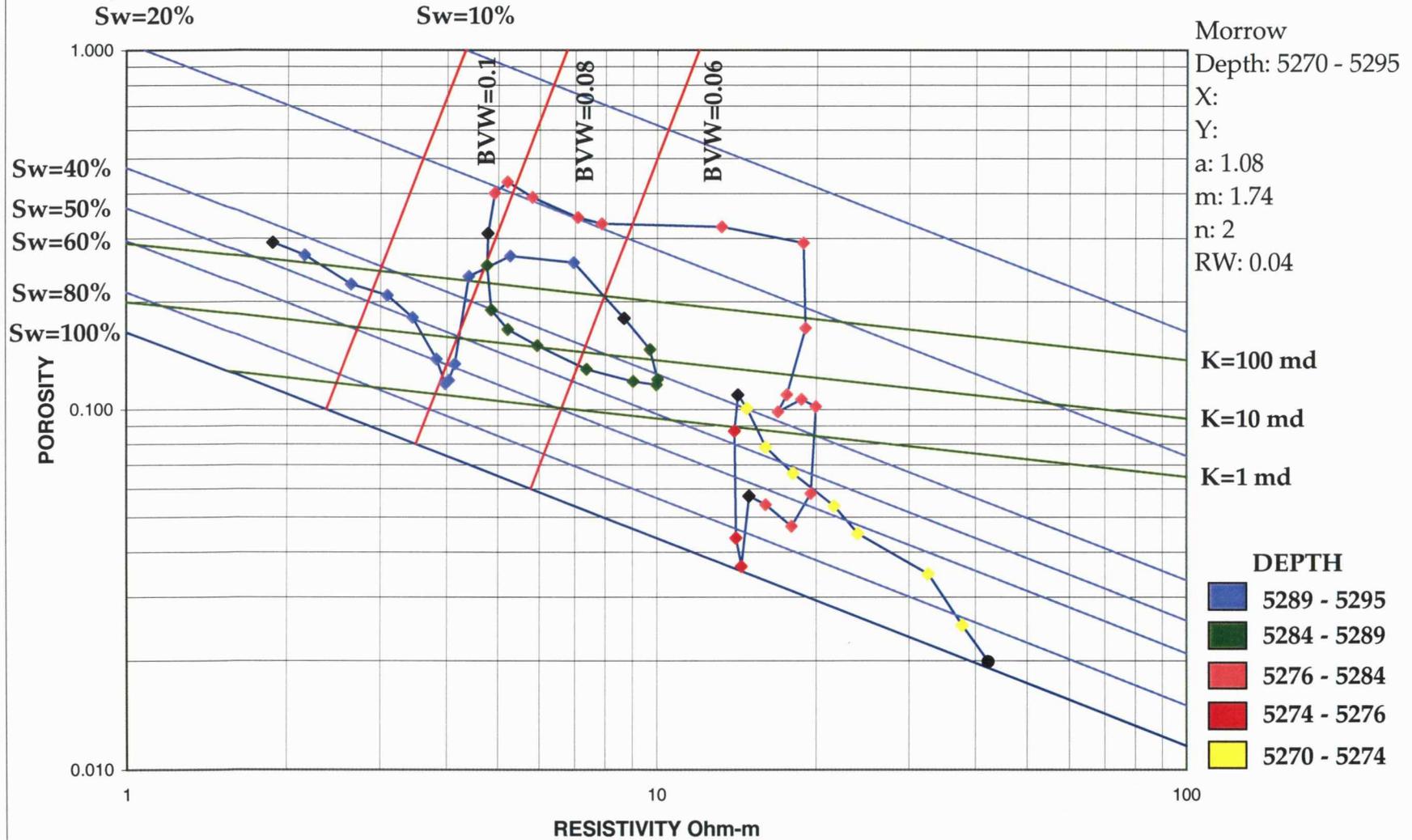
Sand 1 5274-76. Sand 2: 5284-89. Perf. 5284-88: IP 17 bopd & 55 bwpd
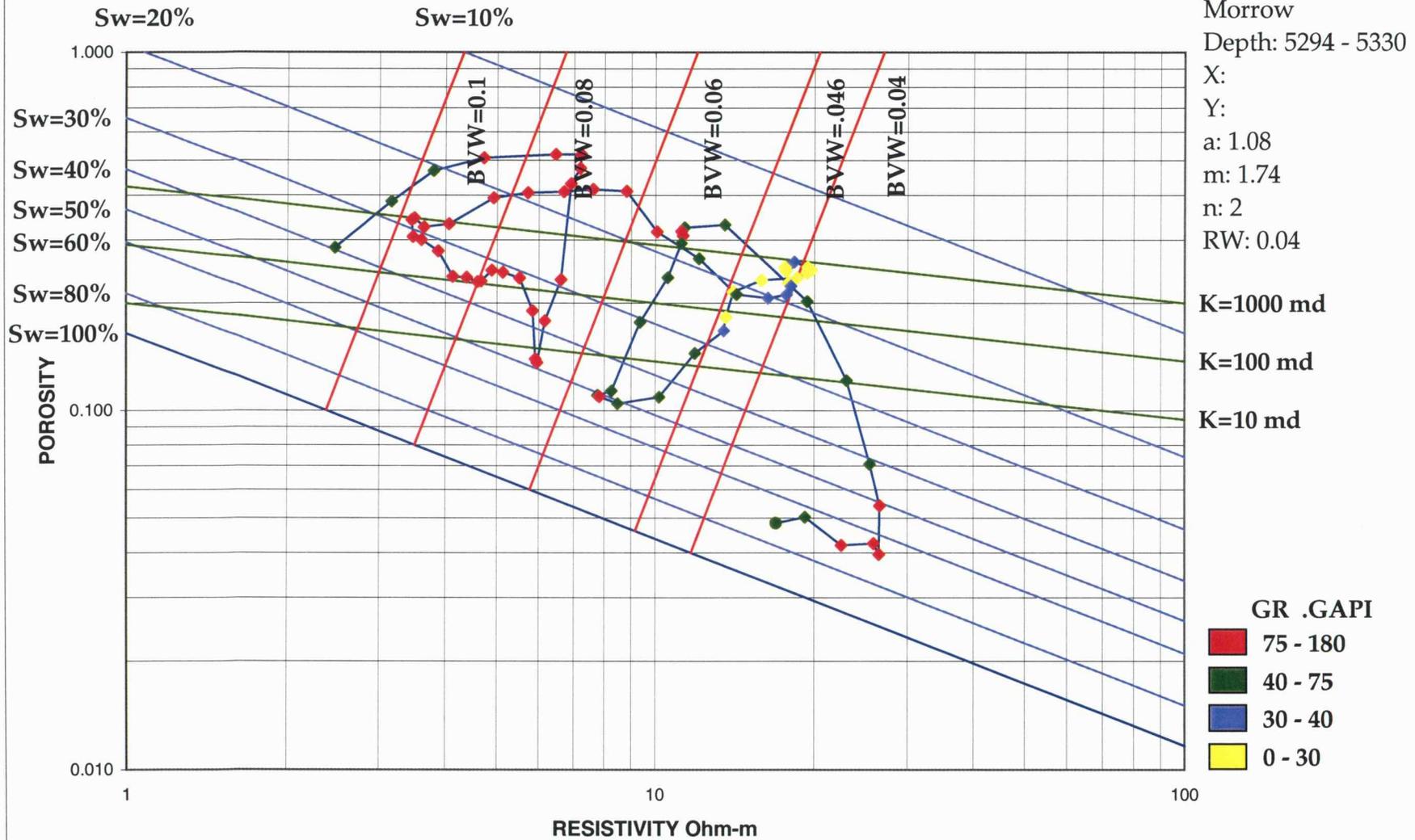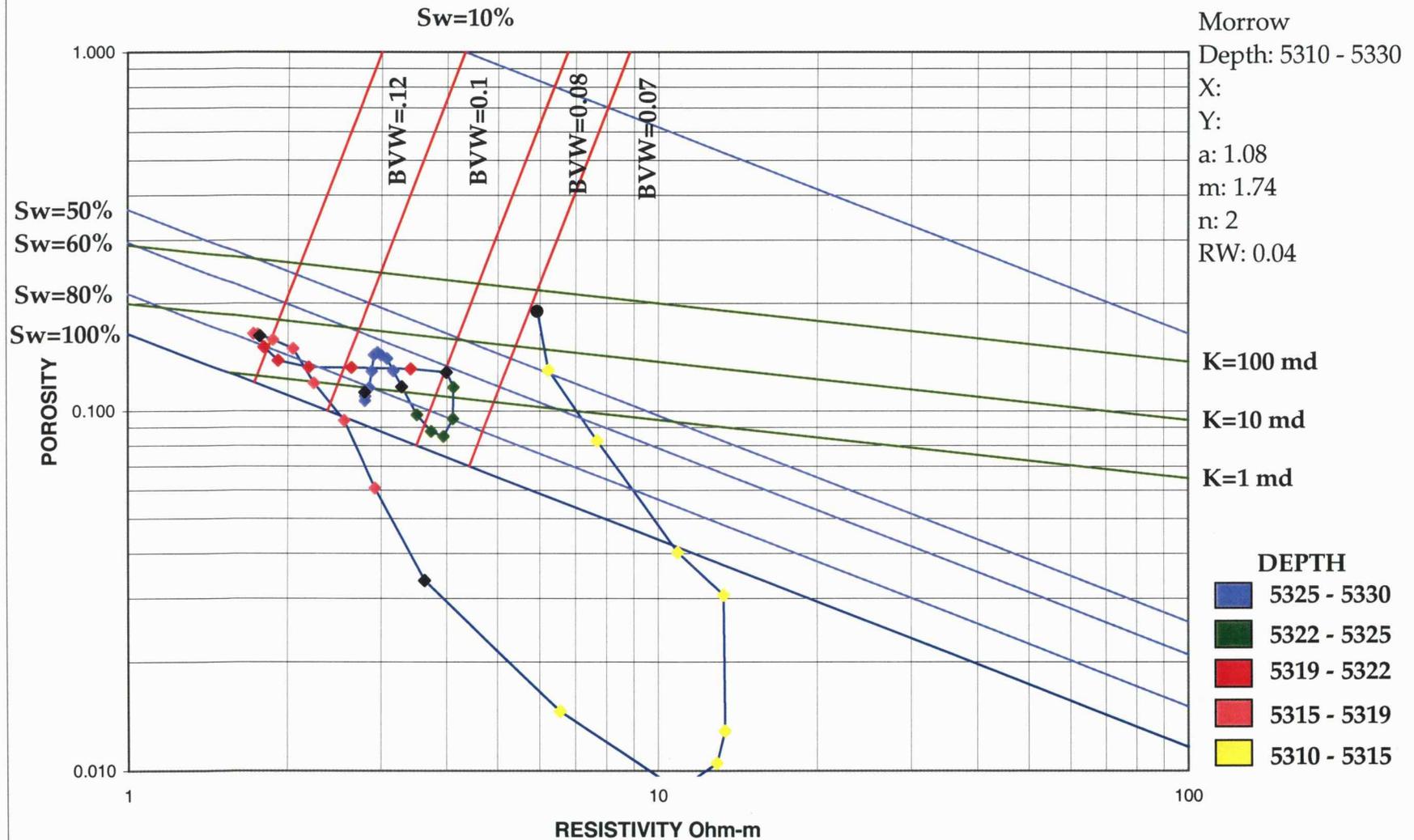
TEDFORD #1 (Ladd, 15-025-20416)

Sw=20%   Sw=10%

Morrow
Depth: 5270 - 5295
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

Sw=40%
Sw=50%
Sw=60%
Sw=80%
Sw=100%

BVW=0.1   BVW=0.08   BVW=0.06

K=100 md

K=10 md

K=1 md

POROSITY

1.000

0.100

0.010

RESISTIVITY Ohm-m

1   10   100

GR .GAPI

🟥	75 - 150
🟩	40 - 75
🟦	30 - 40
🟨	0 - 30
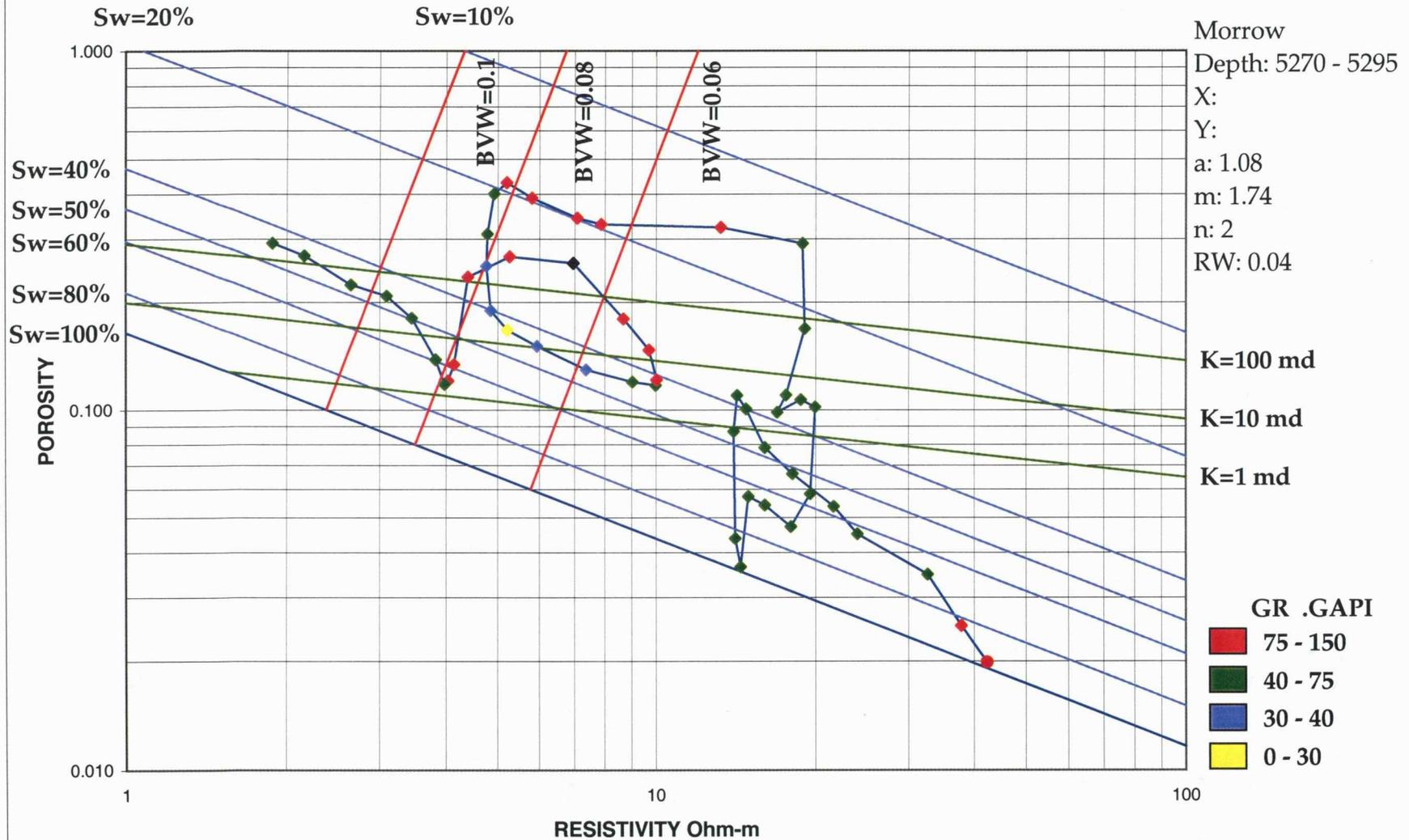
Sand 1 5274-76. Sand 2: 5284-89. Perf. 5284-88: IP 17 bopd & 55 bwpd

TEDFORD #4-10 (Murfin, 15-025-20720)

Morrow
Depth: 5294 - 5330
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

DEPTH

■ (blue)	**5311 - 5330**
■ (red)	**5308 - 5311**
■ (green)	**5300 - 5308**
■ (yellow)	**5294 - 5300**
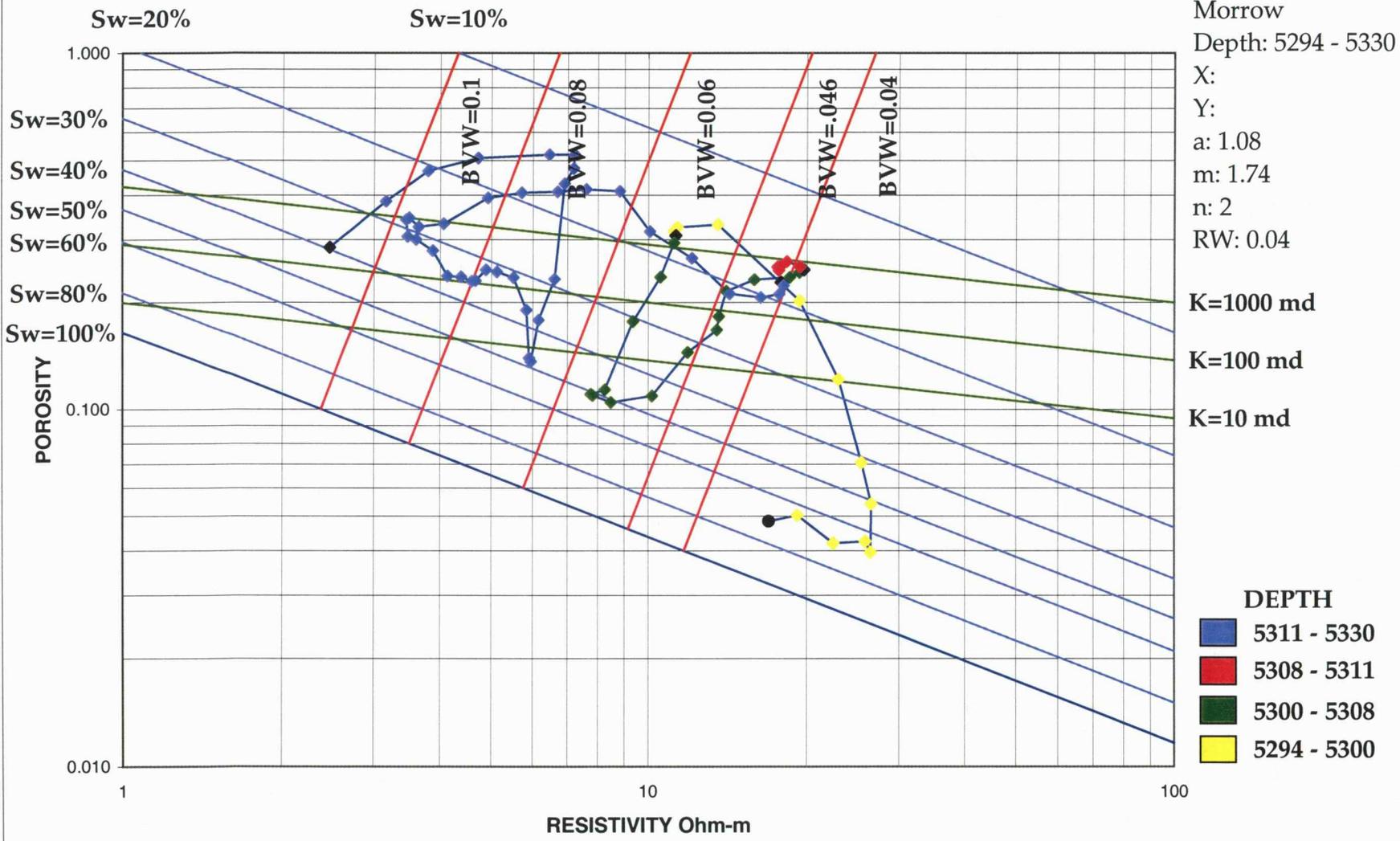
Sand 2: 5300-10. DST 5294-5330: Rec not reported. Perf. 5308-11: IP 164 bopd & 65 mcfd (nw)

TEDFORD #4-10 (Murfin, 15-025-20720)

Sw=20% Sw=10%

Morrow
Depth: 5294 - 5330
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

Sw=30%
Sw=40%
Sw=50%
Sw=60%
Sw=80%
Sw=100%

BVW=0.1 BVW=0.08 BVW=0.06 BVW=.046 BVW=0.04

K=1000 md

K=100 md

K=10 md

POROSITY

RESISTIVITY Ohm-m

GR .GAPI

🟥	75 - 180
🟩	40 - 75
🟦	30 - 40
🟨	0 - 30

Sand 2: 5300-10. DST 5294-5330: Rec not reported. Perf. 5308-11: IP 164 bopd & 65 mcfd (nw)

TEDFORD #2-10 (Ladd, 15-025-20669)

Sw=10%

Morrow
Depth: 5310 - 5330
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

BVW=.12
BVW=0.1
BVW=0.08
BVW=0.07

Sw=50%
Sw=60%
Sw=80%
Sw=100%

POROSITY

1.000

0.100

0.010

K=100 md

K=10 md

K=1 md

DEPTH
5325 - 5330
5322 - 5325
5319 - 5322
5315 - 5319
5310 - 5315

1   10   100

RESISTIVITY Ohm-m

Sand 2: 5315-19. Sand 3: 5322-25.
Perf 5316-23 & 5353-62 (Morrow) and 5376-82 (Miss): IP 20 bopd, 105 mcfpd, 26 bwpd (commingled)

TEDFORD #2-10 (Ladd, 15-025-20669)
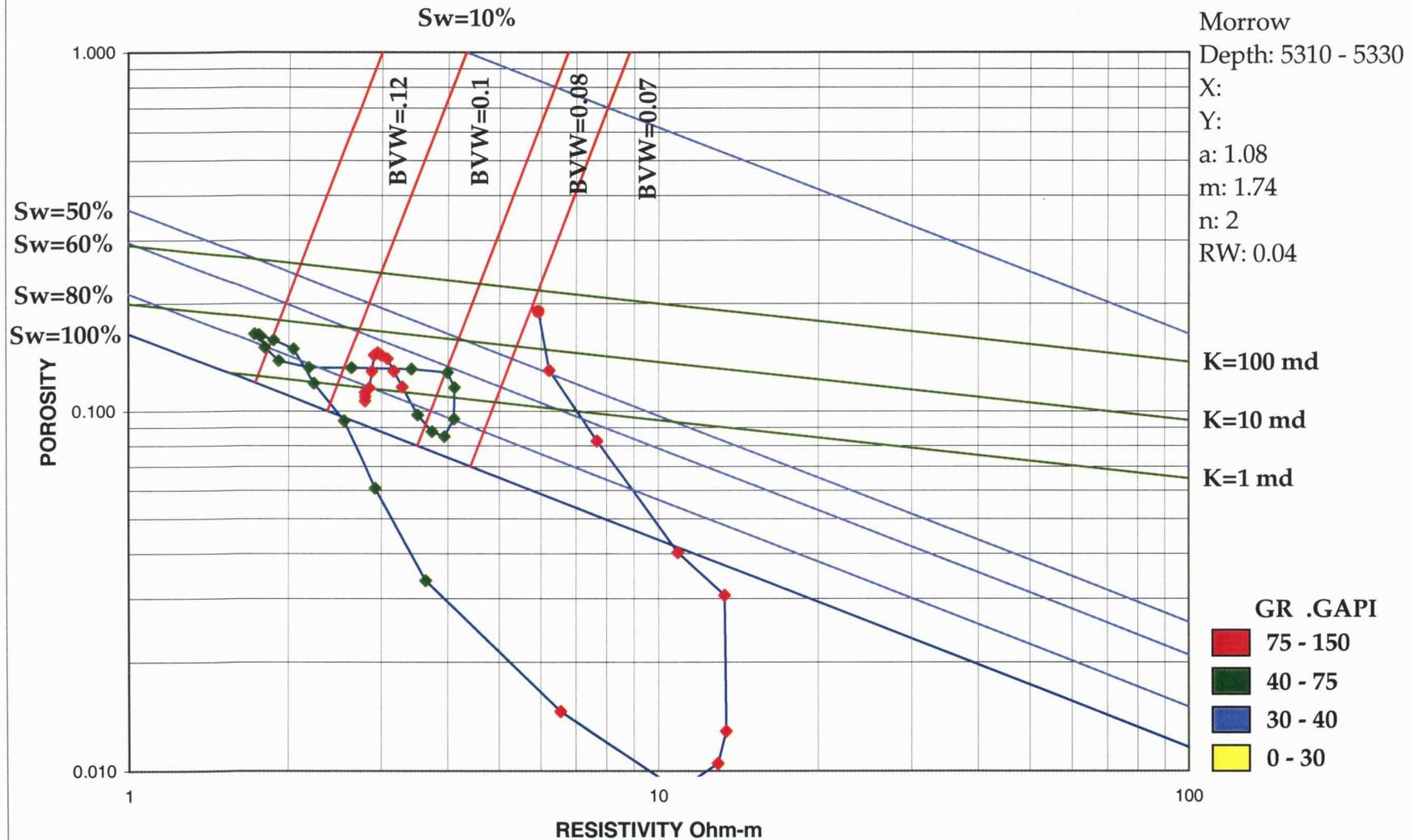
Sw=10%

Morrow
Depth: 5310 - 5330
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

POROSITY (y-axis)

1.000

Sw=50%
Sw=60%

Sw=80%

Sw=100%

0.100

BVW=.12 BVW=0.1 BVW=0.08 BVW=0.07

K=100 md

K=10 md

K=1 md

0.010

1   10   100

RESISTIVITY Ohm-m

GR .GAPI	
	75 - 150
	40 - 75
	30 - 40
	0 - 30

Sand 2: 5315-19. Sand 3: 5322-25.

Perf 5316-23 & 5353-62 (Morrow) and 5376-82 (Miss): IP 20 bopd, 105 mcfpd, 26 bwpd (commingled)

TEDFORD #1-10 (Murfin, 20621)
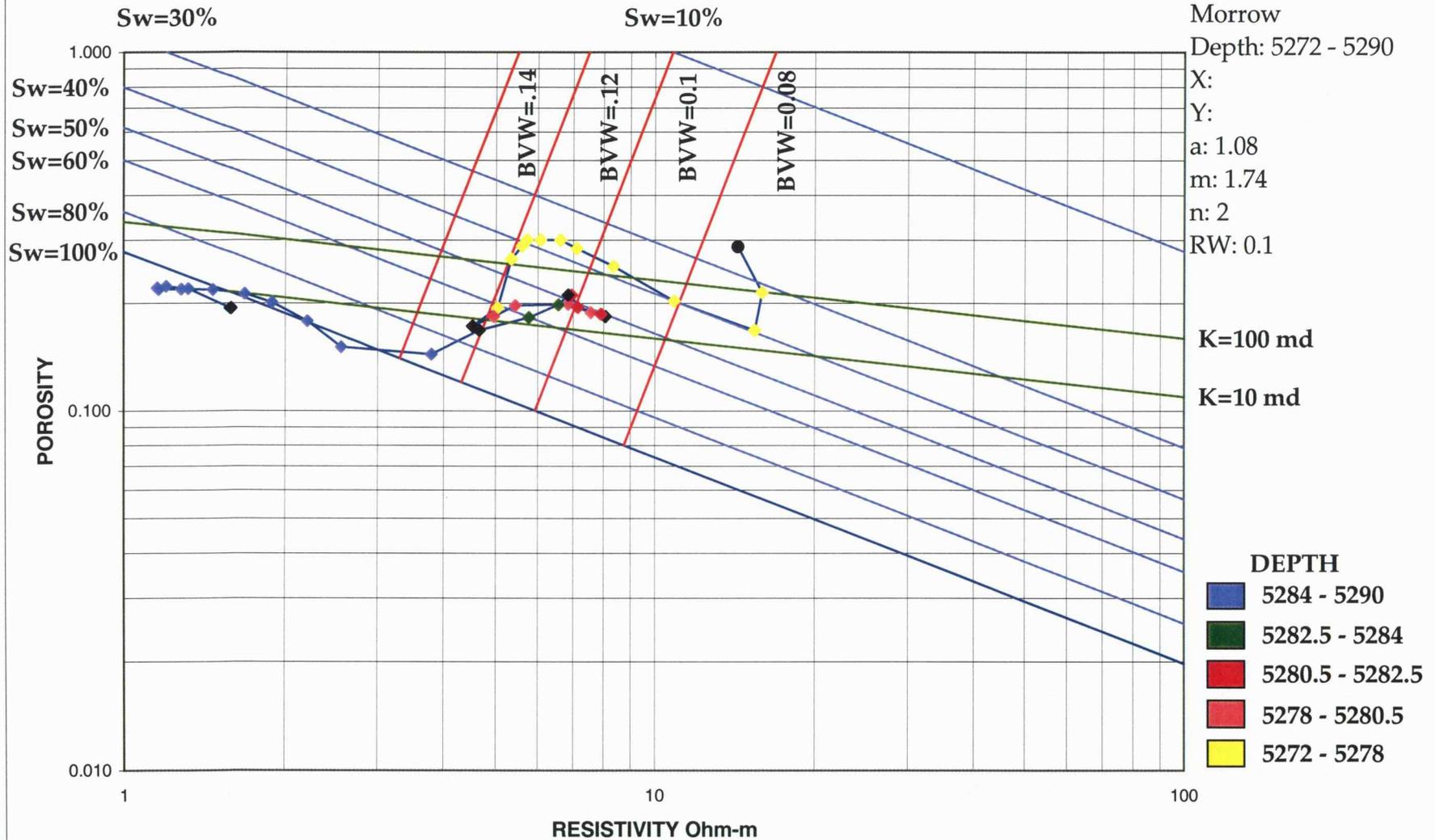
Sand 1: 5278-84. Perf 5280.5-82.5: CAOF 512 mcfpd, NW

TEDFORD #1-10 (Murfin, 20621)
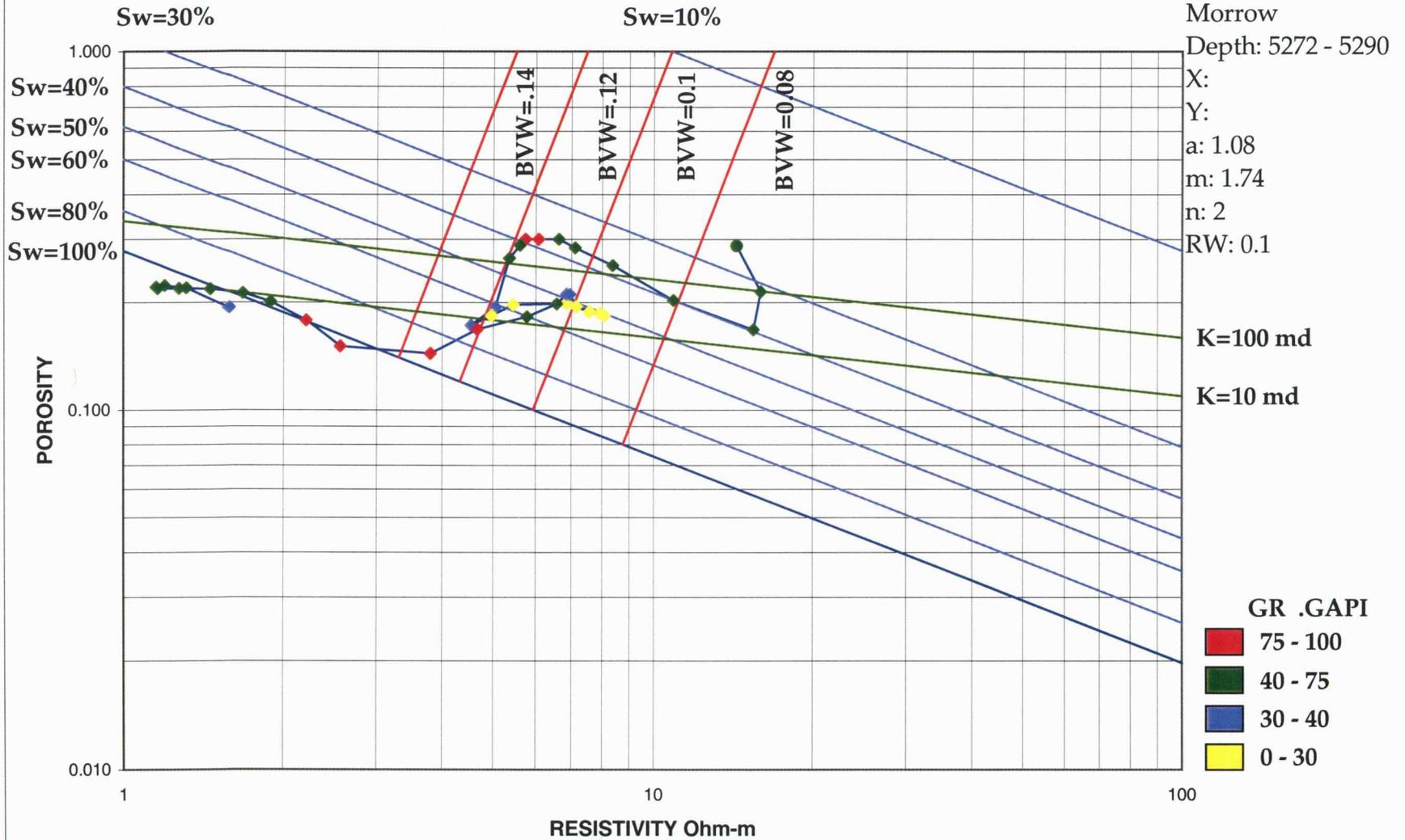
Sand 1: 5278-84. Perf 5280.5-82.5: CAOF 512 mcfpd, NW

TEDFORD #B-1-10 (Murfin, 15-025-20905)

Morrow
Depth: 5295 - 5315
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

Sw=10%

Sw=50%
Sw=60%
Sw=80%
Sw=100%

BVW=.12
BVW=0.1
BVW=0.08
BVW=0.07

POROSITY

RESISTIVITY Ohm-m

K=100 md

K=10 md

K=1 md

DEPTH

■ (blue)	**5308 - 5315**
■ (red)	**5300 - 5308**
□ (yellow)	**5295 - 5300**
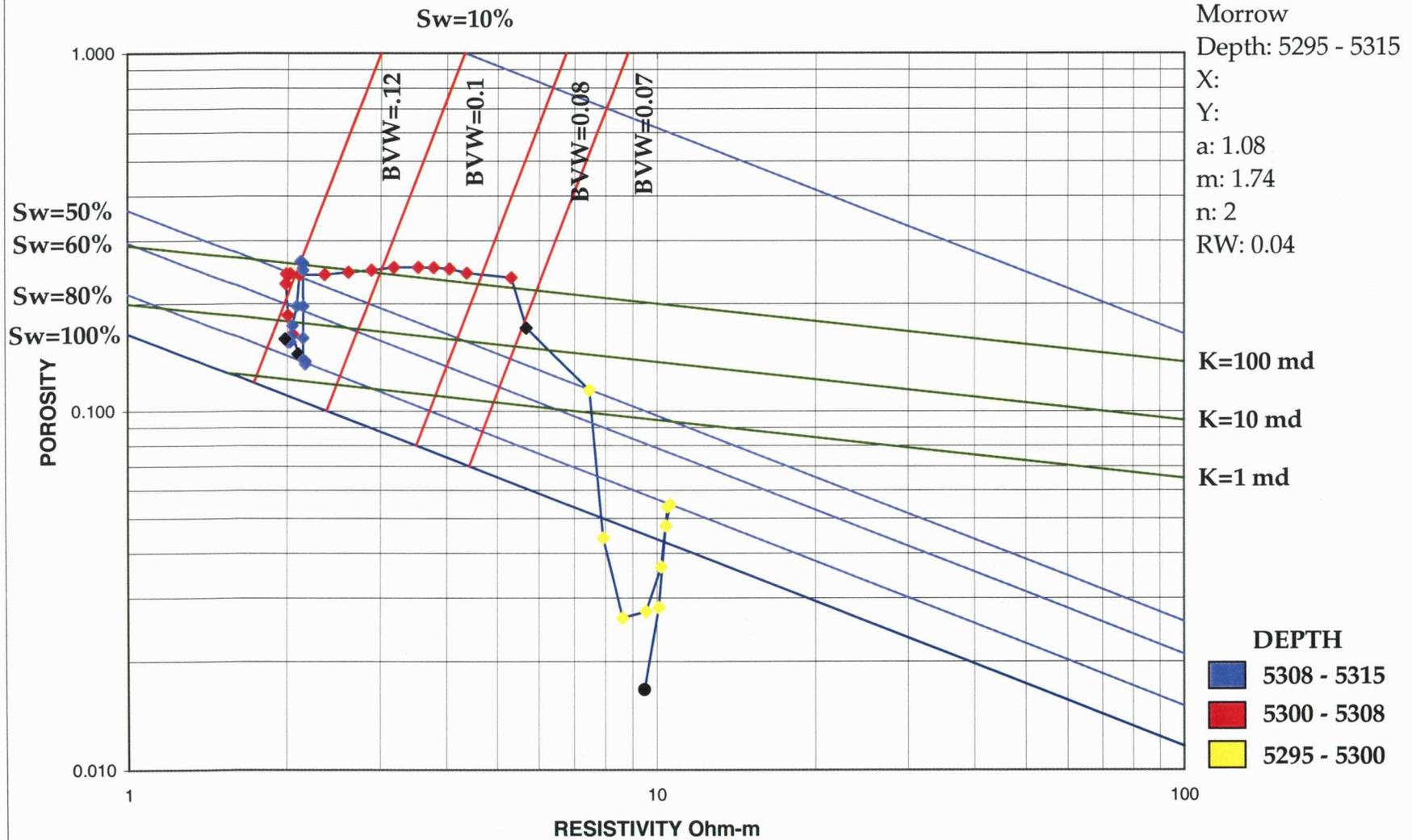
Sand 2: 5300-08. Morrow perf. Interval and IP na. Status OIL

TEDFORD #B-1-10 (Murfin, 15-025-20905)

Sw=10%

Morrow
Depth: 5295 - 5315
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

Sw=50%
Sw=60%
Sw=80%
Sw=100%

BVW=.12
BVW=0.1
BVW=0.08
BVW=0.07

POROSITY

1.000

0.100

0.010

K=100 md

K=10 md

K=1 md

RESISTIVITY Ohm-m

1   10   100

GR .GAPI

🟥	70 - 145
🟩	40 - 70
🟦	30 - 40
🟨	0 - 30
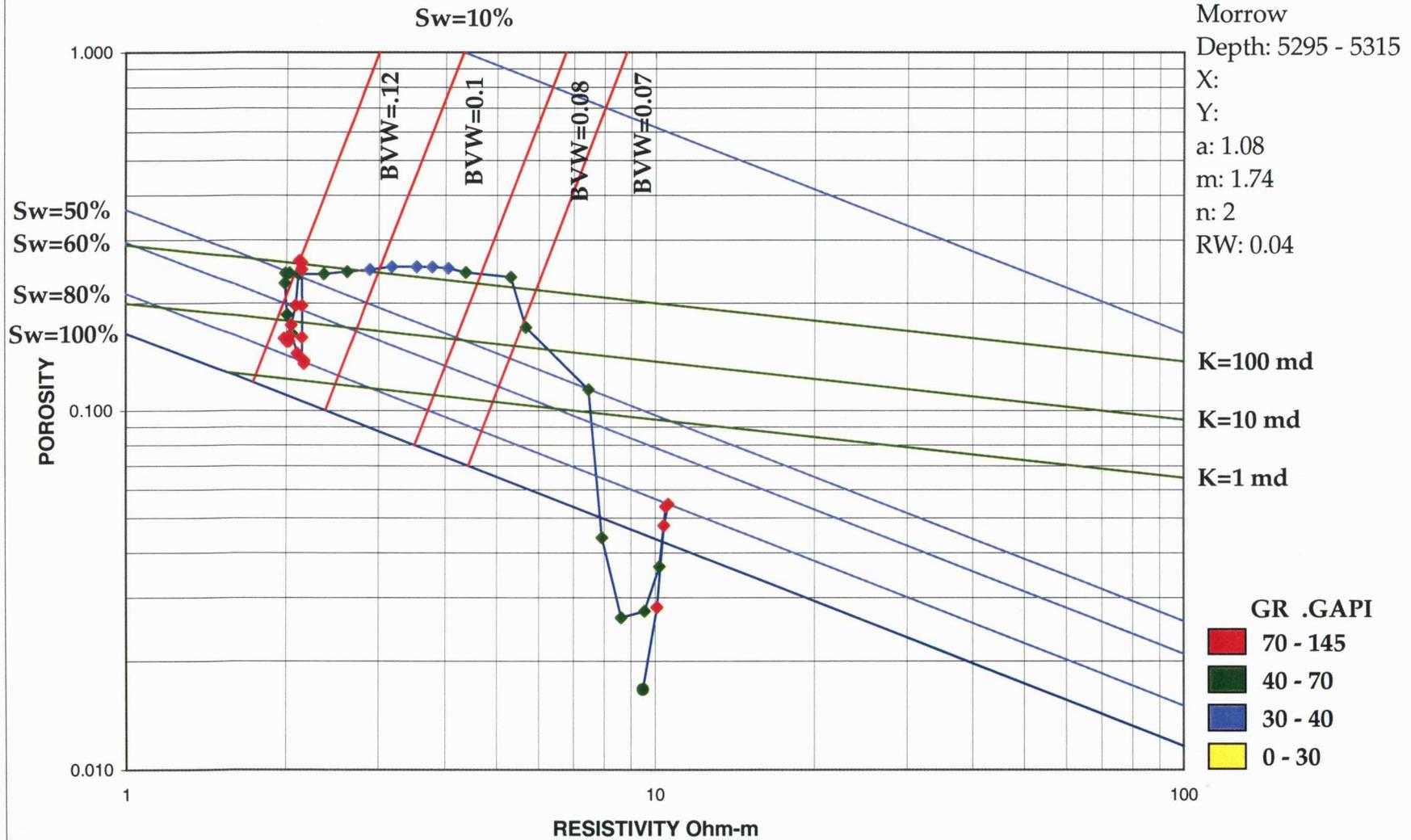
Sand 2: 5300-08. Morrow perf. Interval and IP na. Status OIL

TEDFORD #3-10 (Murfin, 15-025-20788)

Sand 2: 5283-85. Sand 3: 5290-93. DST 5270-5308 (overlaps Miss): Rec 30' mud. D&A

TEDFORD #3-10 (Murfin, 15-025-20788)
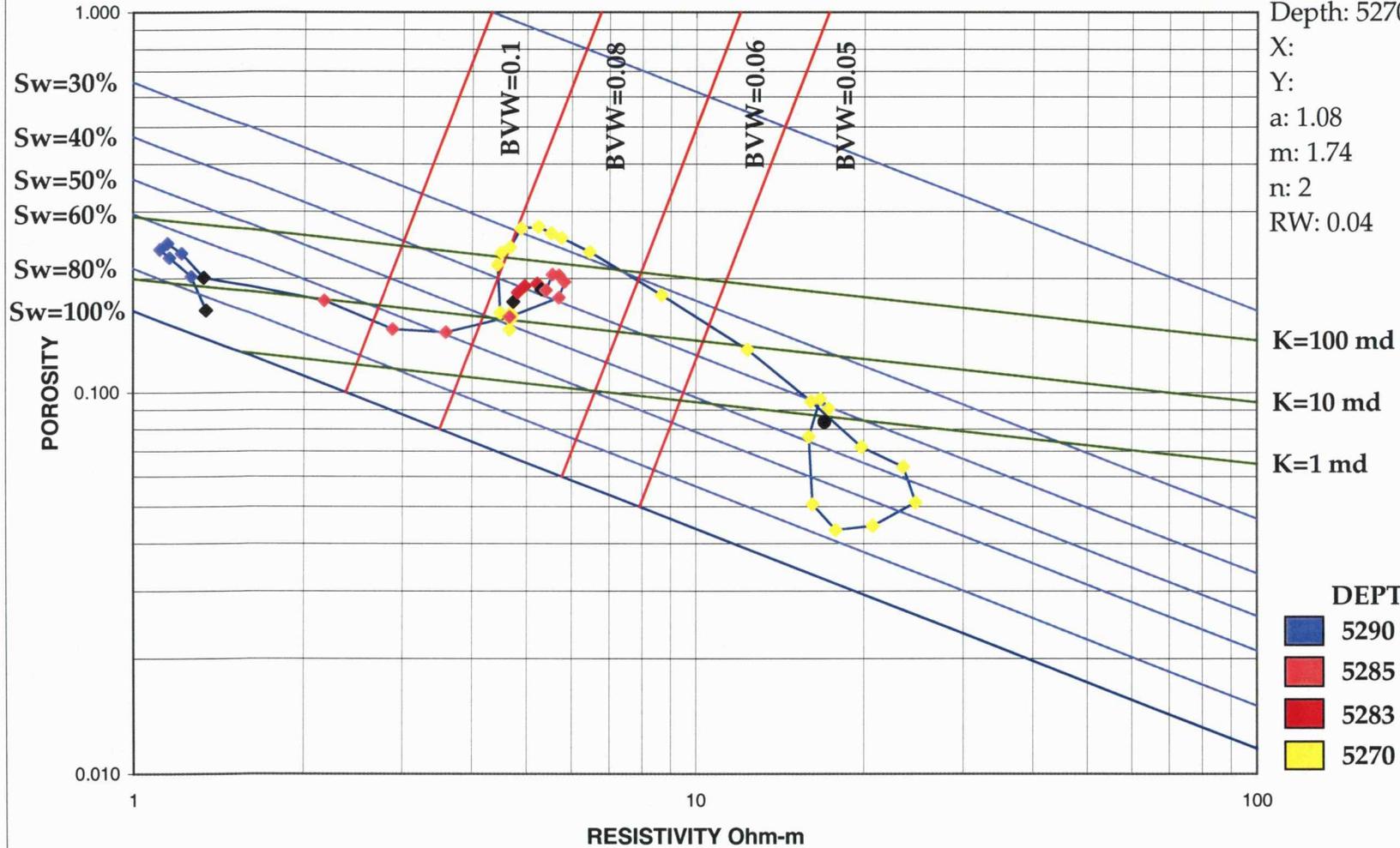
Sw=10%

Morrow
Depth: 5270 - 5293
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

Sw=30%
Sw=40%
Sw=50%
Sw=60%
Sw=80%
Sw=100%

BVW=0.1
BVW=0.08
BVW=0.06
BVW=0.05

POROSITY

1.000

0.100

0.010

K=100 md

K=10 md

K=1 md

1   10   100

RESISTIVITY Ohm-m
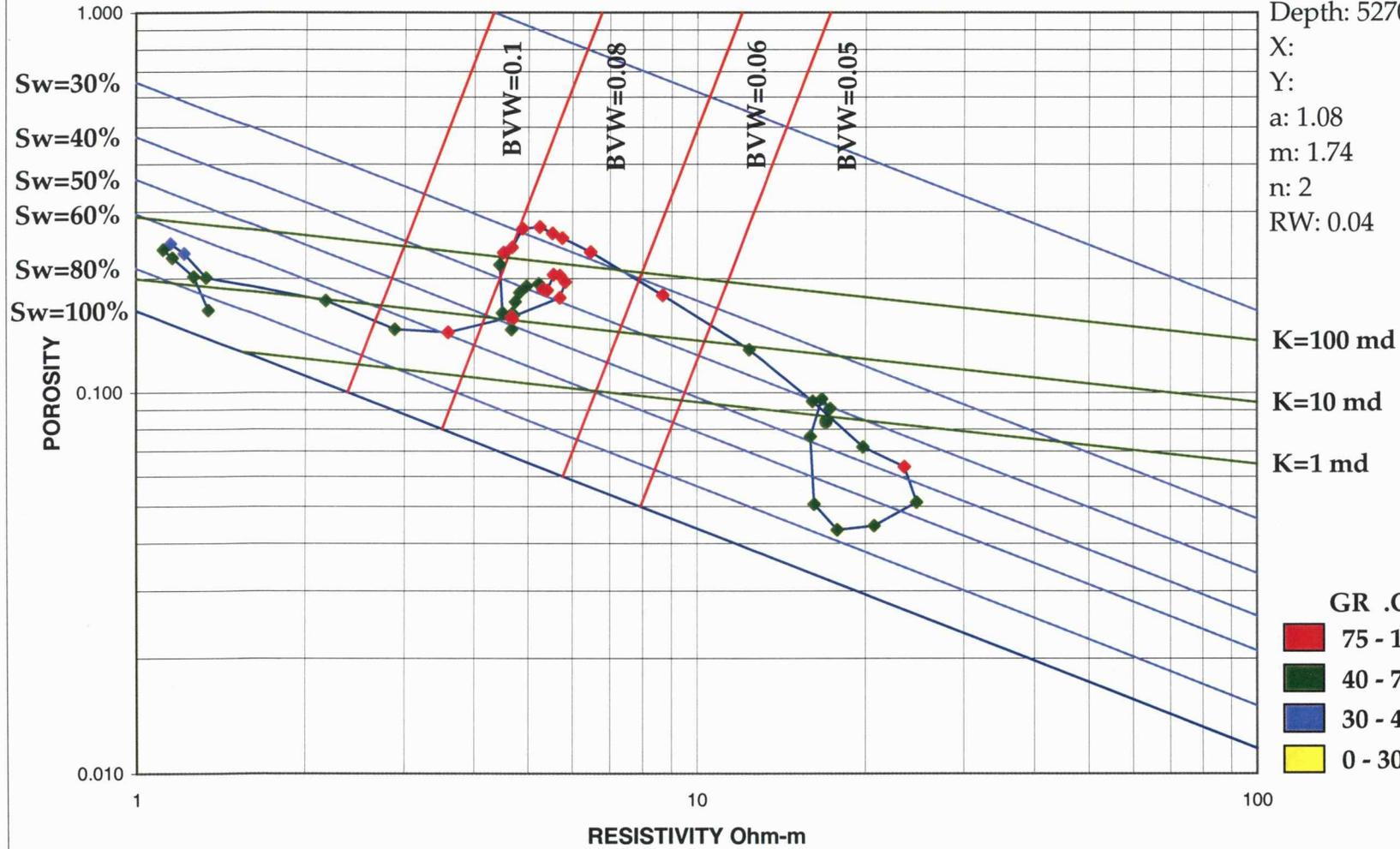
GR .GAPI

75 - 110

40 - 75

30 - 40

0 - 30

Sand 2: 5283-85. Sand 3: 5290-93. DST 5270-5308 (overlaps Miss): Rec 30' mud. D&A

TEDFORD #2-10 (Murfin, 15-025-20686)

Sw=20%   Sw=10%
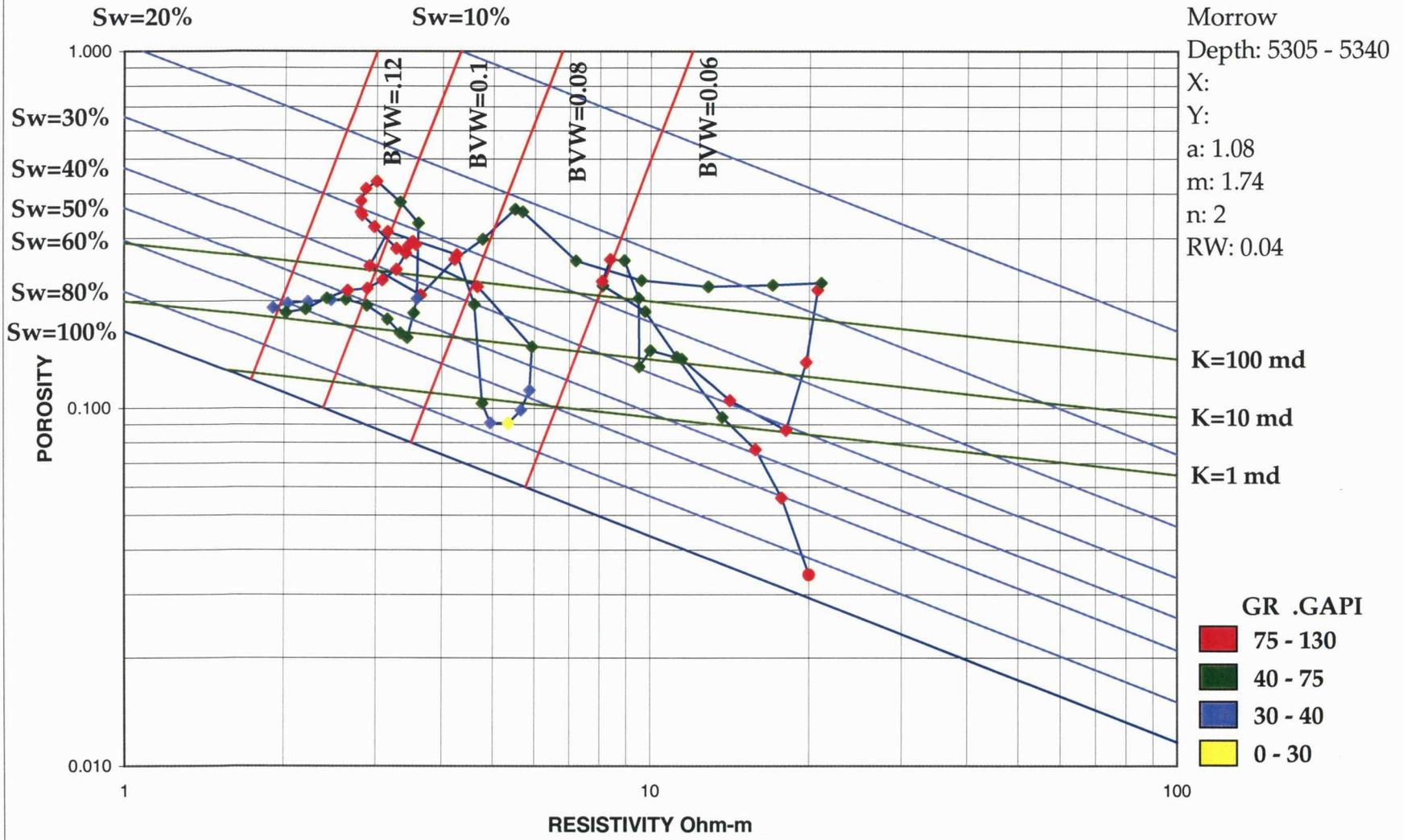
Morrow
Depth: 5305 - 5340
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

Sw=30%
Sw=40%
Sw=50%
Sw=60%
Sw=80%
Sw=100%

BVW=.12   BVW=0.1   BVW=0.08   BVW=0.06

POROSITY

K=100 md

K=10 md

K=1 md

RESISTIVITY Ohm-m

GR .GAPI
75 - 130
40 - 75
30 - 40
0 - 30

Sand 1: 5310-16. Sand 2: 5329-35. D&A

TEDFORD #2-10 (Murfin, 15-025-20686)

LATZKE #1-11 (Ladd, 15-025-20611)

Sw=10%

Morrow
Depth: 5298 - 5319
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

K=100 md

K=10 md

Sw=40%
Sw=50%
Sw=60%
Sw=70%
Sw=80%
Sw=100%

POROSITY

RESISTIVITY Ohm-m

BVW=.15   BVW=.13   BVW=.115
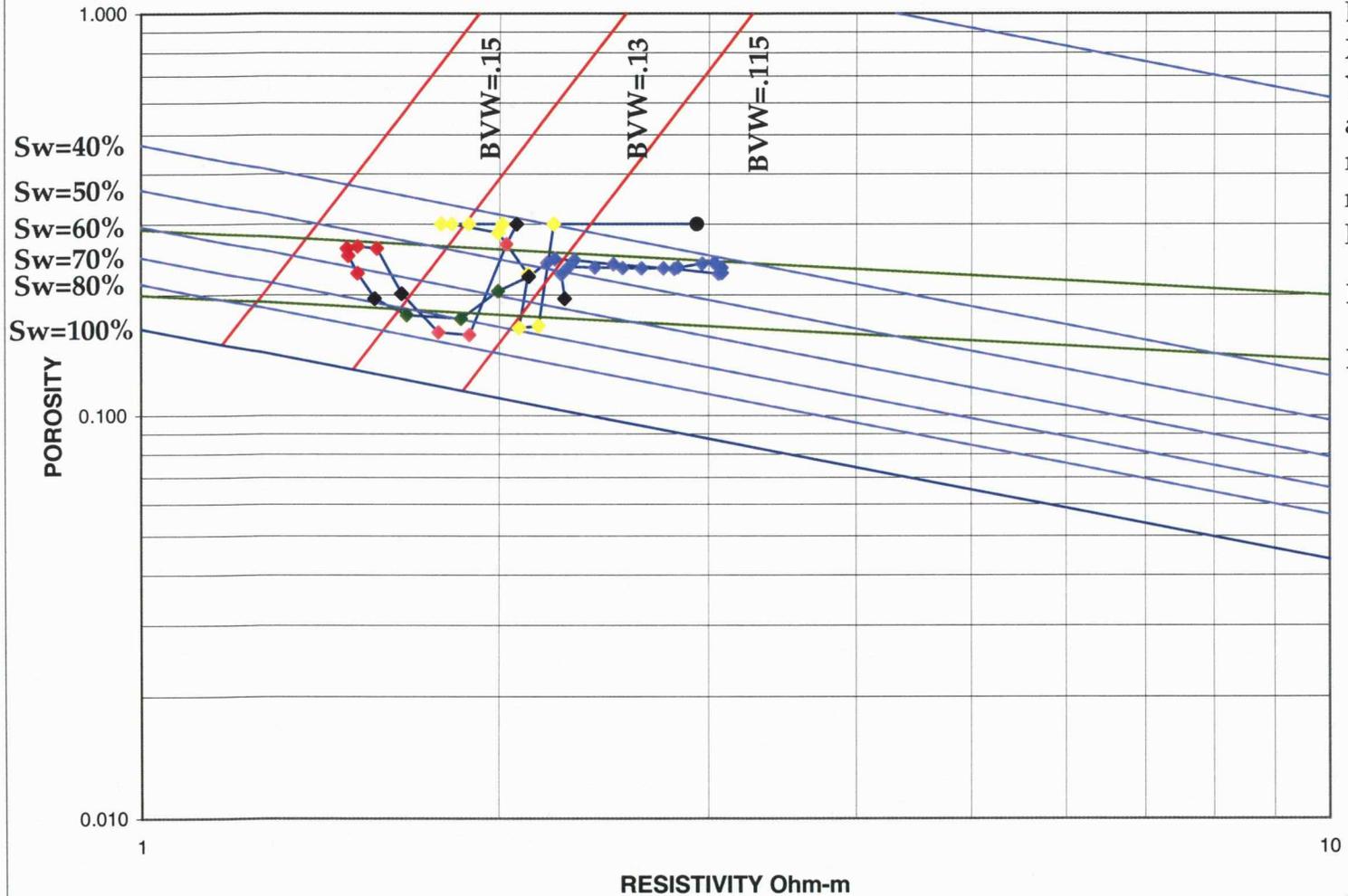
DEPTH
- 5310 - 5319
- 5308 - 5310
- 5305 - 5308
- 5303 - 5305
- 5298 - 5303

Sand 2: 5303-08. Sand 3: 5310-19. Perf. 5305-18: 205 bopd & 120 mcfd

LATZKE #1-11 (Ladd, 15-025-20611)

Sw=10%

Morrow
Depth: 5298 - 5319
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

Sw=40%
Sw=50%
Sw=60%
Sw=70%
Sw=80%
Sw=100%

BVW=.15
BVW=.13
BVW=.115

K=100 md
K=10 md

POROSITY

RESISTIVITY Ohm-m

GR .GAPI

■ (red)	75 - 200
■ (green)	40 - 75
■ (blue)	30 - 40
□ (yellow)	0 - 30
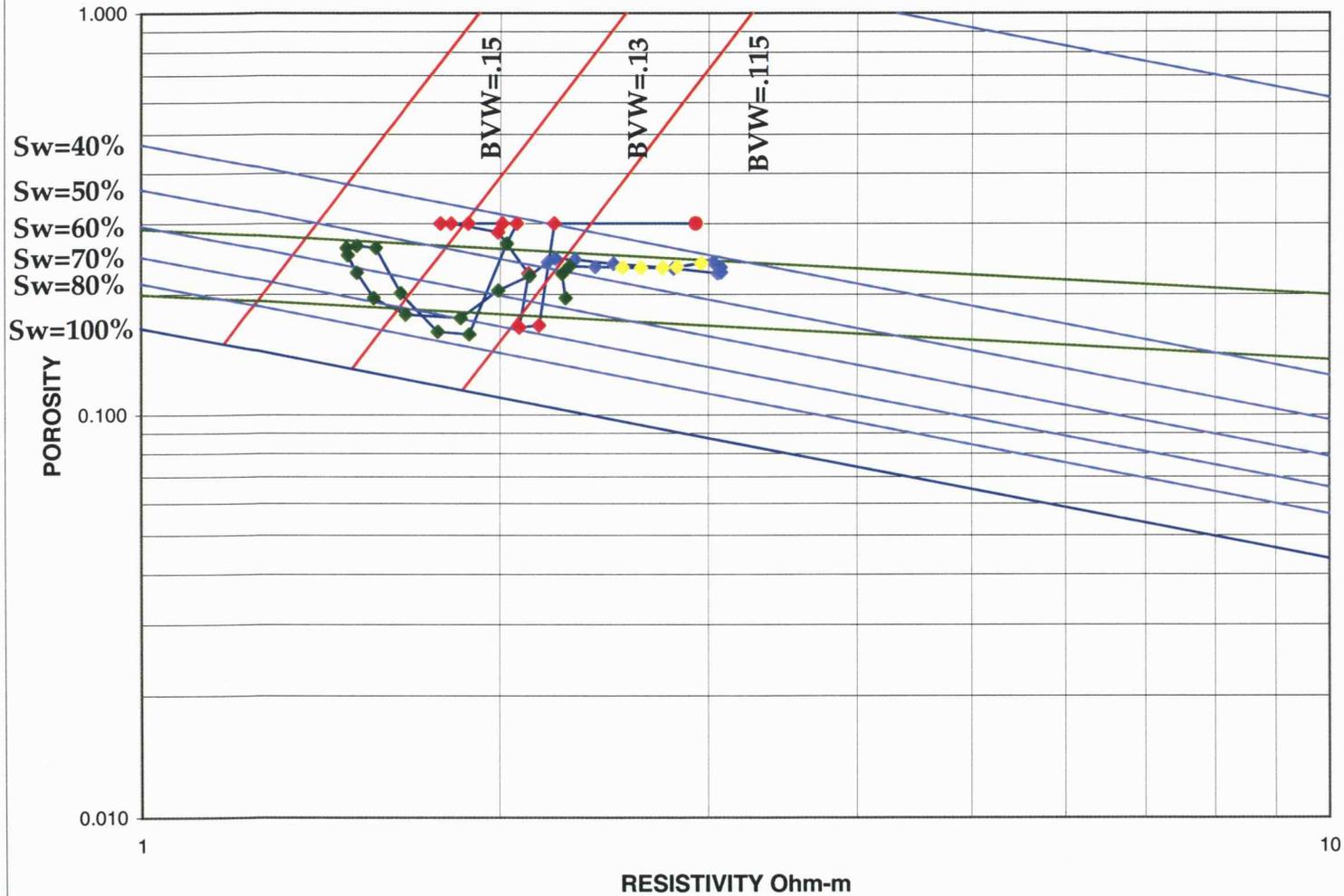
Sand 2: 5303-08. Sand 3: 5310-19. Perf. 5305-18: 205 bopd & 120 mcfd

ROONEY #1-11 (Ladd, 15-025-20702)
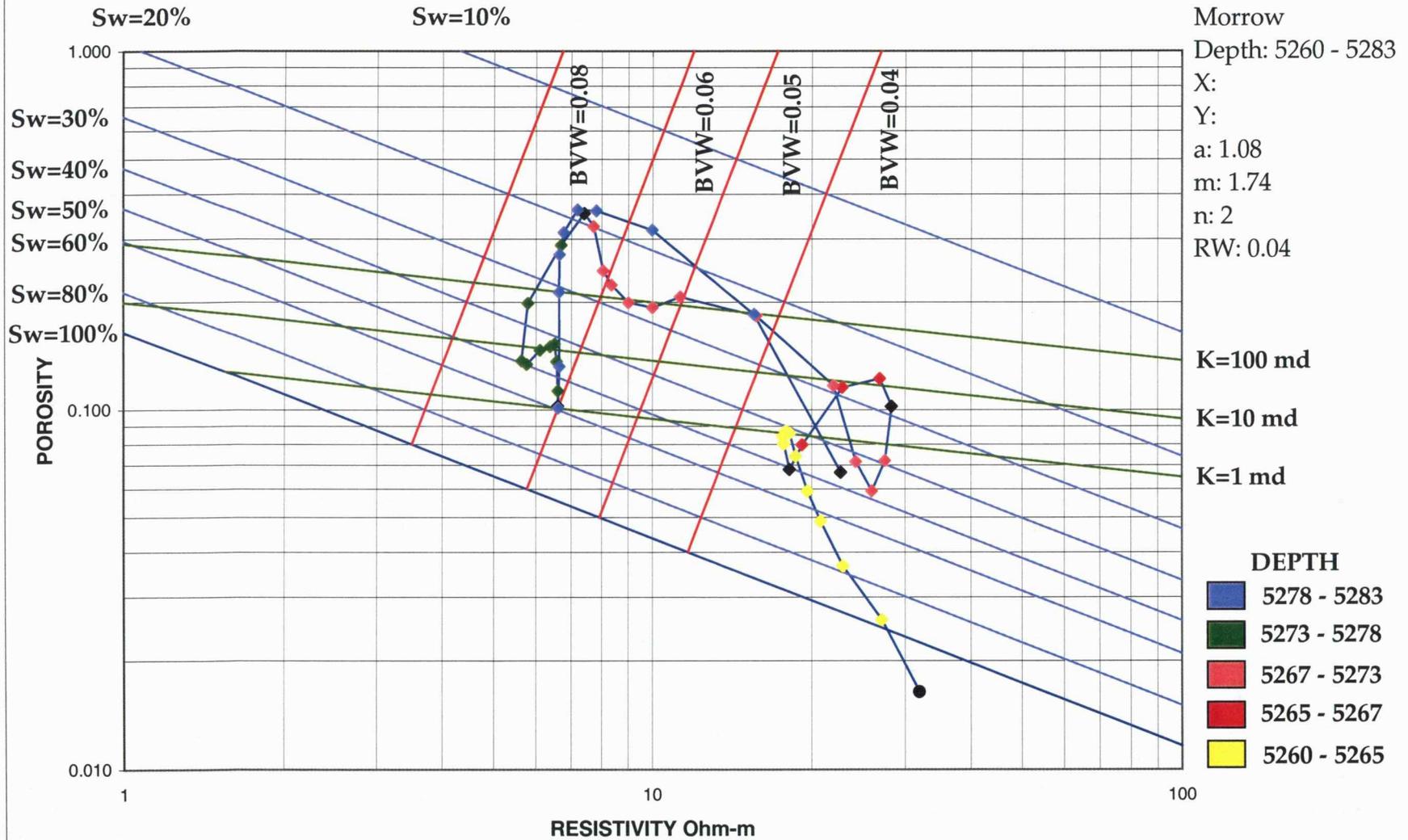
Sand 1: 5265-67. Sand 2: 5273-78. D&A.

ROONEY #1-11 (Ladd, 15-025-20702)

Sw=20%   Sw=10%

Morrow
Depth: 5260 - 5283
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

Sw=30%
Sw=40%
Sw=50%
Sw=60%
Sw=80%
Sw=100%

BVW=0.08   BVW=0.06   BVW=0.05   BVW=0.04

POROSITY

K=100 md

K=10 md

K=1 md

1.000

0.100

0.010

1   10   100

RESISTIVITY Ohm-m

GR .GAPI

🟥	75 - 110
🟩	40 - 75
🟦	30 - 40
🟨	0 - 30
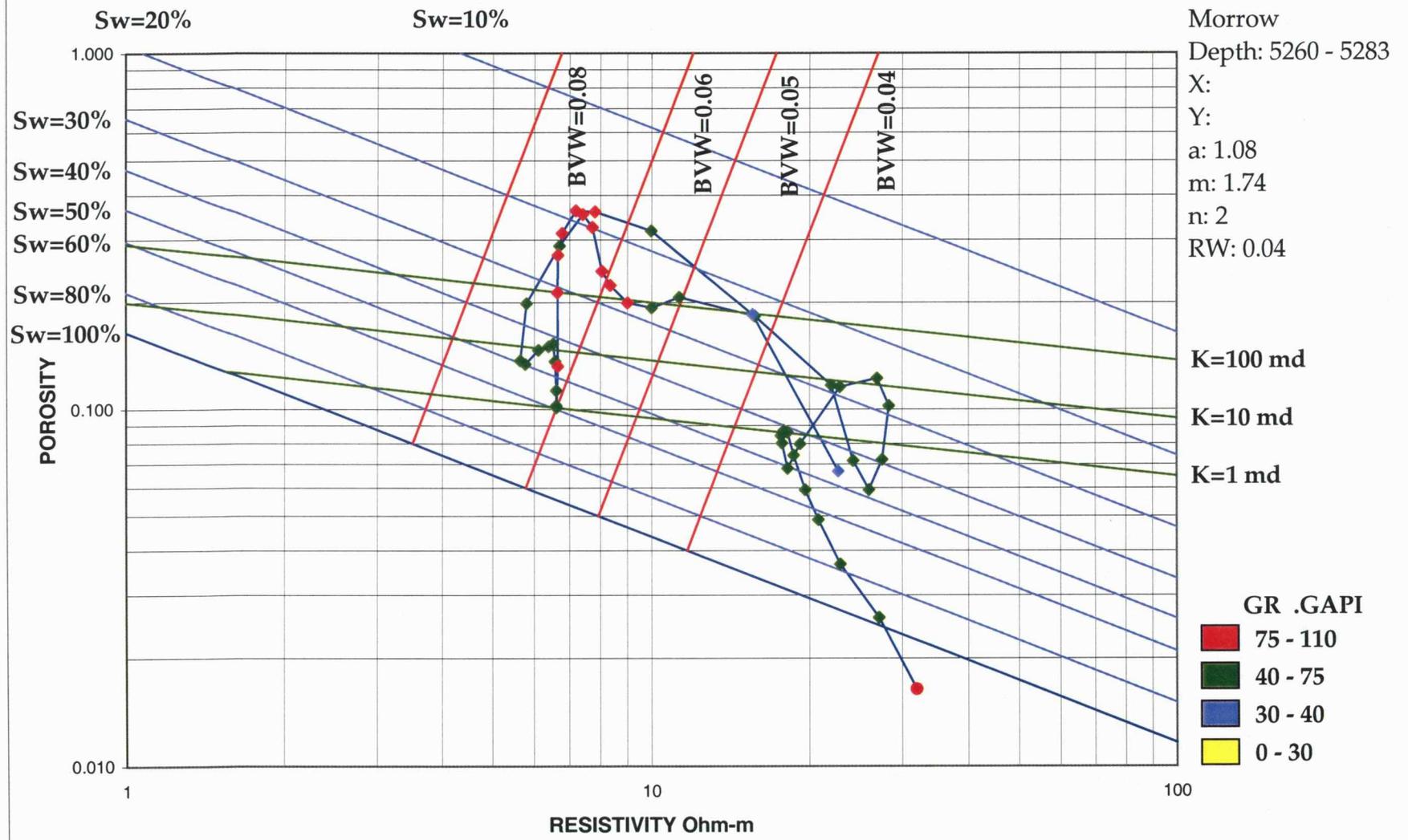
Sand 1: 5265-67. Sand 2: 5273-78. D&A.

ROONEY #1-11 (Vern Jones, 20965)

Morrow
Depth: 5293 - 5313
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

Sw=20%   Sw=10%

Sw=30%
Sw=40%
Sw=50%
Sw=60%
Sw=80%
Sw=100%

BVW=0.09 BVW=0.08 BVW=0.07 BVW=0.06

POROSITY

1.000

0.100

0.010

K=100 md

K=10 md

K=1 md

RESISTIVITY Ohm-m

1   10   100

DEPTH
5310 - 5313
5301 - 5310
5299 - 5301
5297 - 5299
5293 - 5297
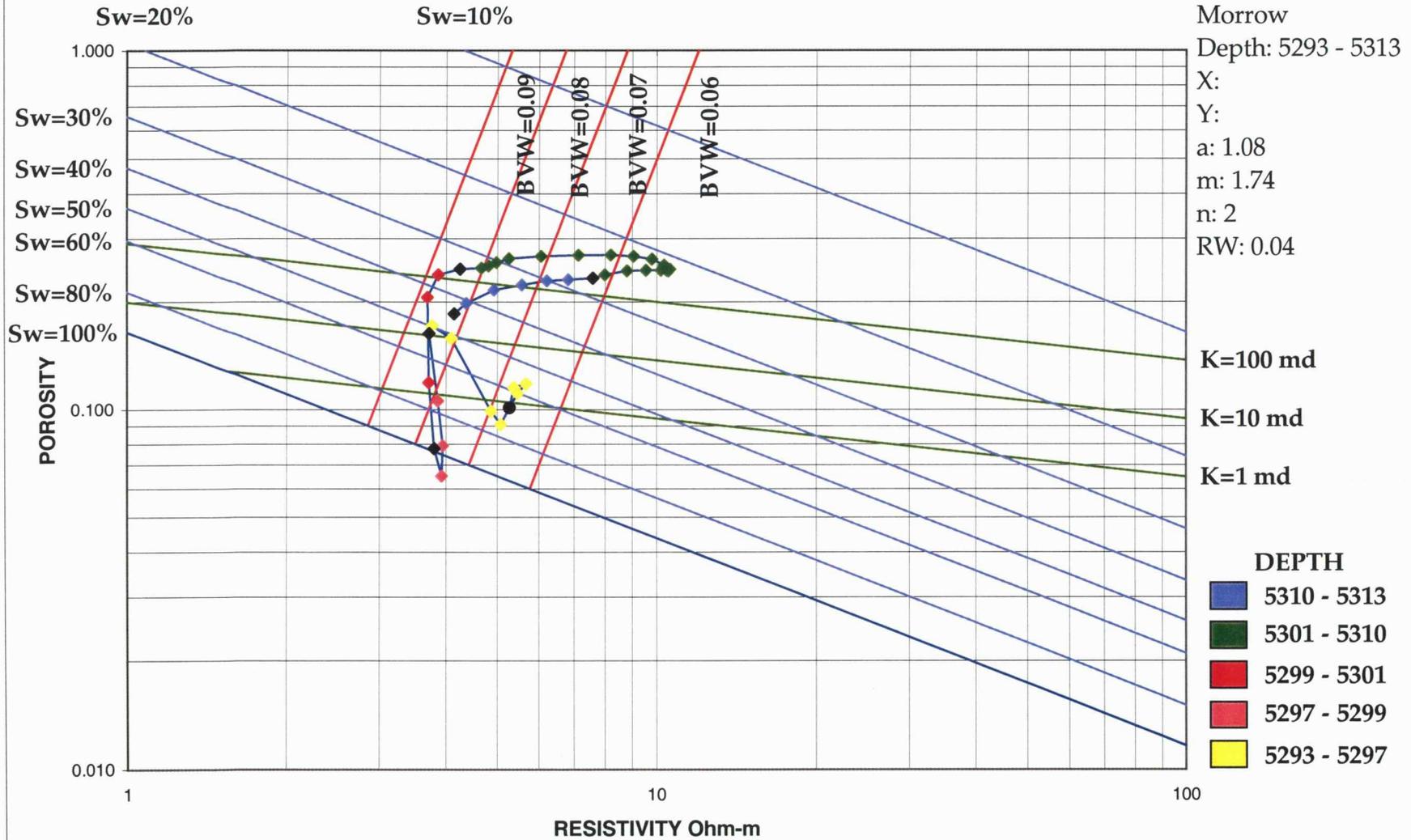
Sand 1: 5293-97. Sand 2: 5301-10. Sand 3: 5310-13.
Perf. 5299-5311. IP: 62 bopd, 83 mcfd, no wtr.

ROONEY #1-11 (Vern Jones, 20965)

Sw=20%   Sw=10%

Morrow
Depth: 5293 - 5313
X:
Y:
a: 1.08
m: 1.74
n: 2
RW: 0.04

Sw=30%

Sw=40%

Sw=50%
Sw=60%

Sw=80%

Sw=100%

BVW=0.09
BVW=0.08
BVW=0.07
BVW=0.06

POROSITY

K=100 md

K=10 md

K=1 md

1.000

0.100

0.010

1   10   100

RESISTIVITY Ohm-m

GR .GAPI

🟥	75 - 120
🟩	40 - 75
🟦	30 - 40
🟨	0 - 30
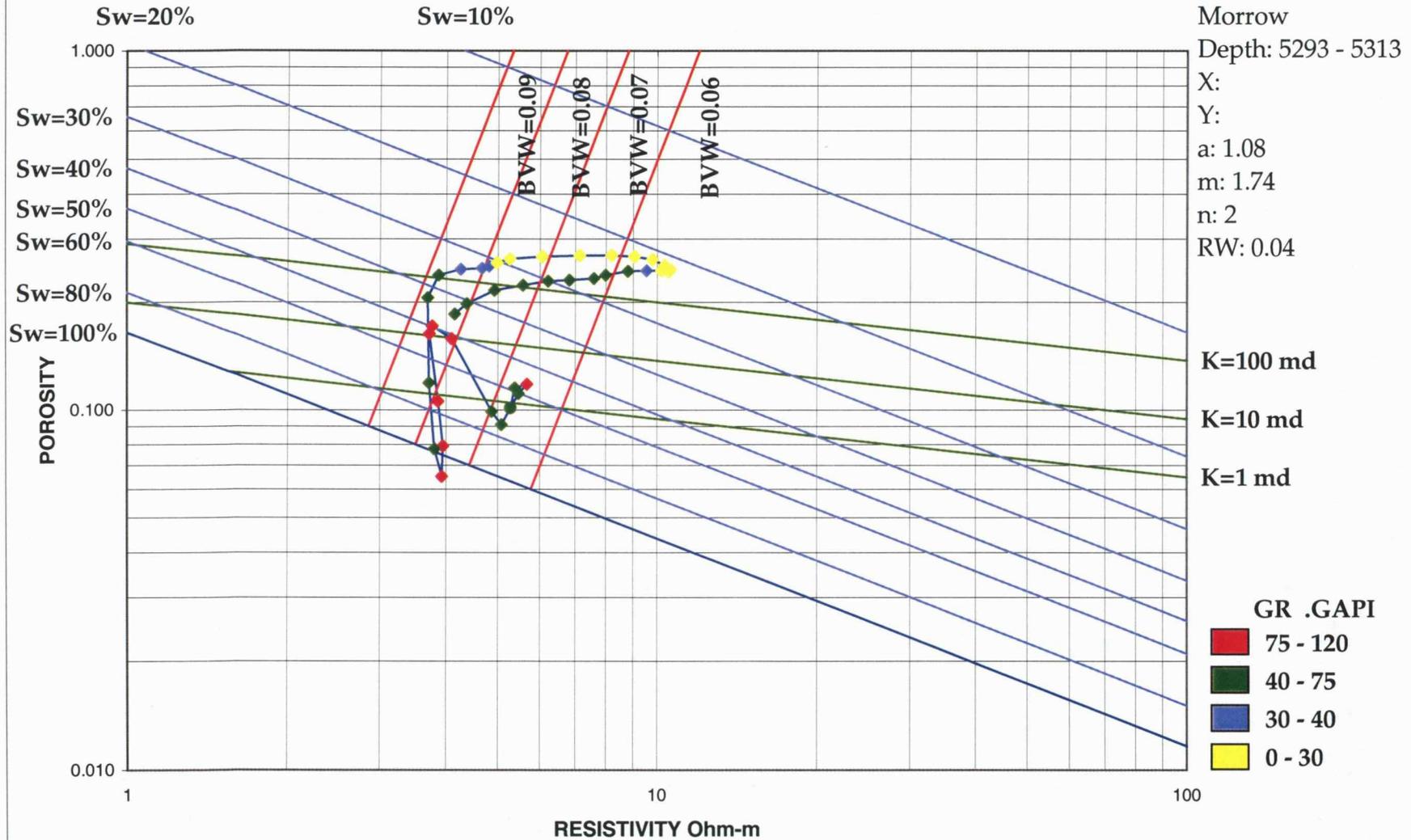
Sand 1: 5293-97. Sand 2: 5301-10. Sand 3: 5310-13.
Perf. 5299-5311. IP: 62 bopd, 83 mcfd, no wtr.

STATTON #2-12 (Murfin, 20991)
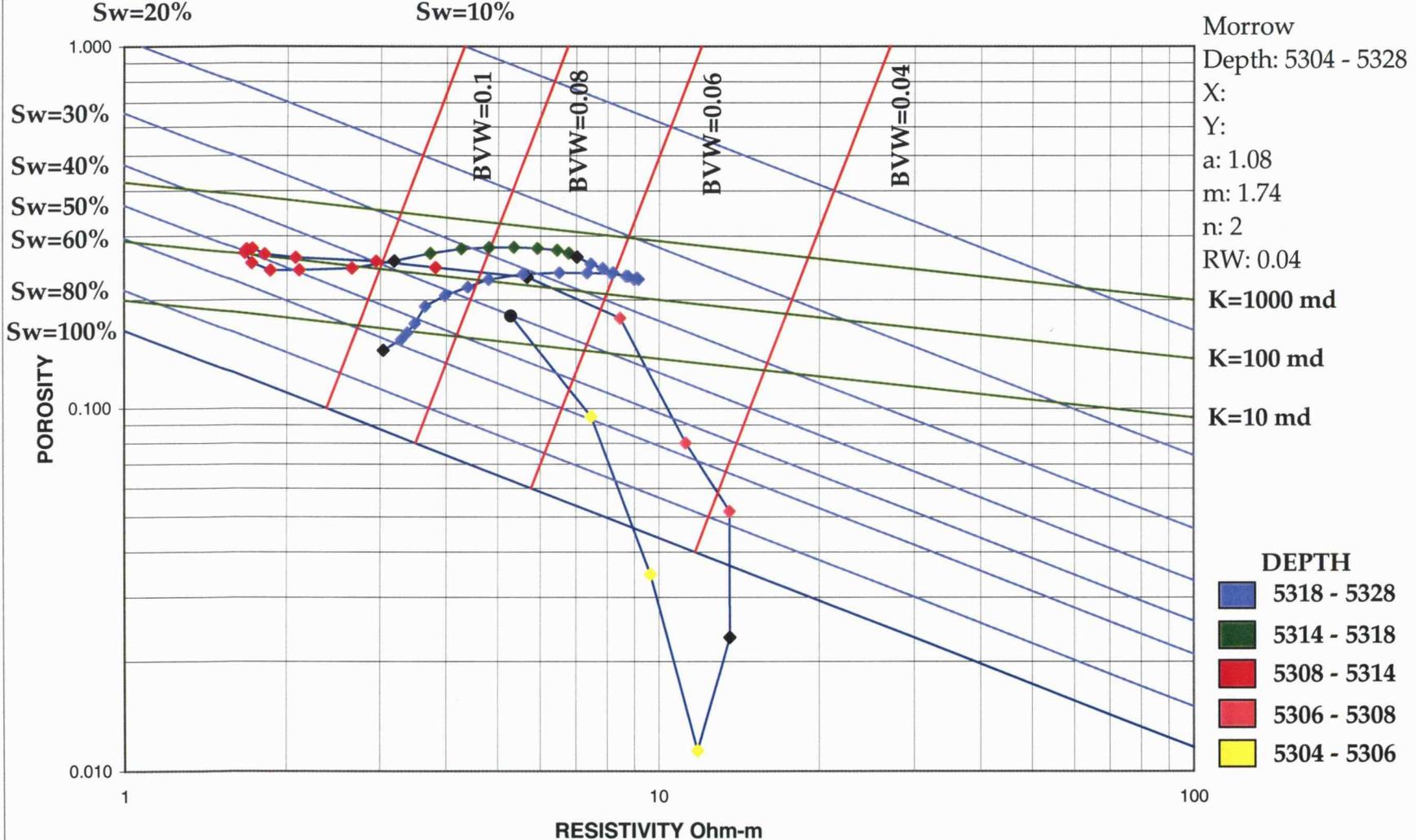
Sand 1: 5306-14. Sand 2: 5314-20. Sand 3: 5320-27. DST 5304-28: 180' GCM
Perf. 5308-18: 100 bopd, 1000 mcfd

STATTON #2-12 (Murfin, 20991)

STATTON #1-12 (Murfin, 15-025-20881)

Sw=10%

Sw=30%
Sw=40%
Sw=50%
Sw=60%
Sw=80%
Sw=100%

POROSITY

BVW=0.09
BVW=0.08
BVW=0.06
BVW=0.05
BVW=0.04

Morrow
Depth: 5270 - 5304
X:
Y:
a: 1.08
m: 1.74

K=100 md

K=10 md

K=1 md

GR .GAPI
75 - 150
40 - 75
30 - 40
0 - 30

RESISTIVITY Ohm-m

1.000
0.100
0.010

1   10   100
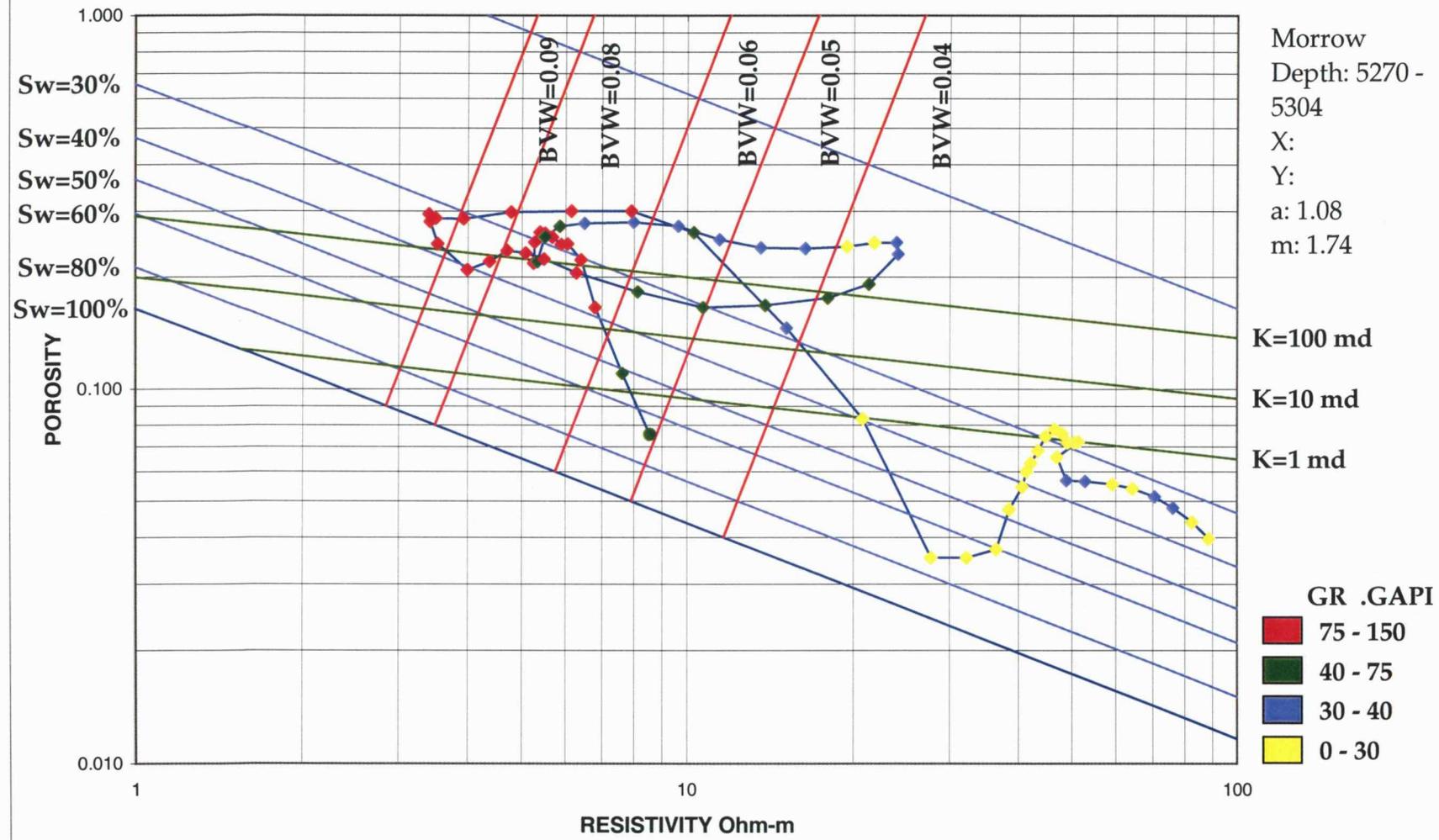
Sand 1: 5274-84. DST 5270-5304: Rec 90' SOCM. Perf.: 5276-82: IP n/a. Gas well.

STATTON #1-12 (Murfin, 15-025-20881)
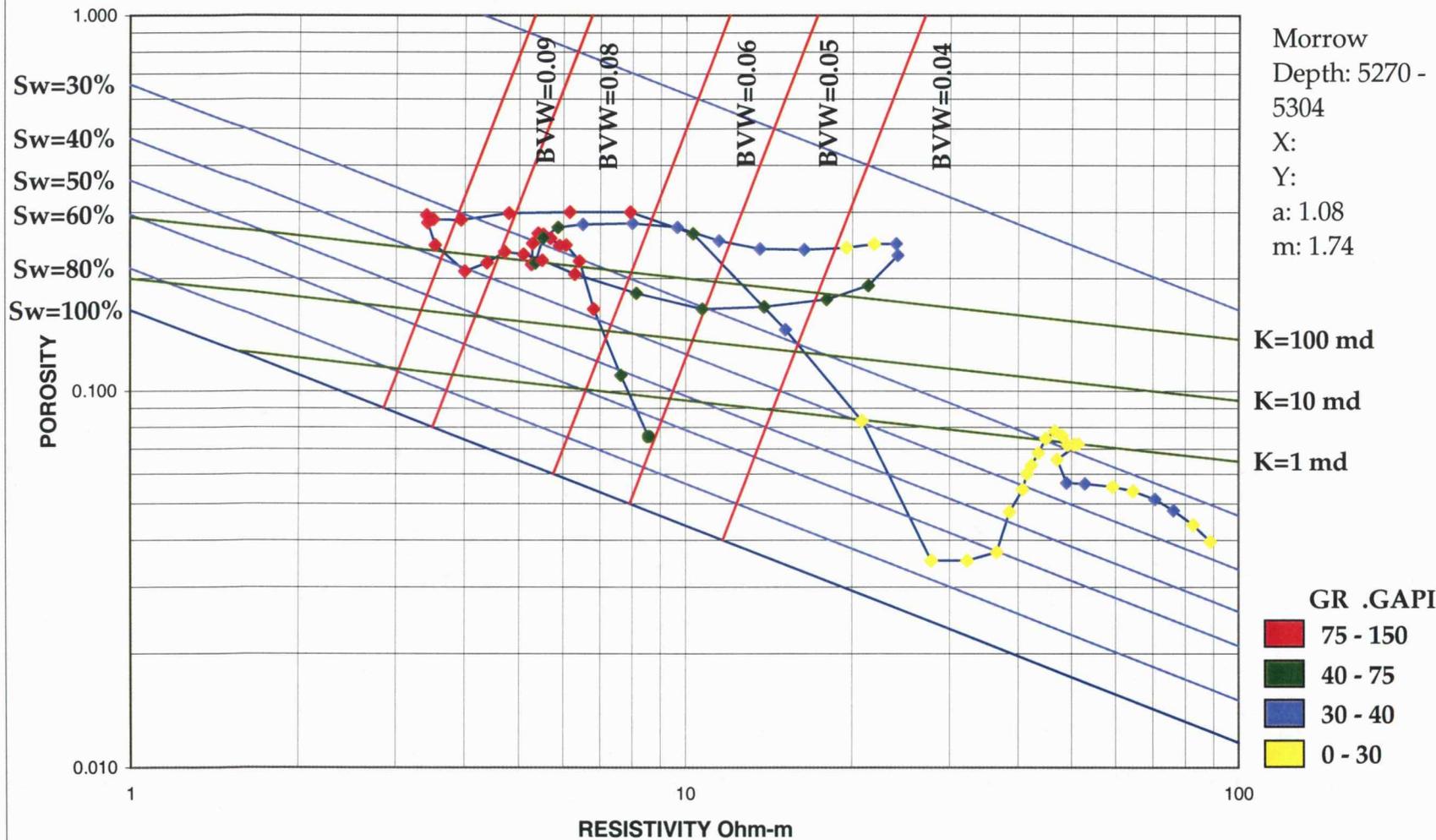
Sand 1: 5274-84. DST 5270-5304: Rec 90' SOCM. Perf.: 5276-82: IP n/a. Gas well.

Appendix B

Production Sales Data

<u>Input Parameters for Reservoir Simulation Study – Minneola Field, Clark County, Kansas</u>

Fager 2-3 (Ladd)
Production sales
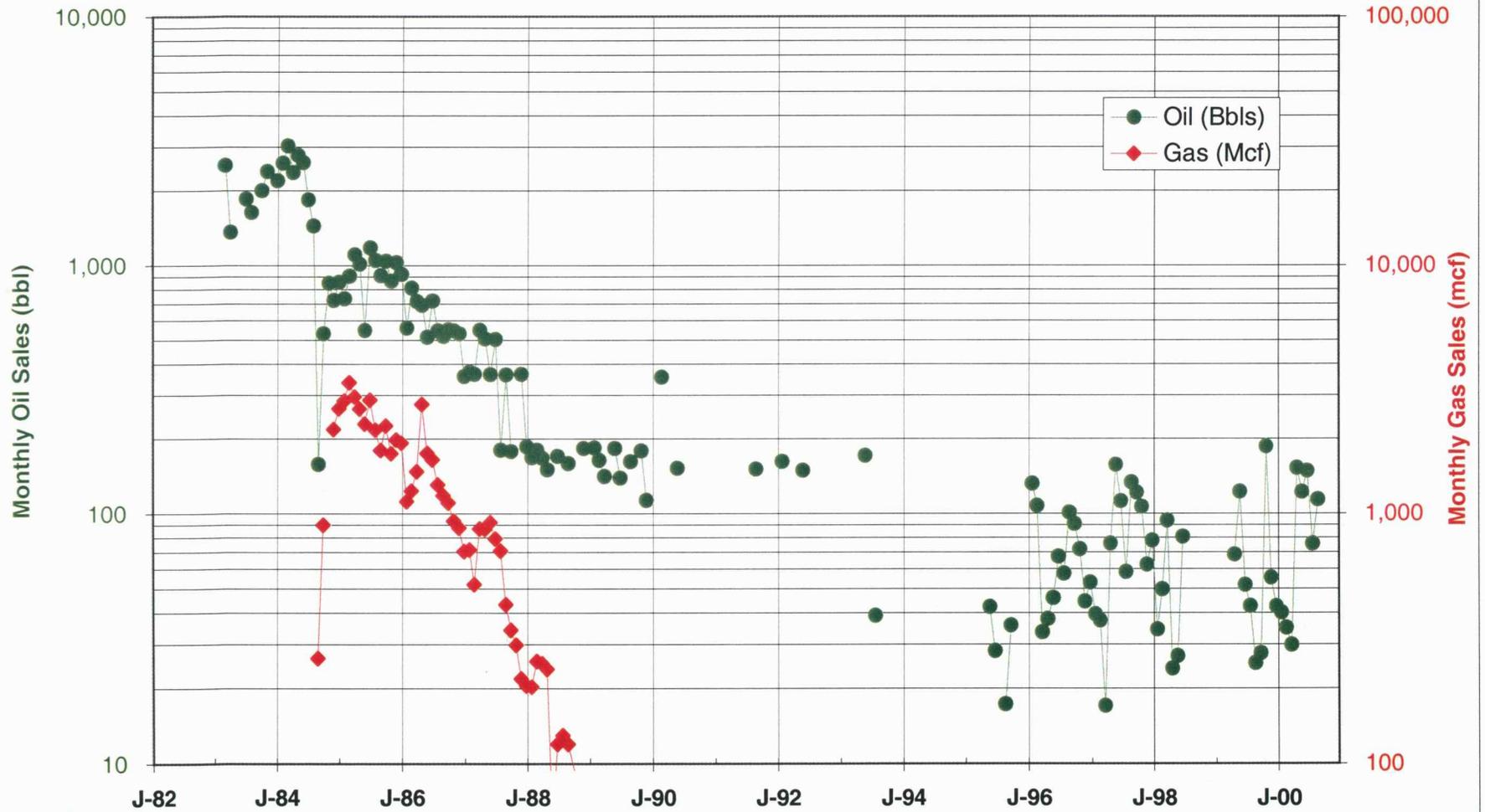
Geoller 1-4 (Ladd)
Production sales
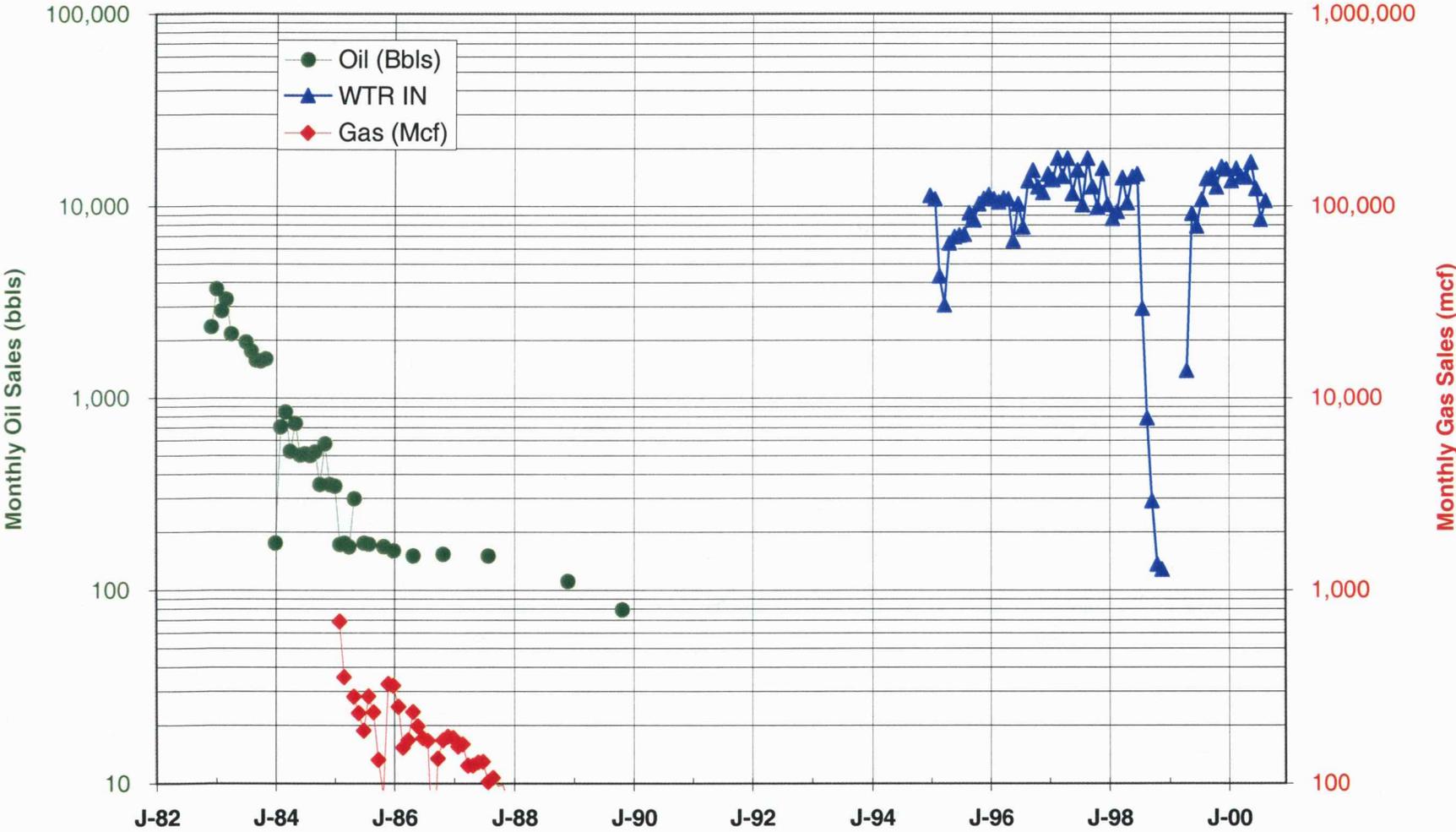
Goeller 1-4 (Murfin)
Production sales

Legend:
- Oil (Bbls)
- Wtr (Bbls)
- Gas (Mcf)

Y-axis (left): Monthly Oil/Wtr Sales (bbls) — 10, 100, 1,000, 10,000, 100,000

Y-axis (right): Monthly Gas Sales (Mcf) — 100, 1,000, 10,000, 100,000, 1,000,000

X-axis: J-82, J-84, J-86, J-88, J-90, J-92, J-94, J-96, J-98, J-00
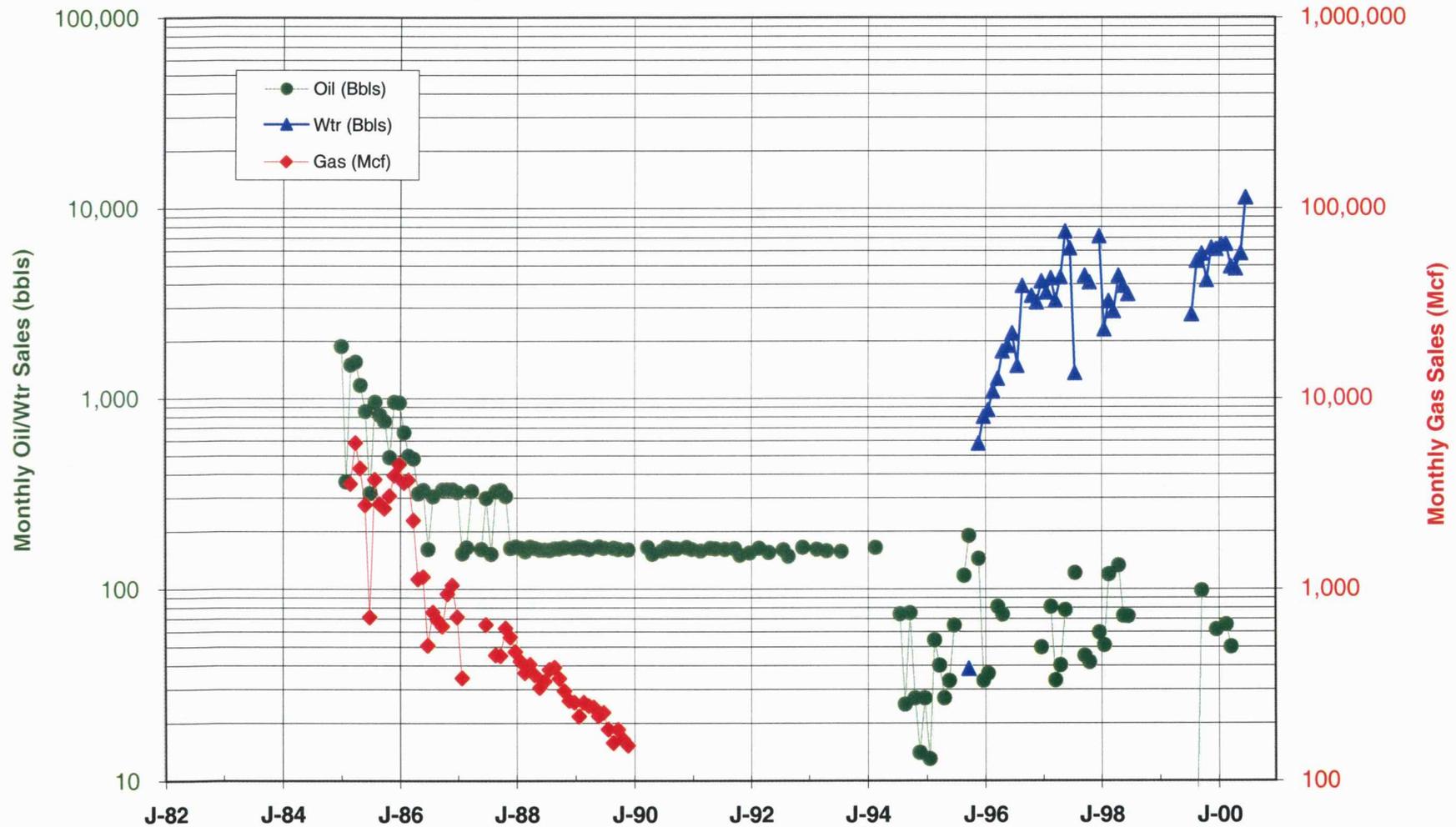
Hall 1-2 (Murfin)
Production sales
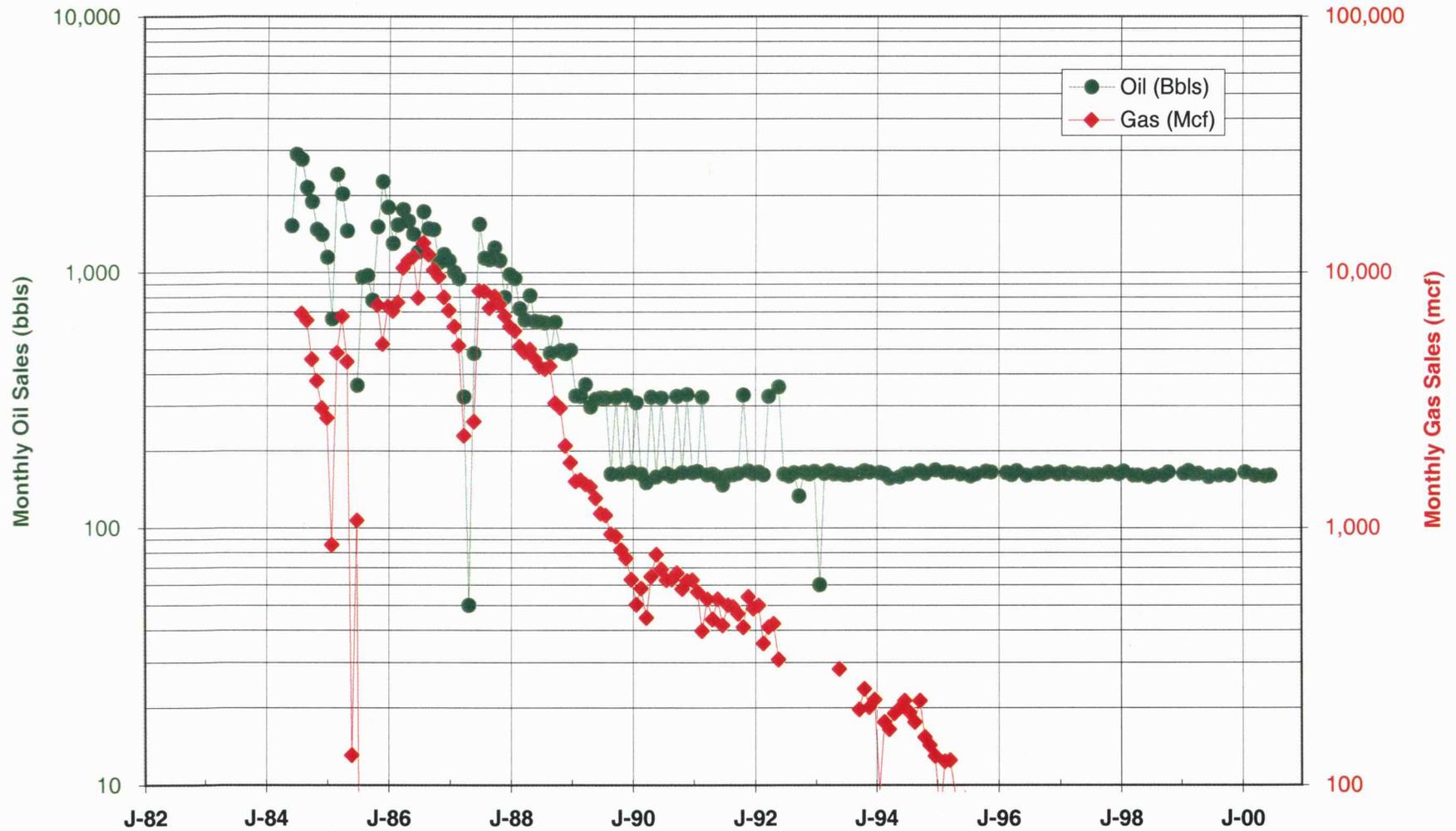
Harris 1-3 (Ladd)
Production sales
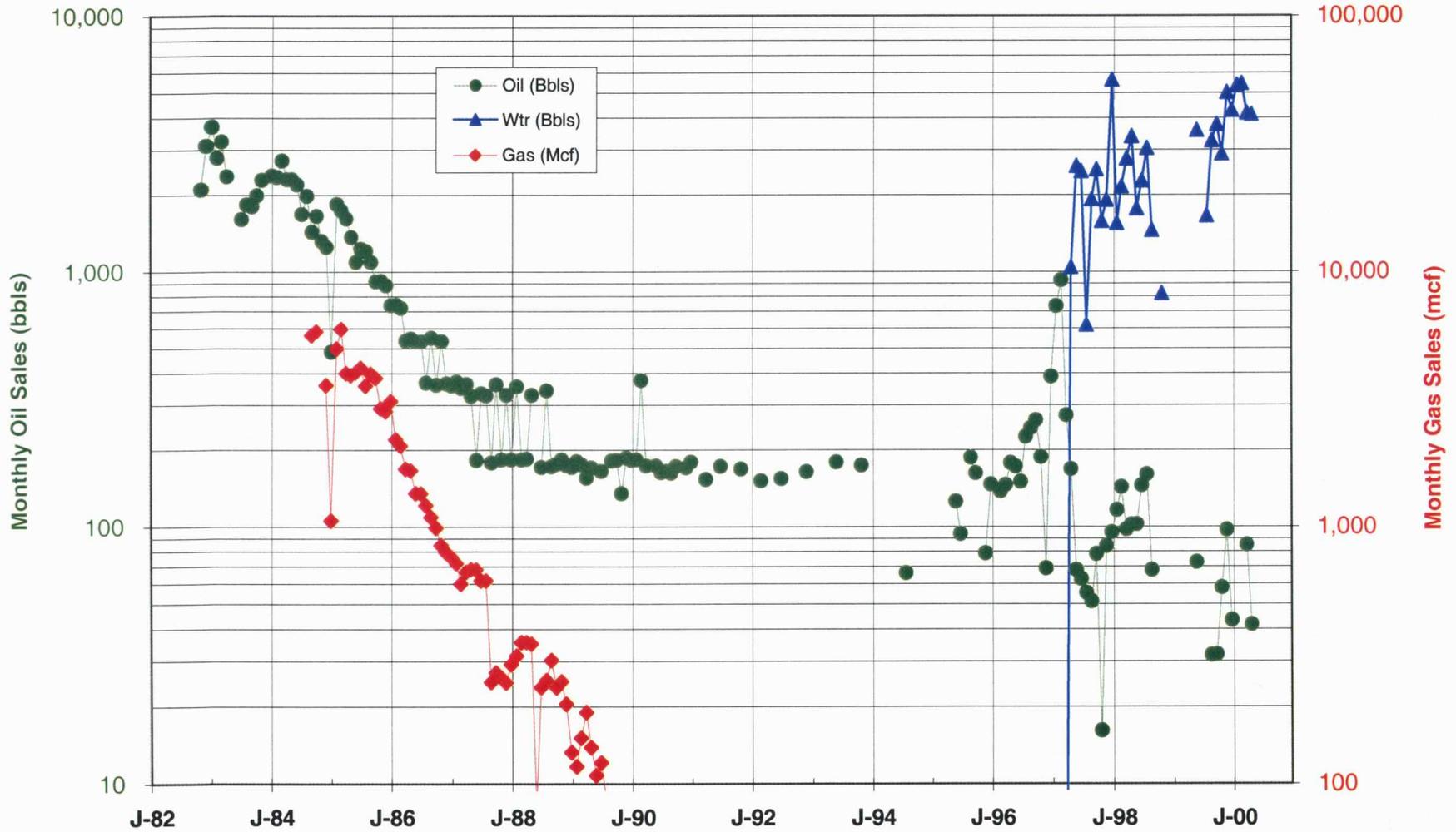
Harris 2-3 (Ladd)
Production sales
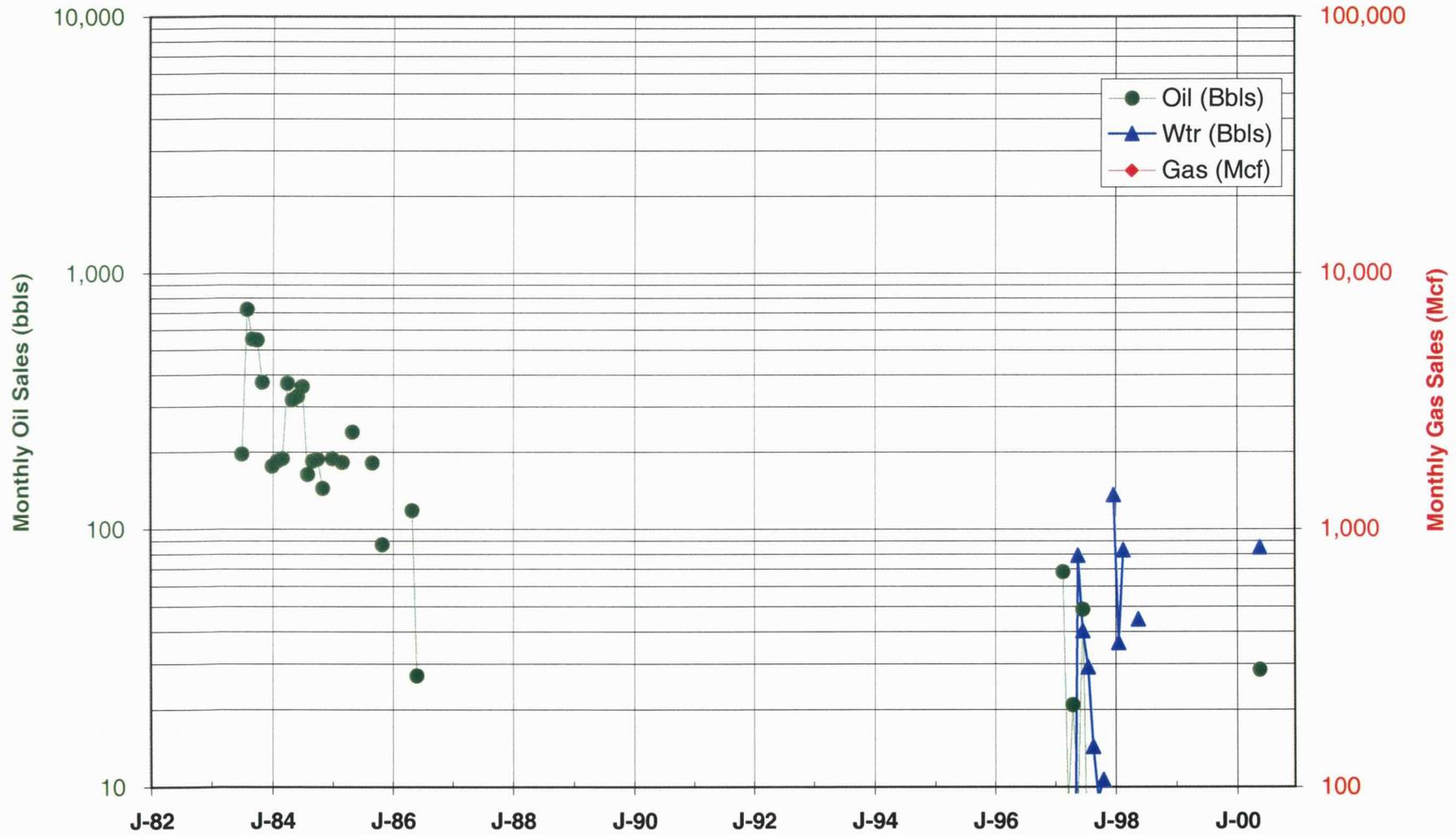
Hindman 1-3 (Ladd)
Production sales
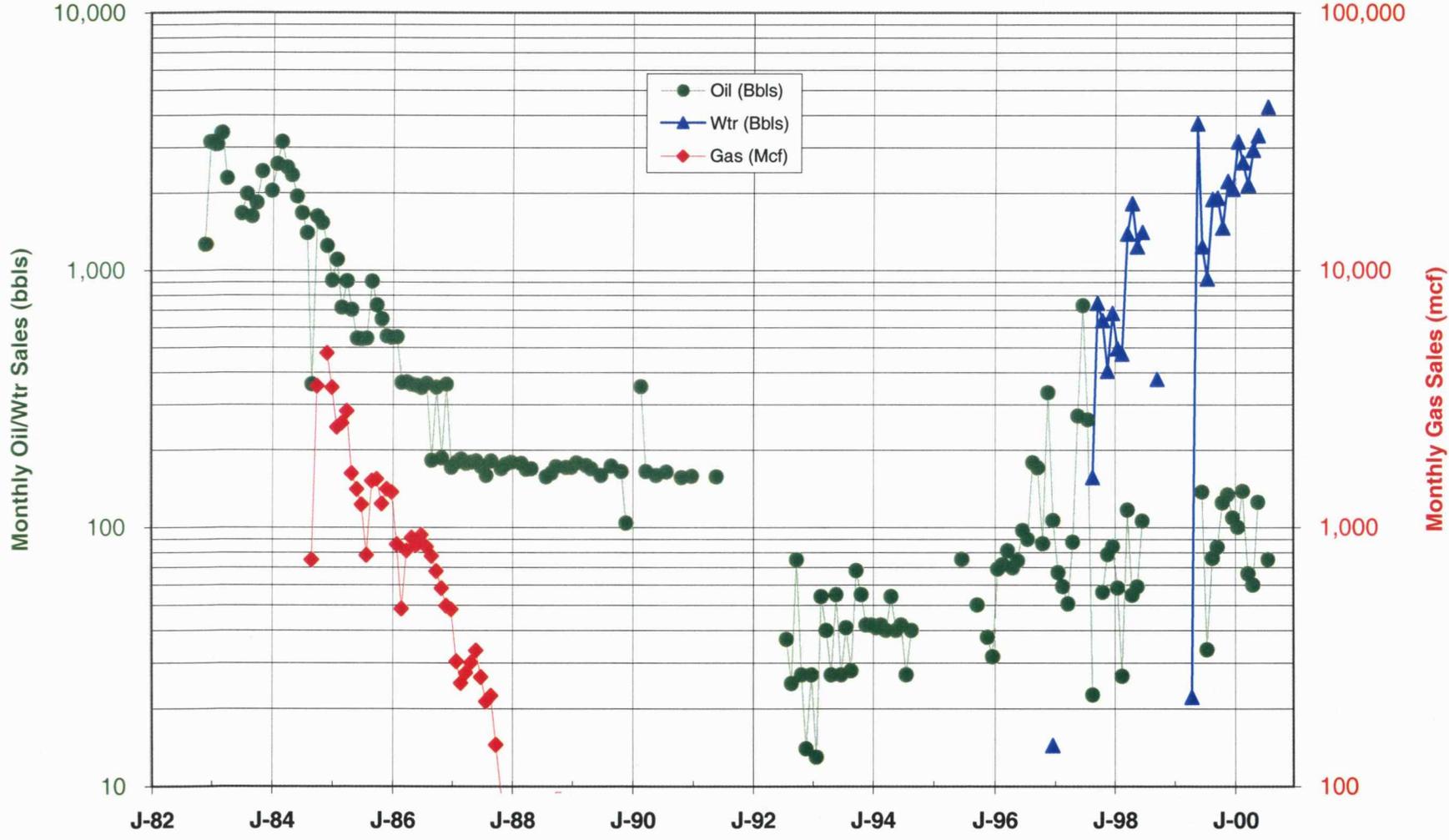
Latzke 1 (Ladd)
Production sales
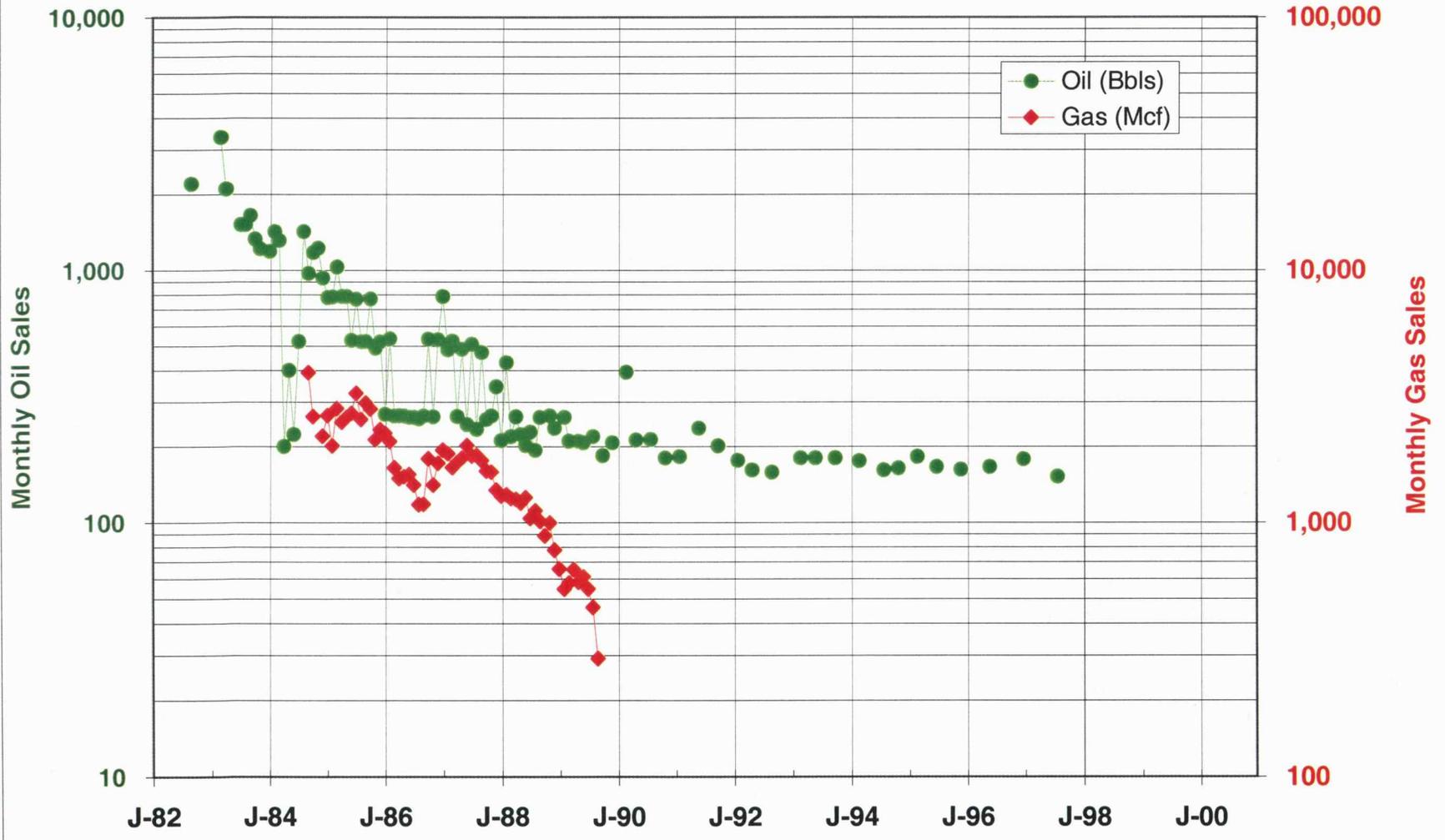
McGee 1-1 (Murfin)
Production sales
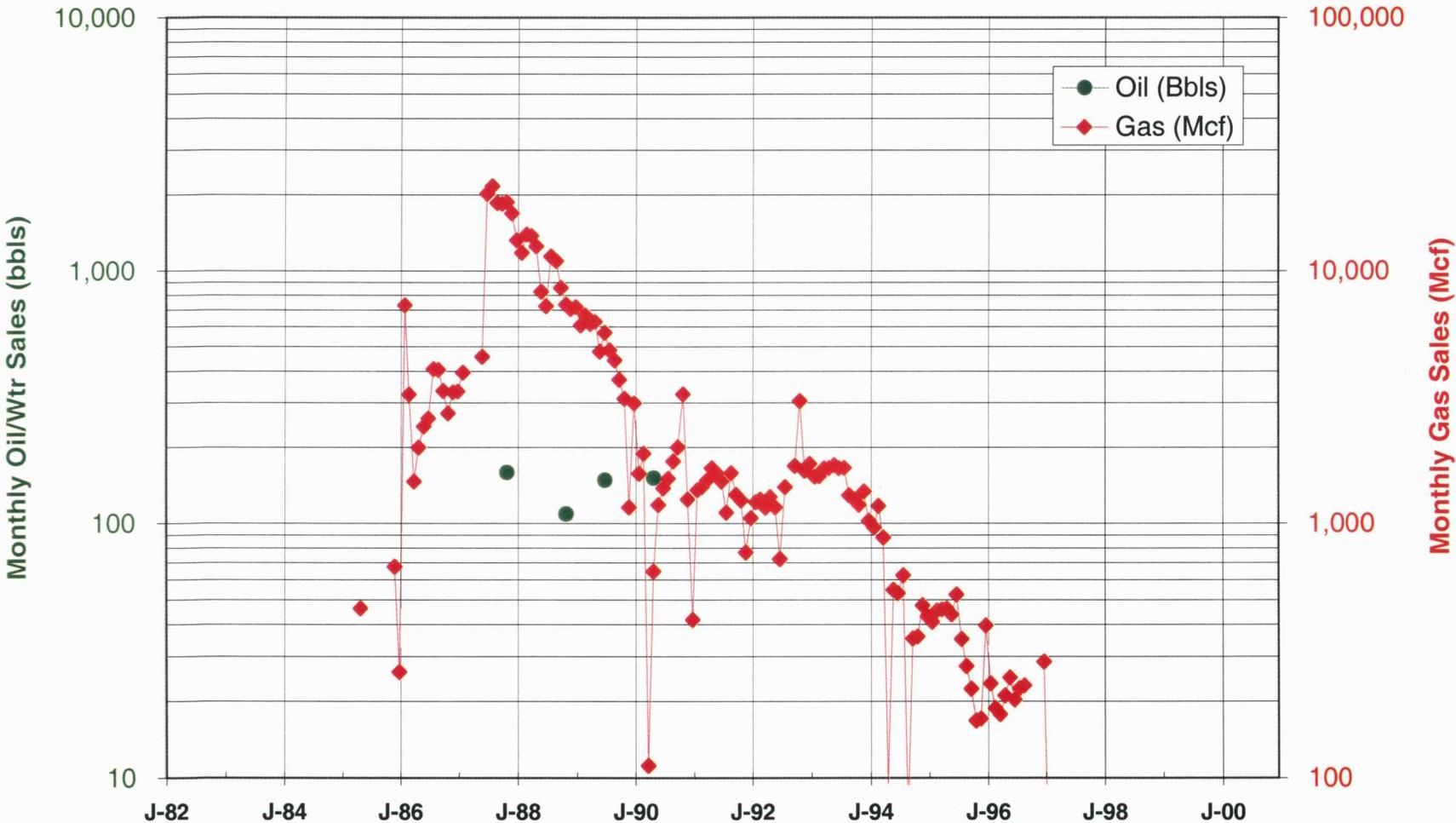
Norton 1-4 (Murfin)
Production sales
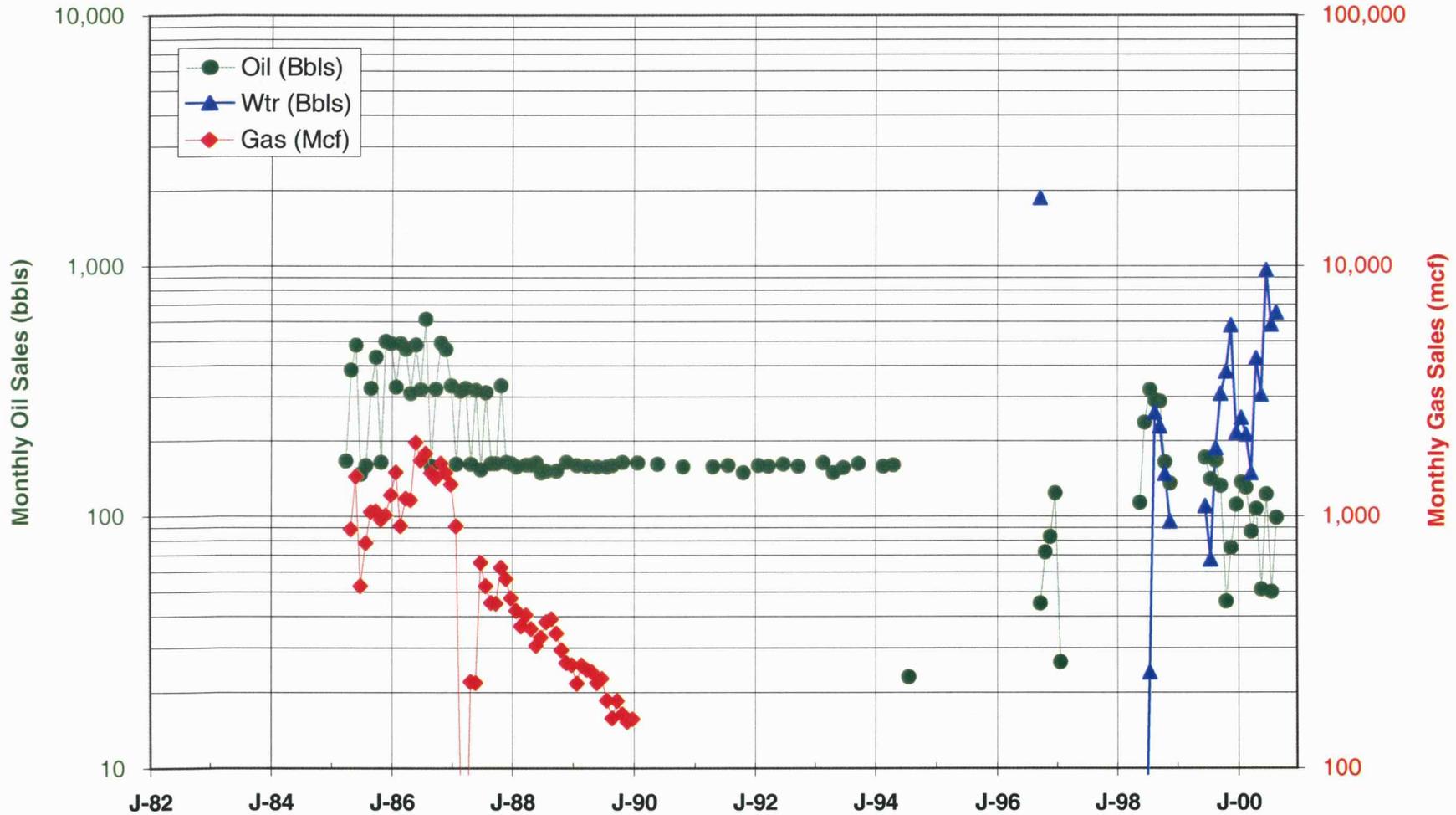
Patton 1-3 & 2-3 (Murfin)
Production sales
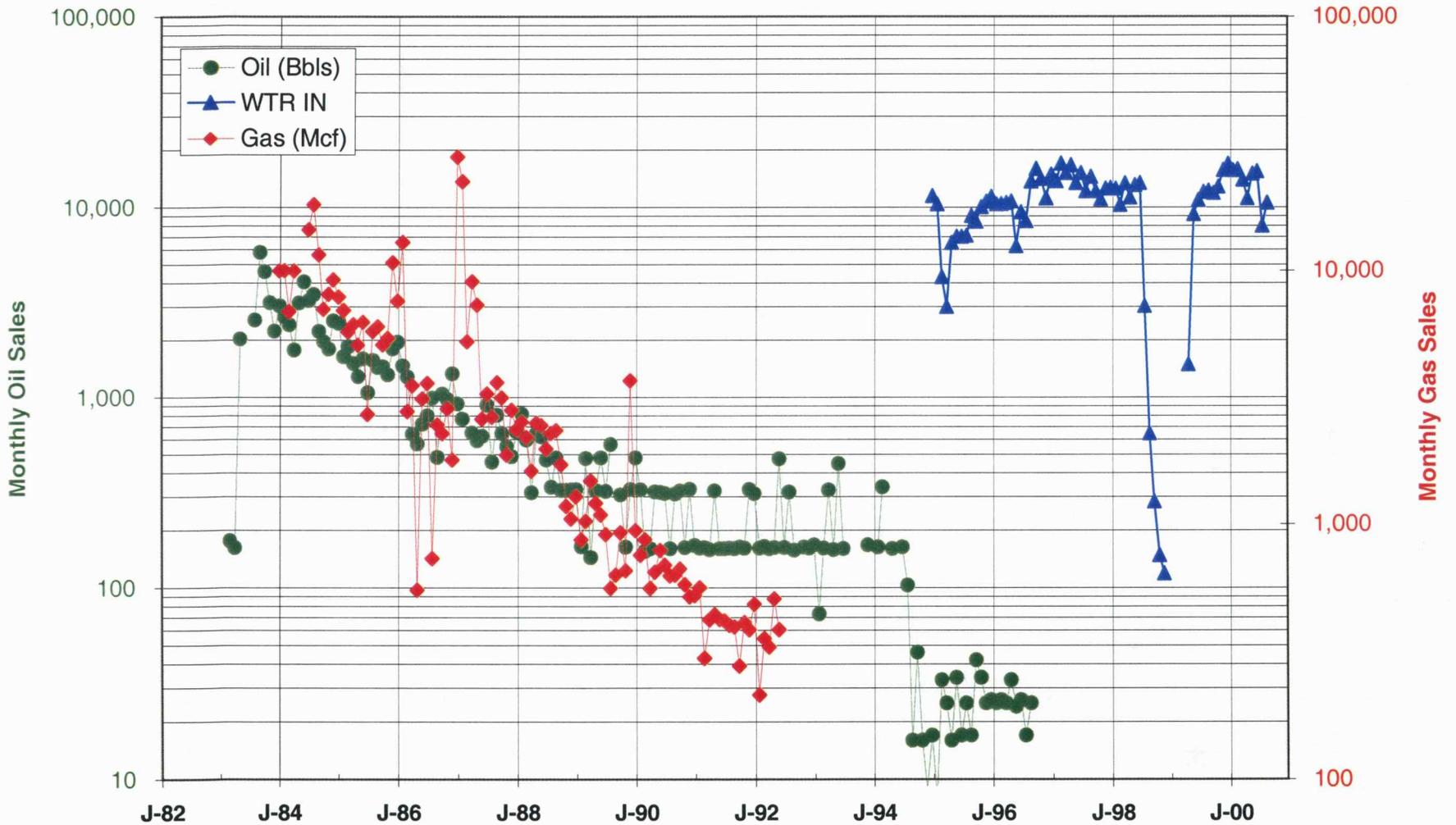
Patton 1 (Ladd)
Production sales
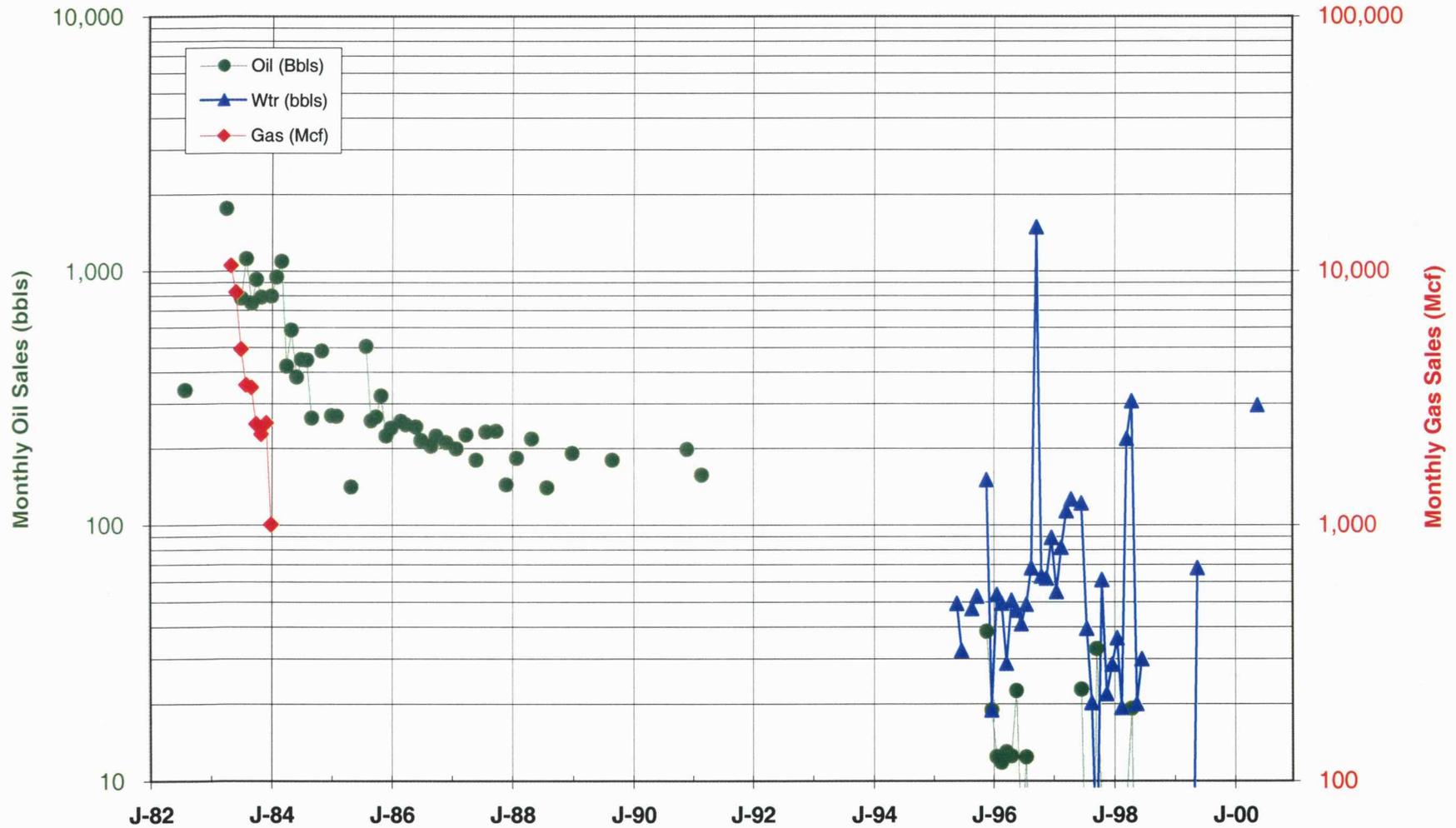
Rooney 1 (Vern Jones)
Production sales
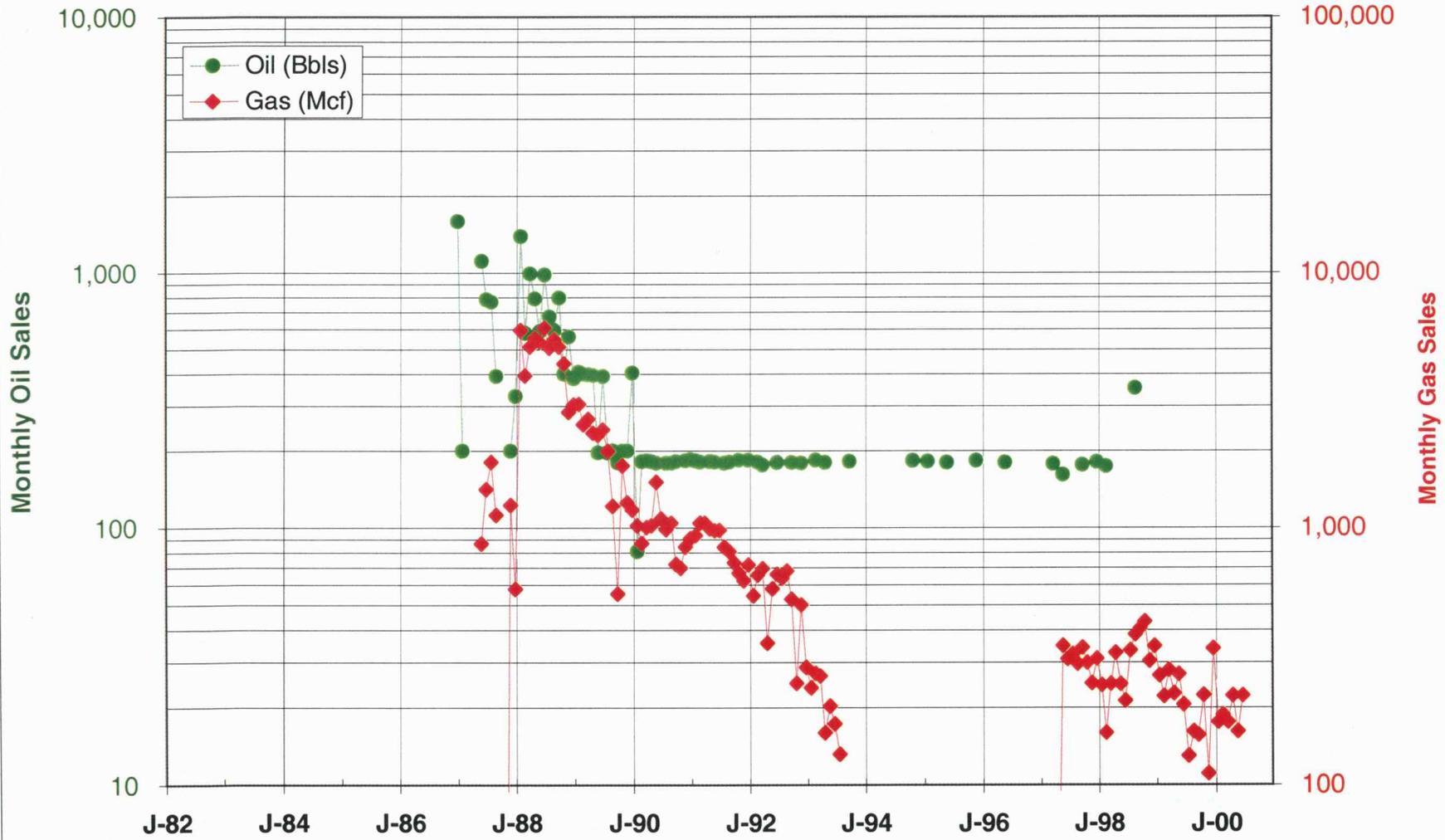
Schlicting 1-2 (Ladd)
Production sales
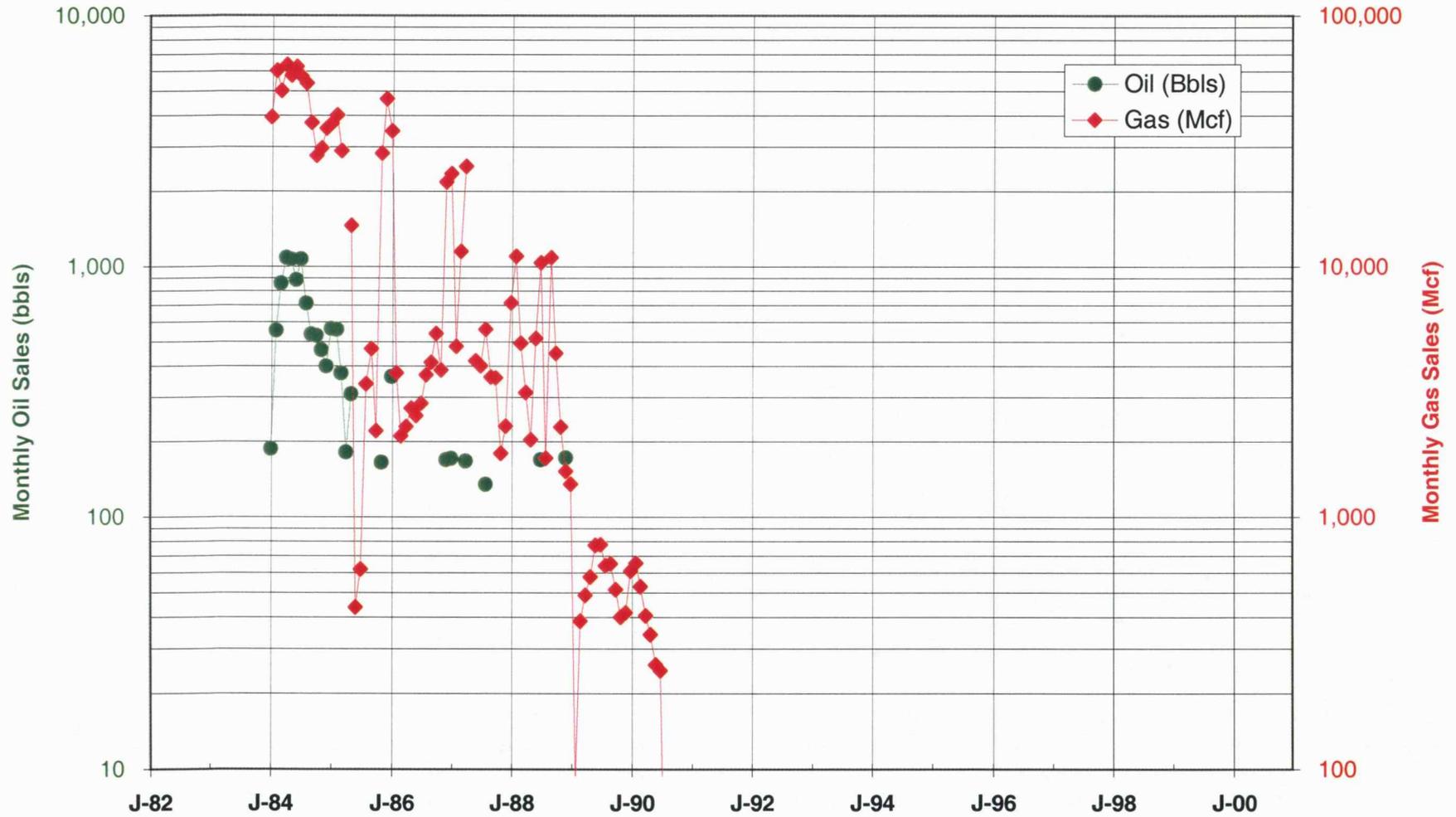
Statton 1-12 & 2-12 (Murfin)
Production sales
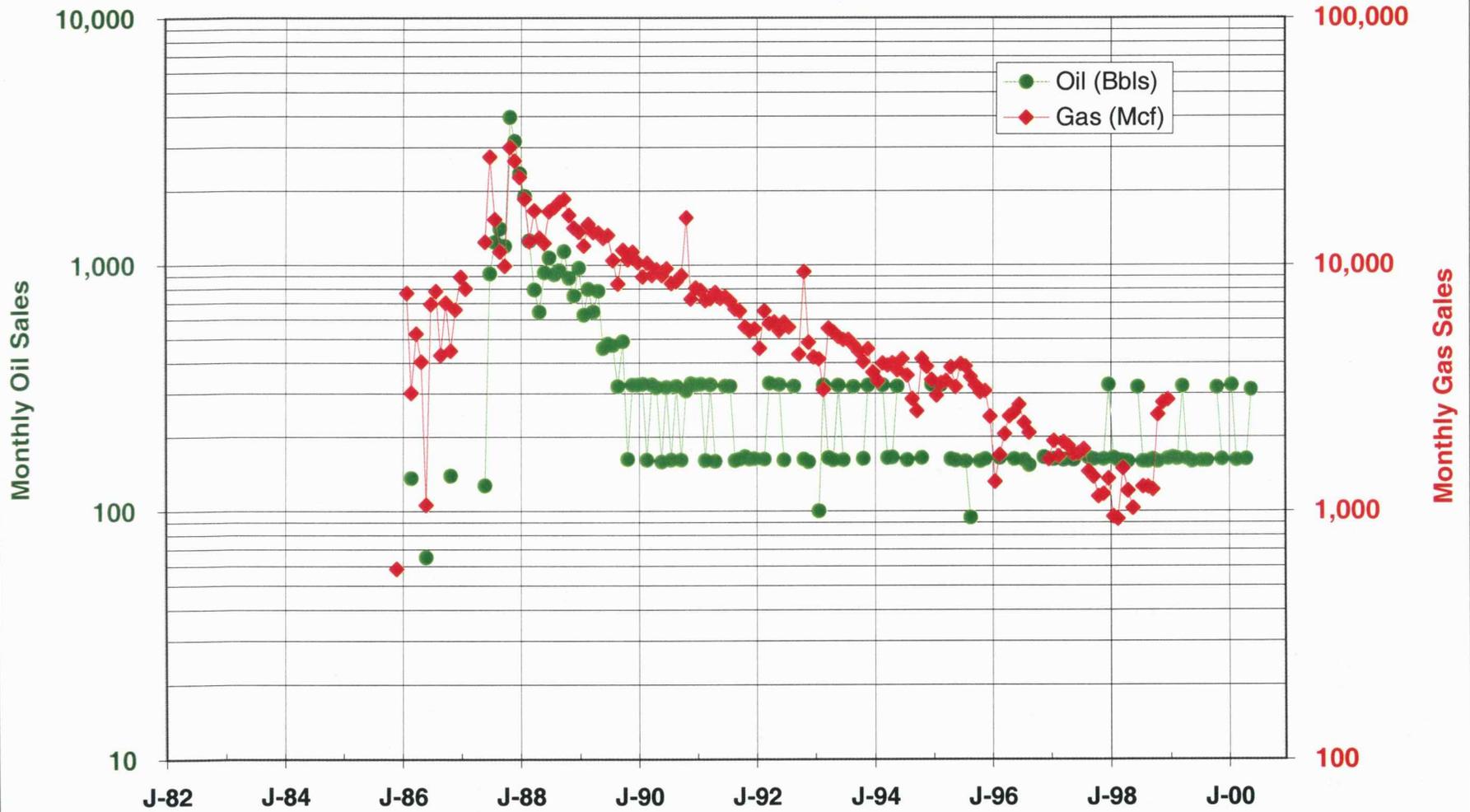
Tedford 1 (Ladd)
Production sales
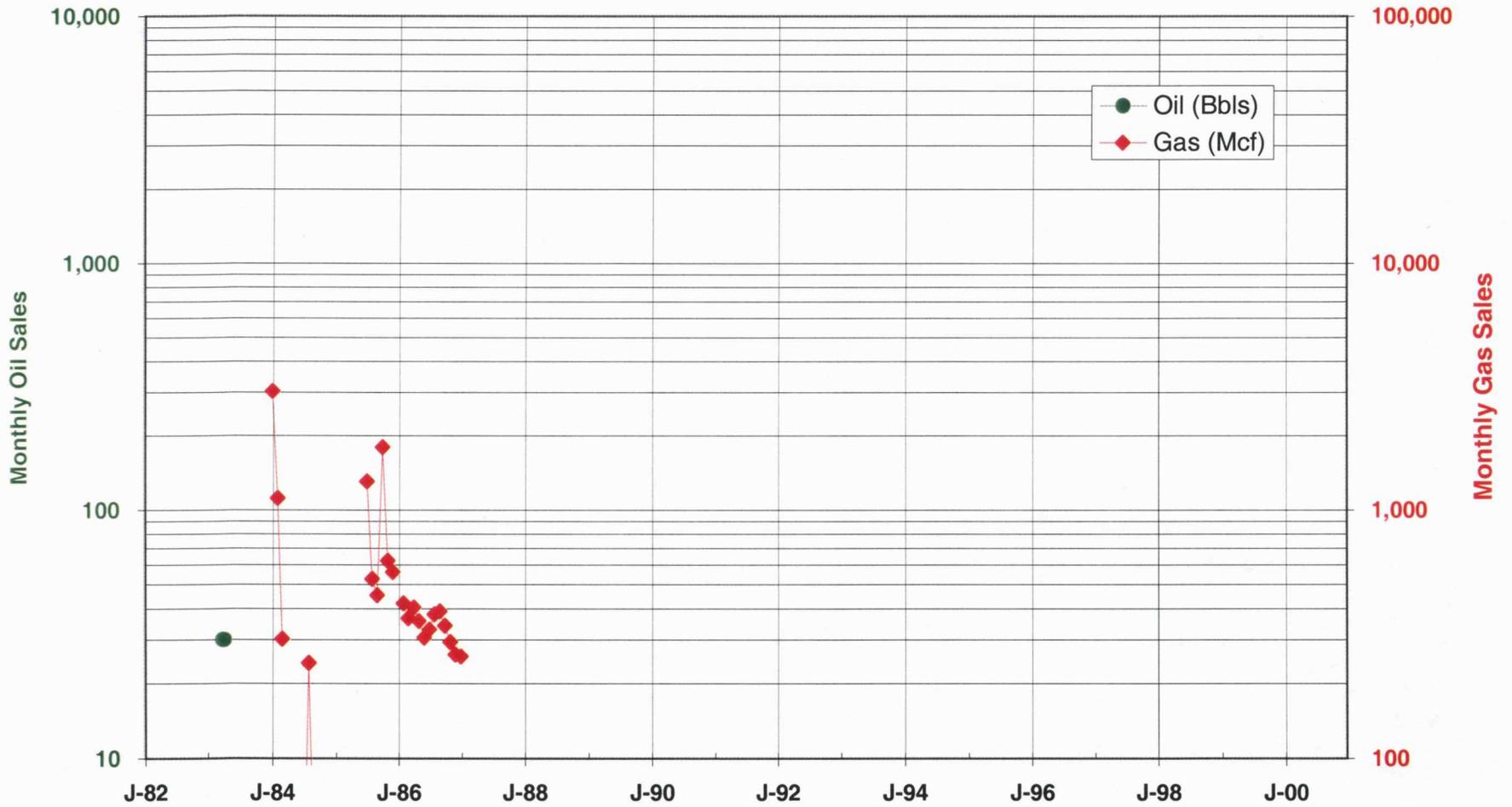
Tedford 2-10 (Ladd)
Production sales

Legend:
- Oil (Bbls)
- Wtr (Bbls)
- Gas (Mcf)

Left axis: Monthly Oil Sales (1 to 10,000)
Right axis: Monthly Gas Sales (10 to 100,000)
X-axis: J-82, J-84, J-86, J-88, J-90, J-92, J-94, J-96, J-98, J-00
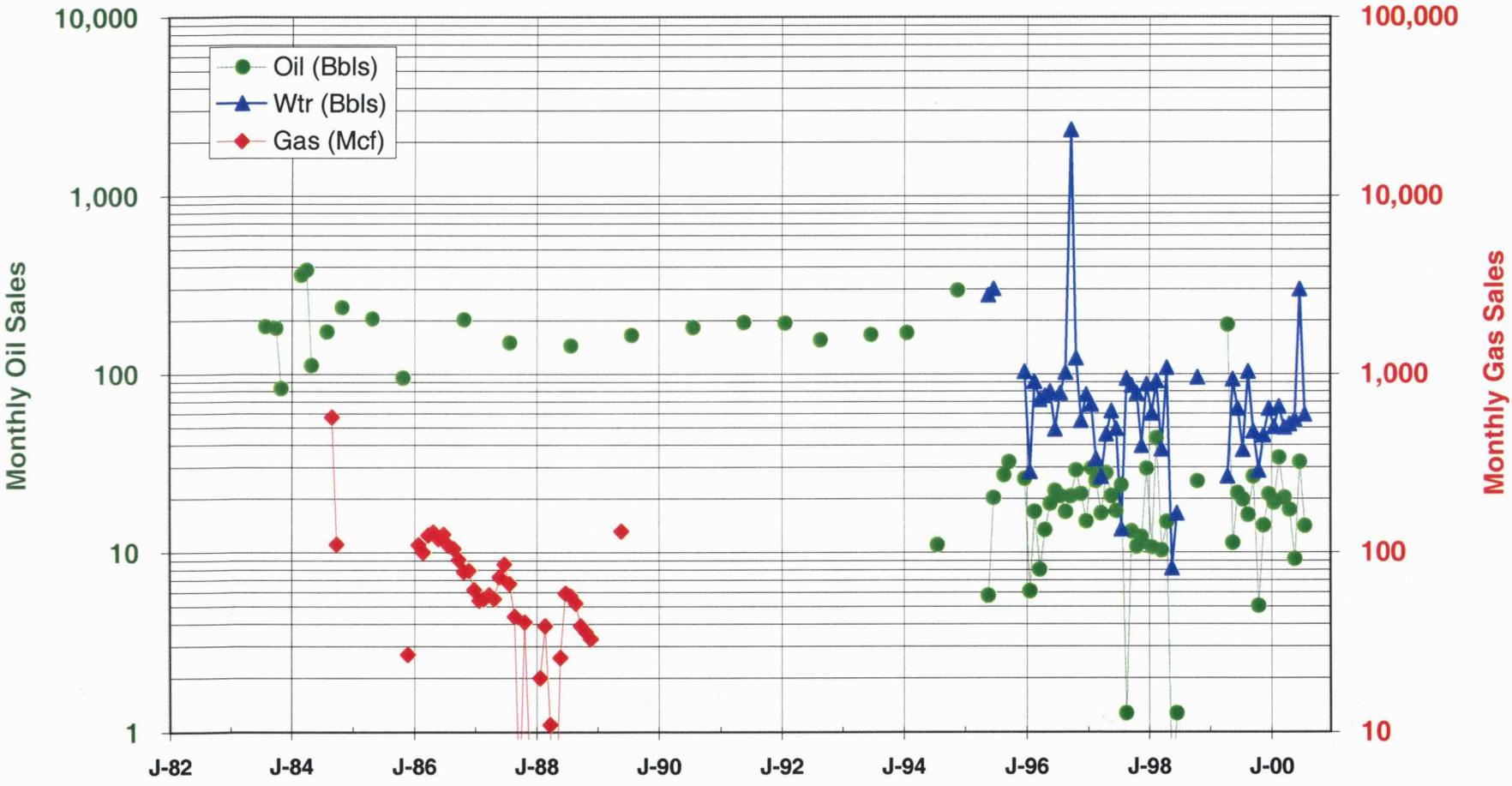
Tedford 4-10 & 1-10 (Murfin)
Production sales

Tedford B1-10 (Murfin)
Production sales
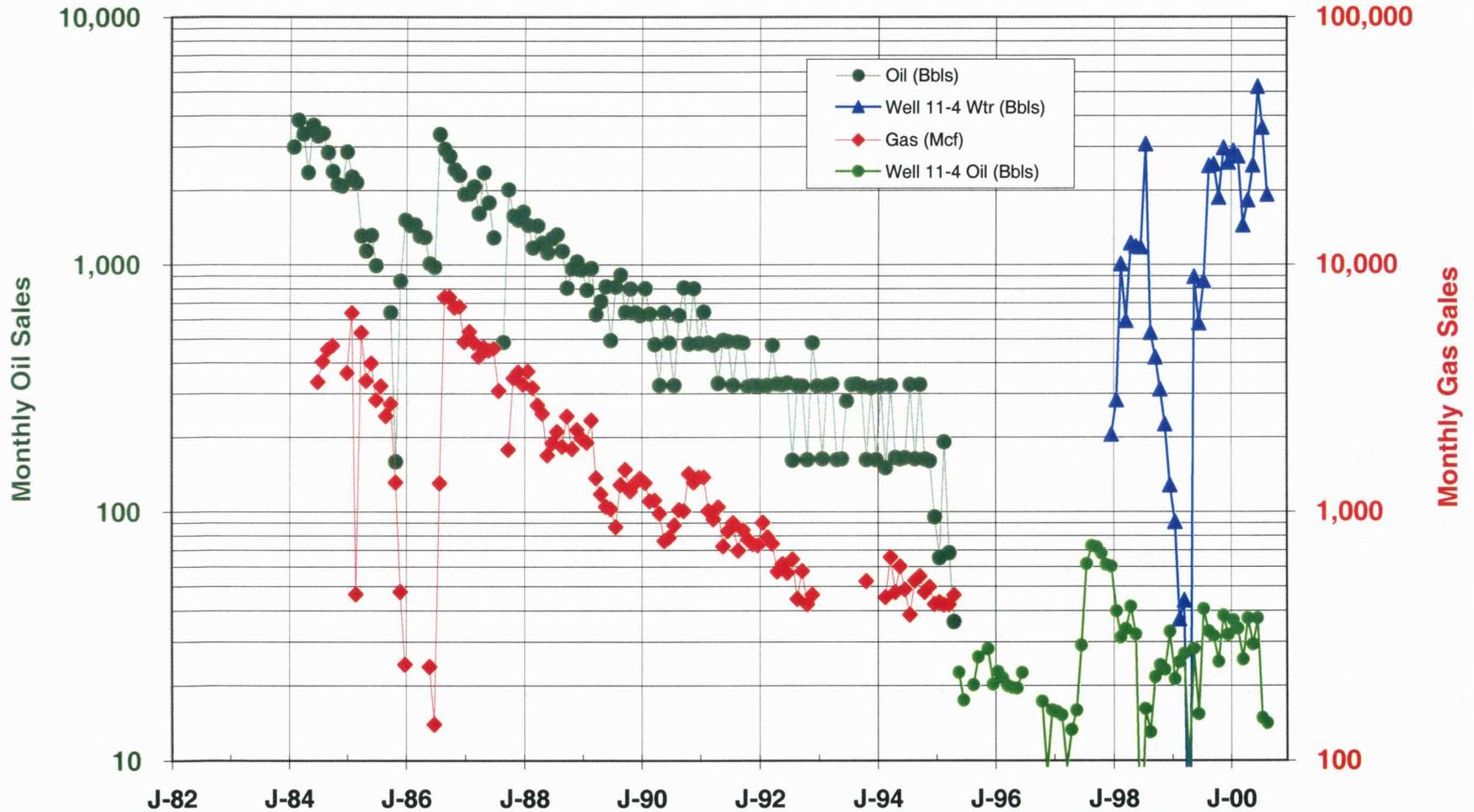
Appendix C

Production Data Averaged

Input Parameters for Reservoir Simulation Study – Minneola Field, Clark County, Kansas

Fager 2-3 (Ladd)
Averaged over 6 months
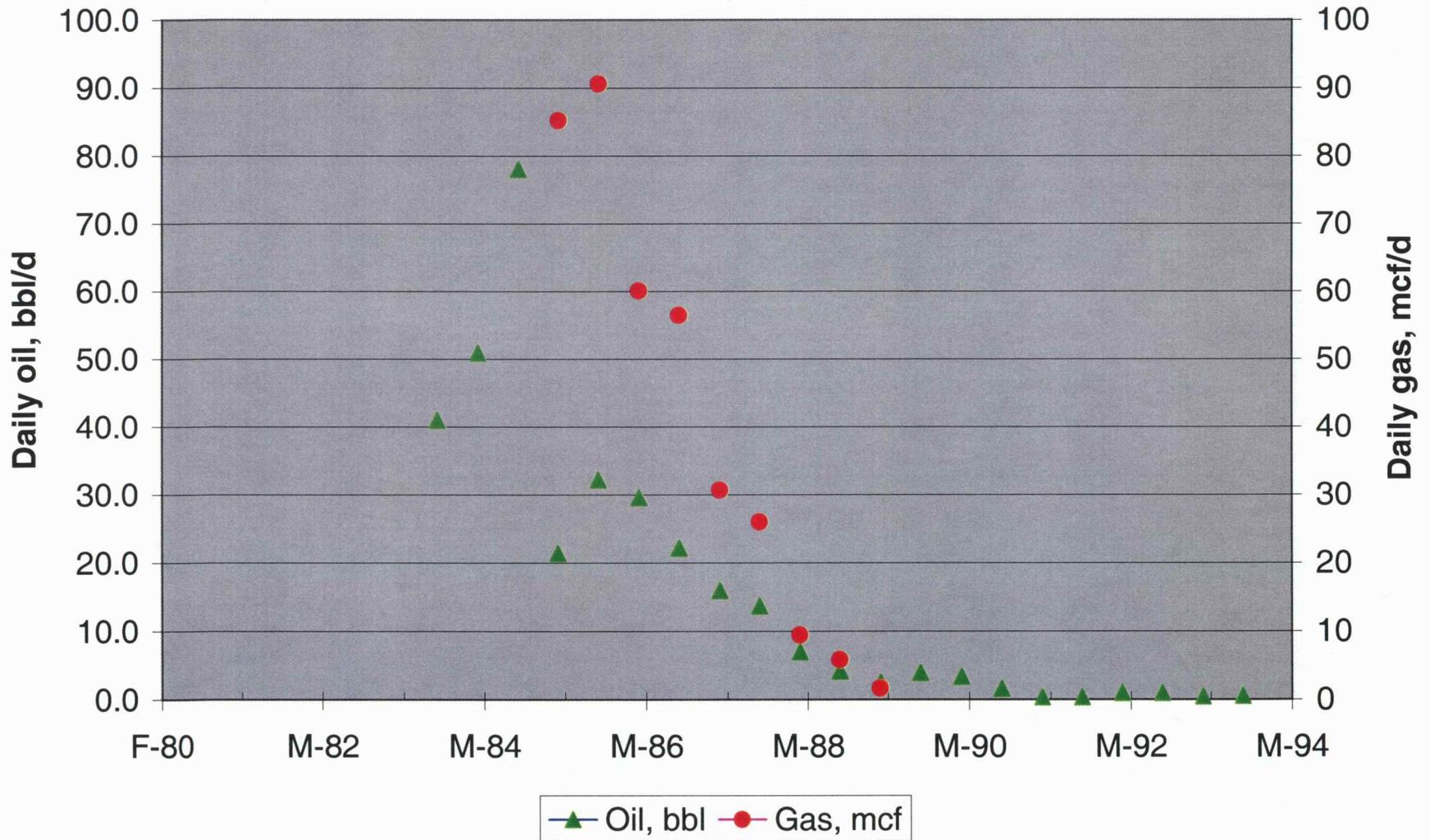
Goeller 1-4 (Ladd)
Averaged over 6 months
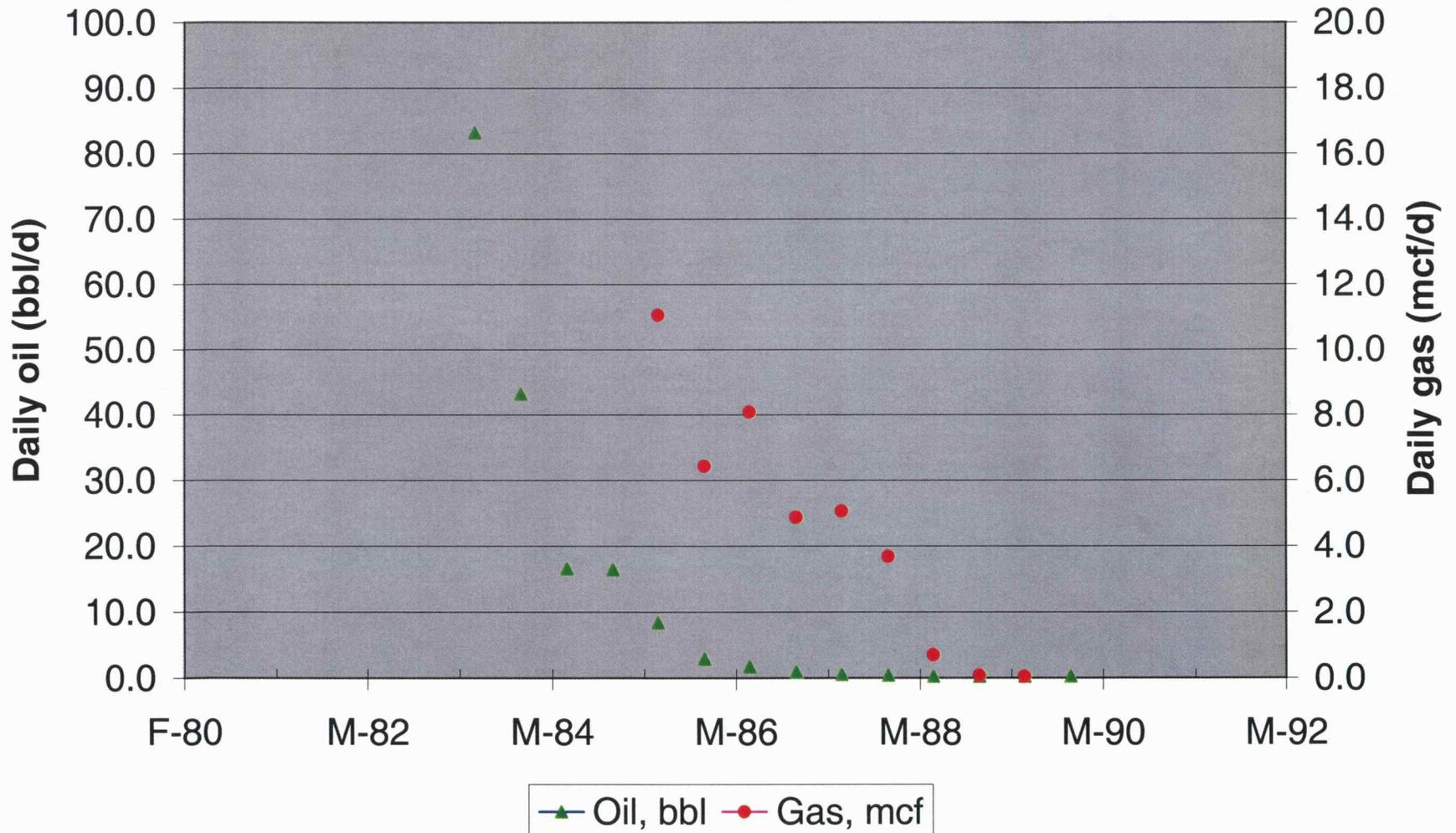
Goeller 1-4 (Murfin)
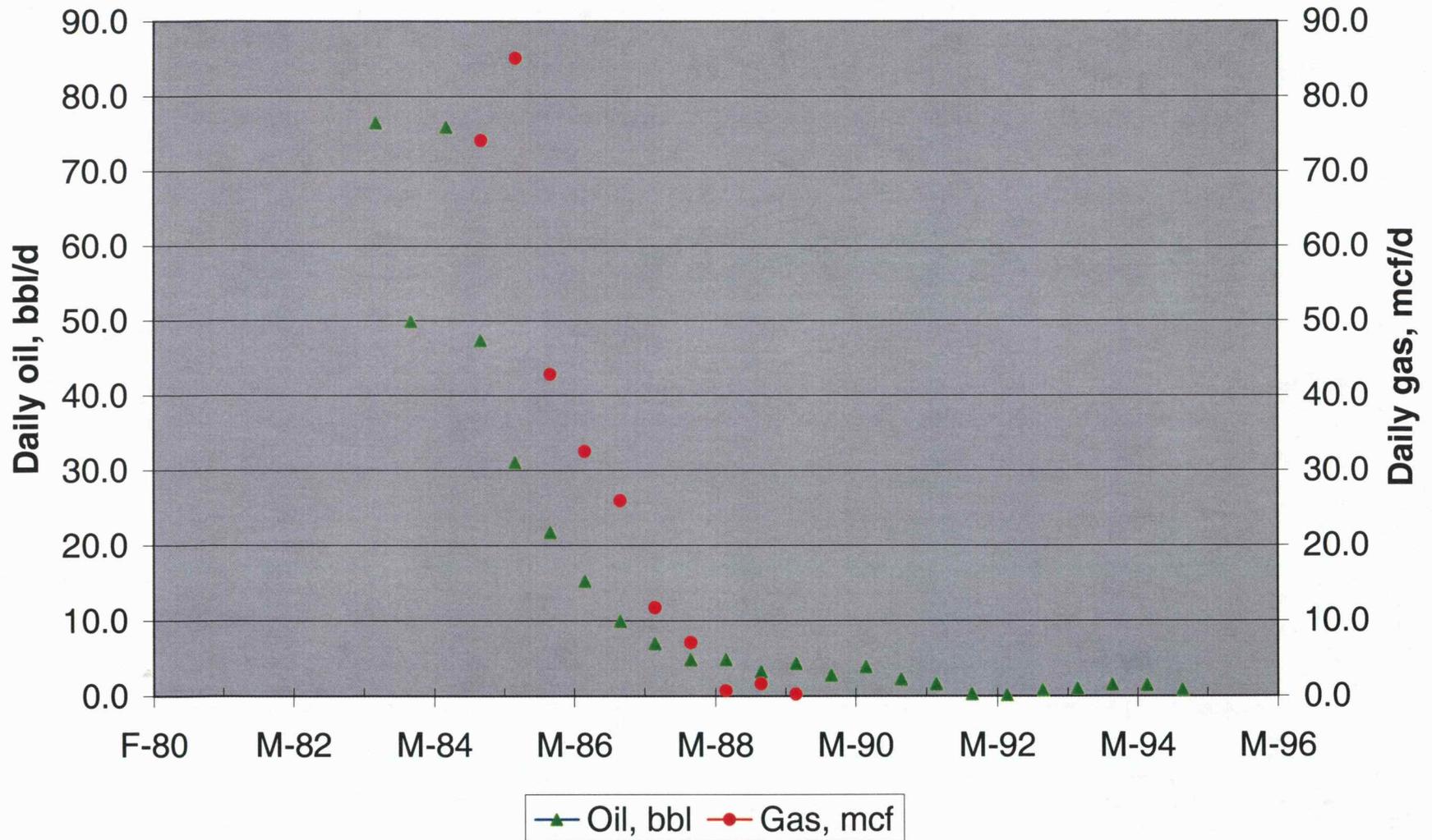Averaged over 6 months
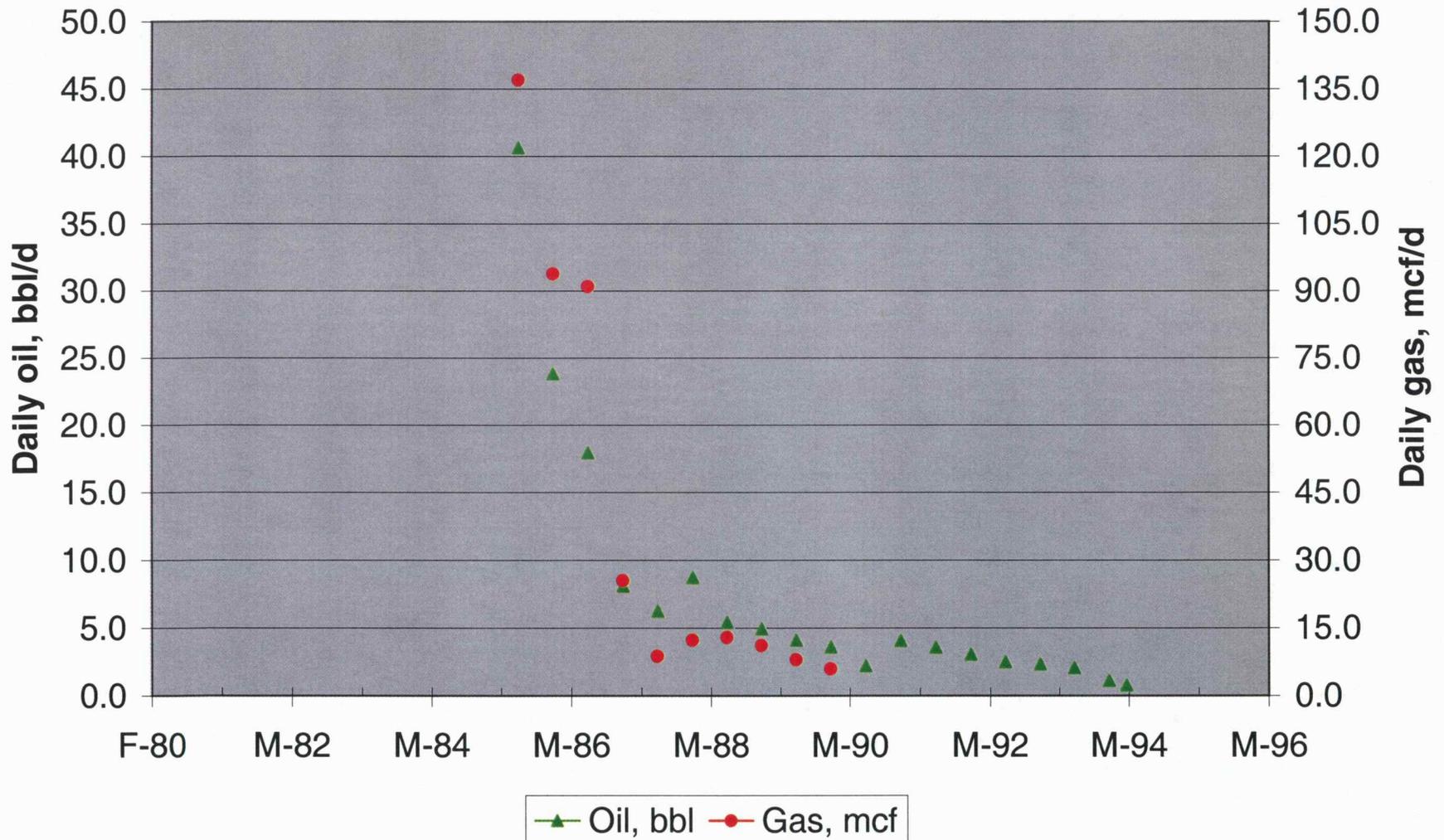
Hall 1-2 (Murfin)
Averaged over 6 months
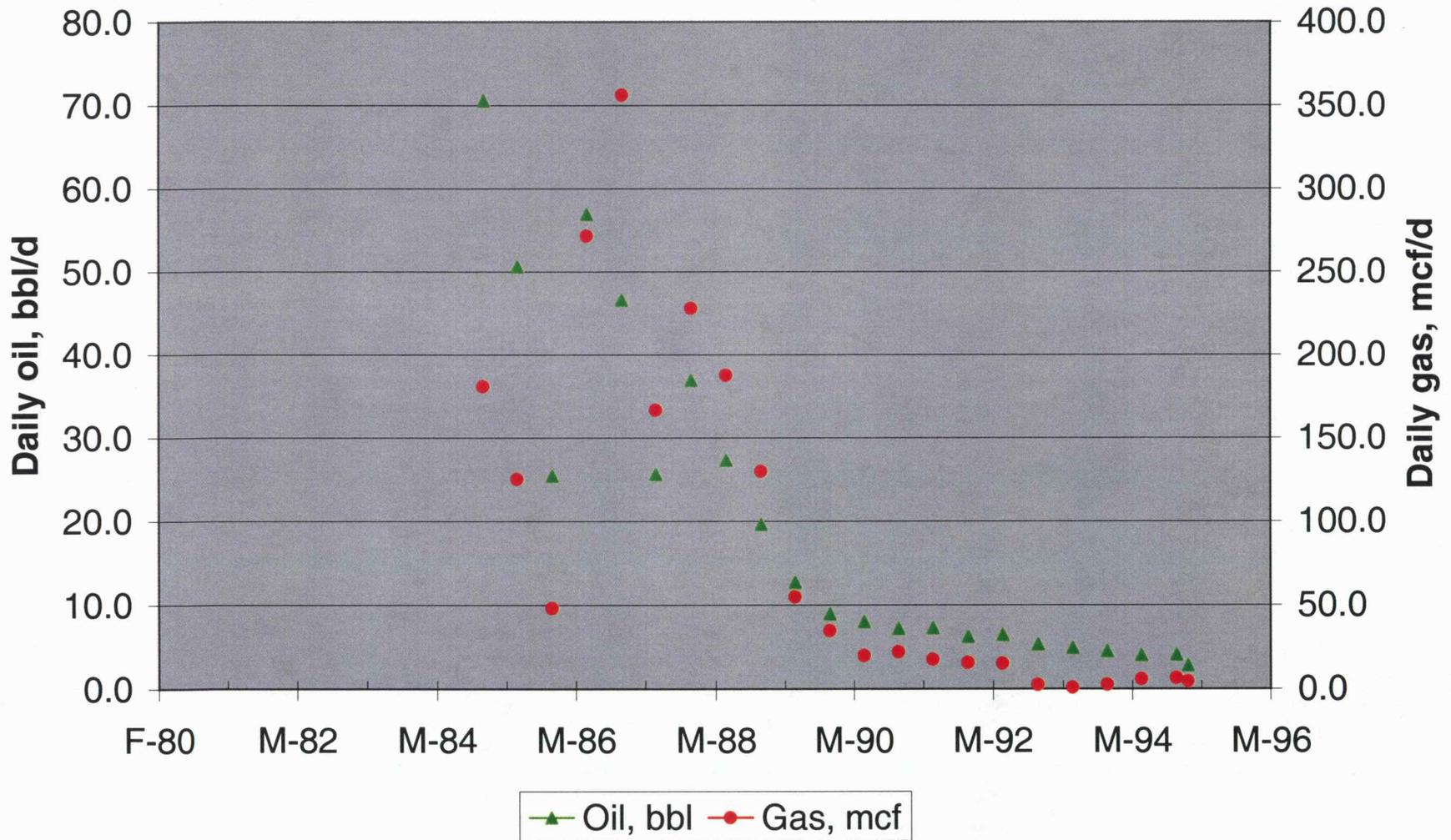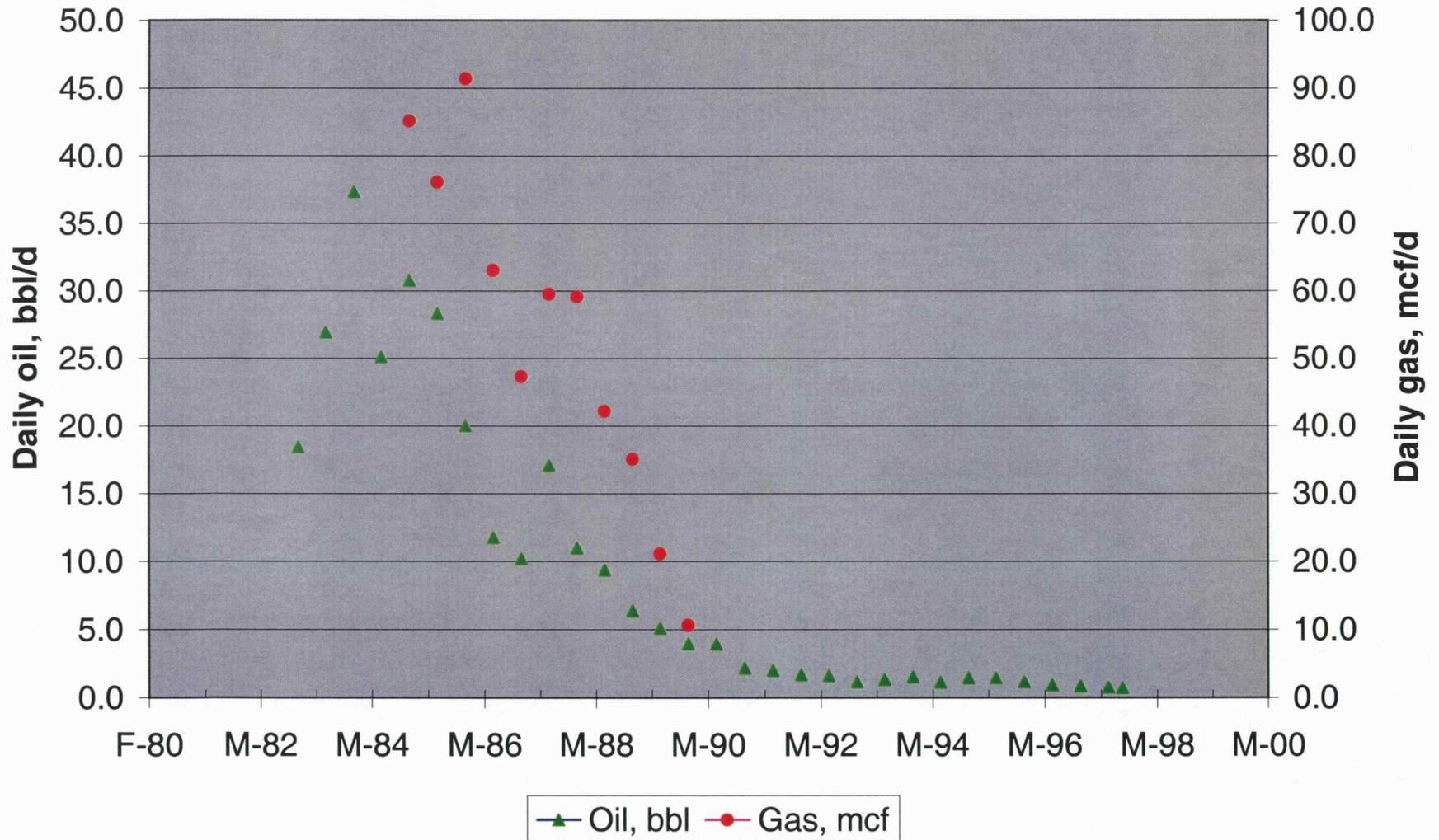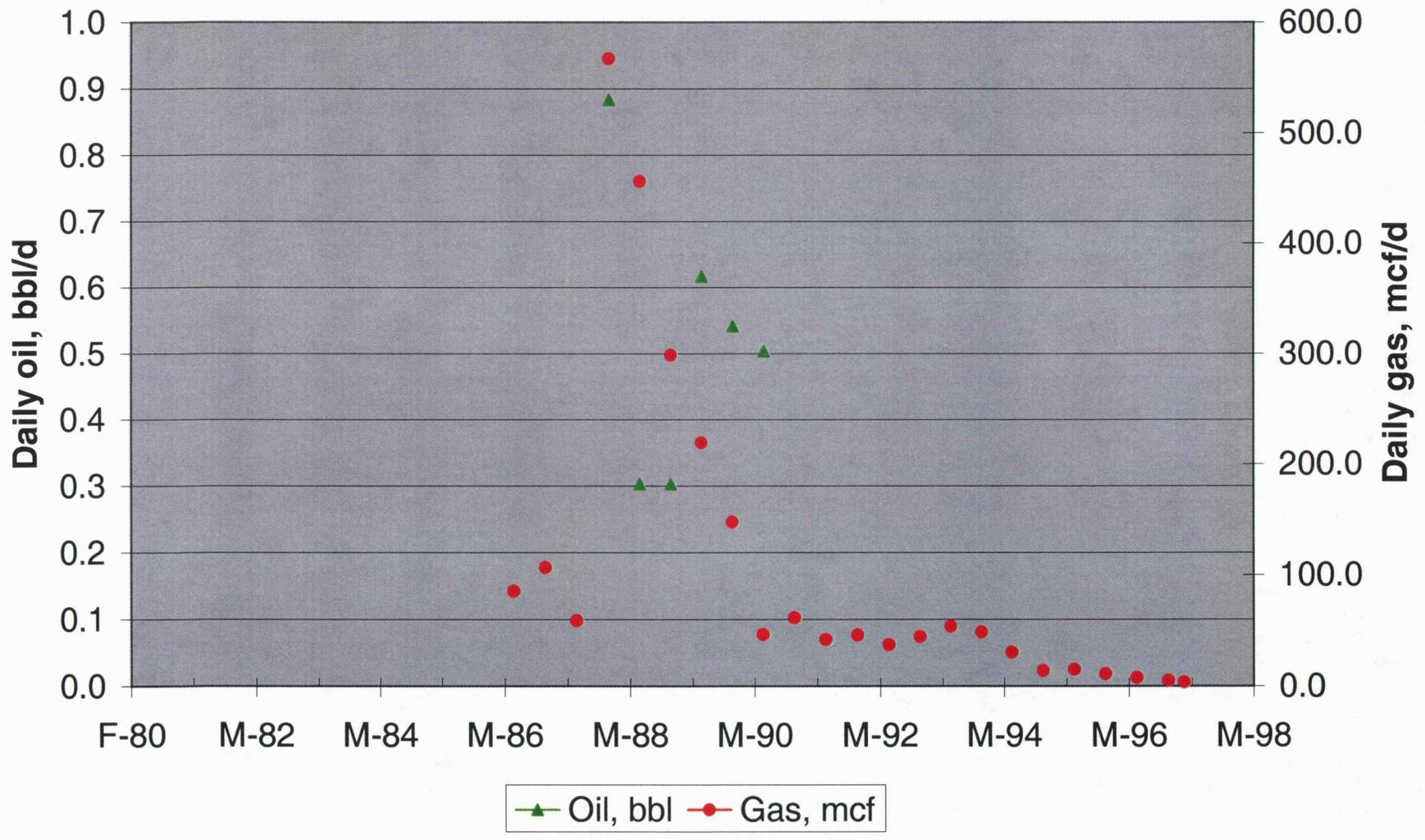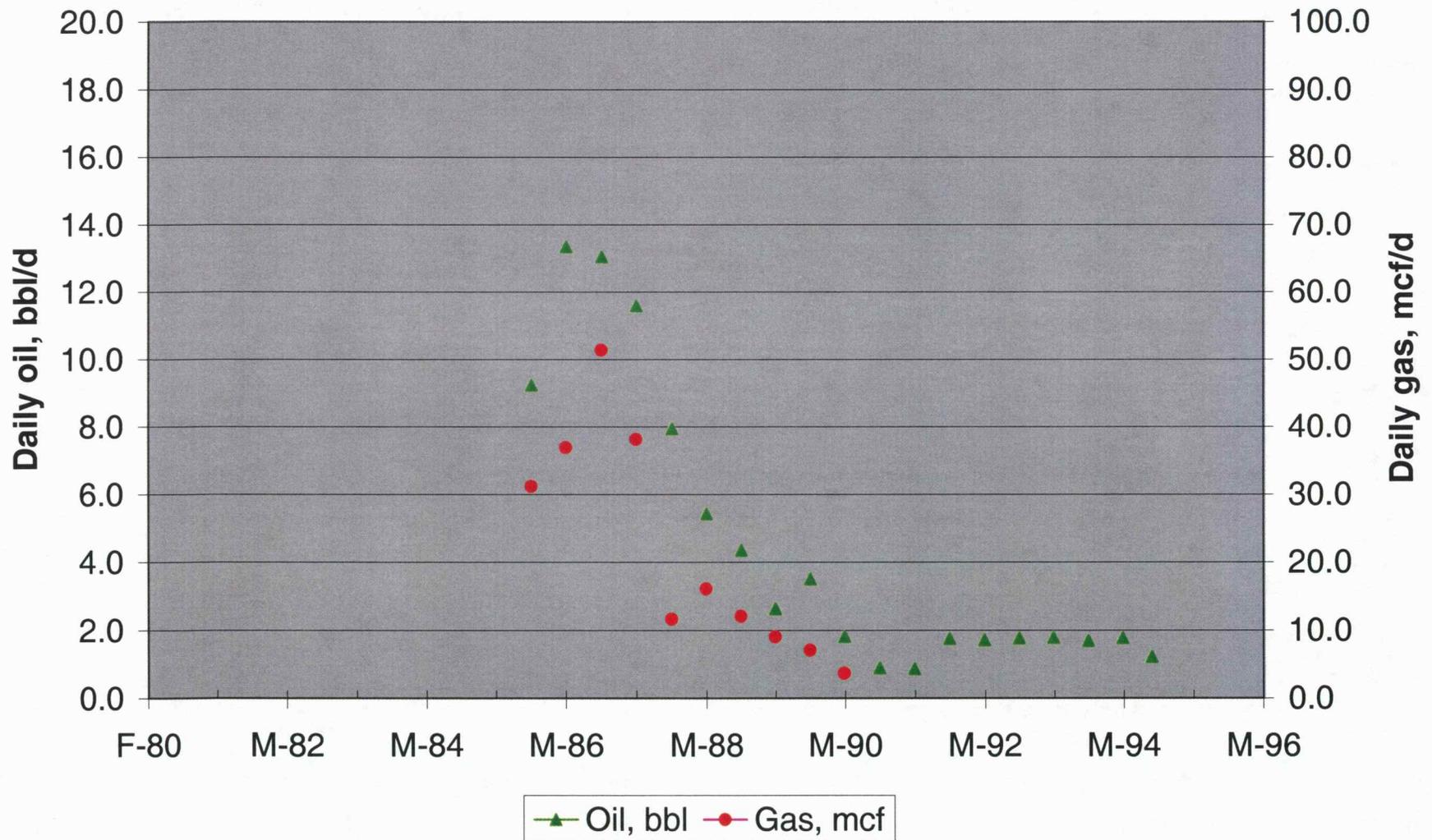
Harris 1-3 (Ladd)
Averaged over 6 months
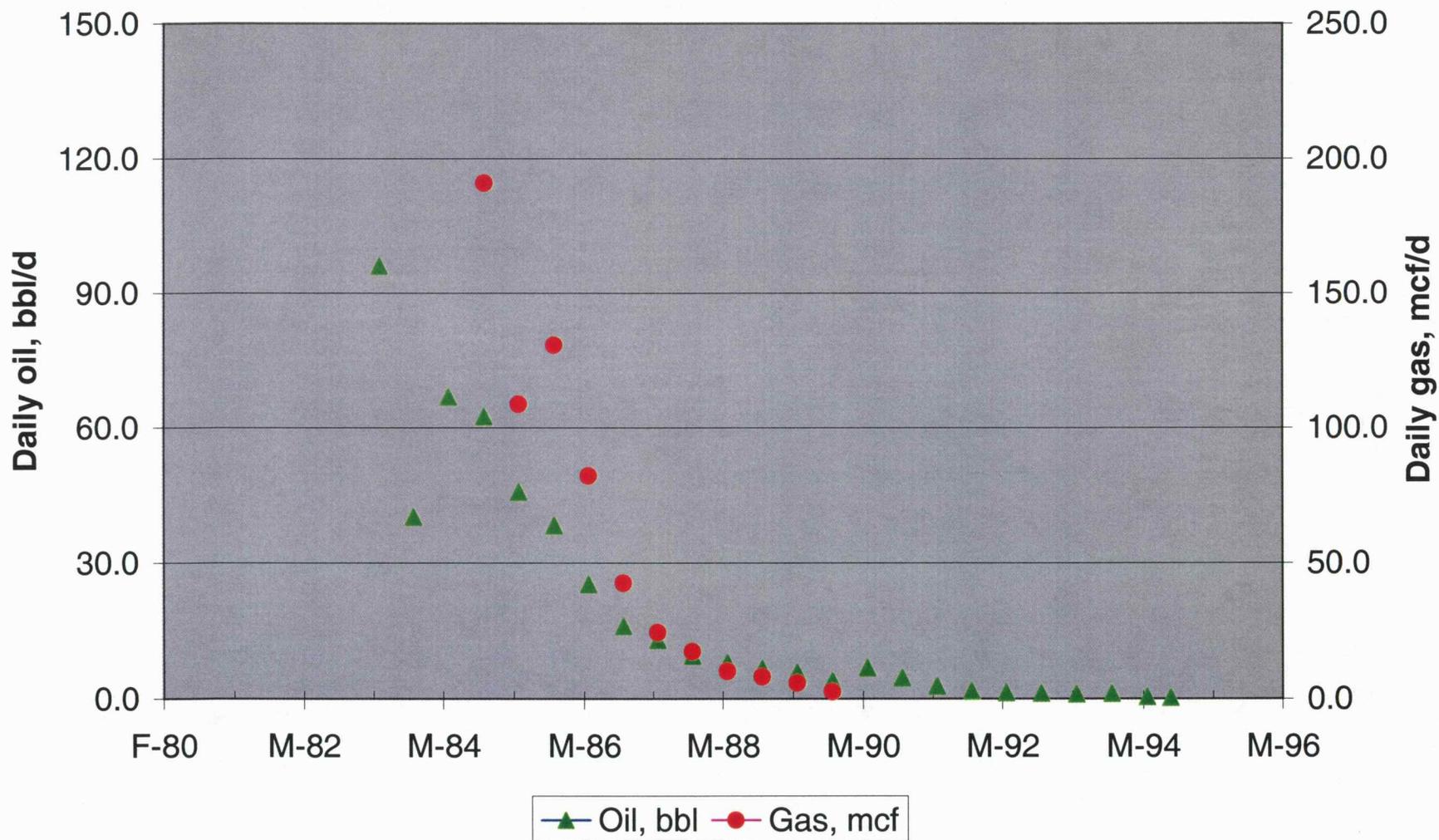
Harris 2-3 (Ladd)
Averaged over 6 months

Chart: Daily oil, bbl/d (y-axis, 0.0 to 16.0) versus time (x-axis, F-80 to M-88). Data series: Oil, bbl
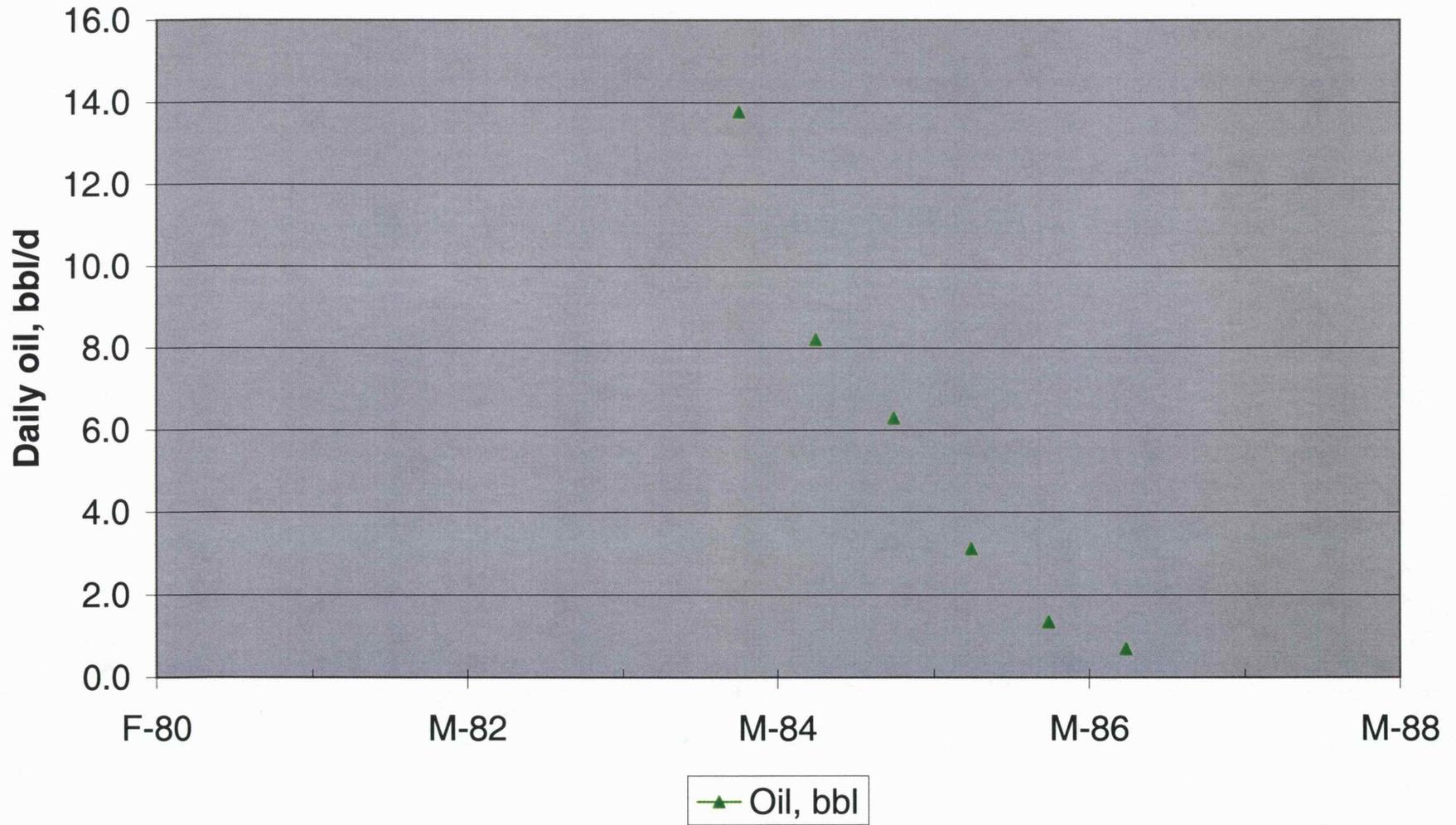
Hindman 1-3 (Ladd)
Averaged over 6 months

Latzke 1 (Ladd)
Averaged over 6 months

McGee 1-1 (Murfin)
Averaged over 6 months

Daily oil, bbl/d

Daily gas, mcf/d
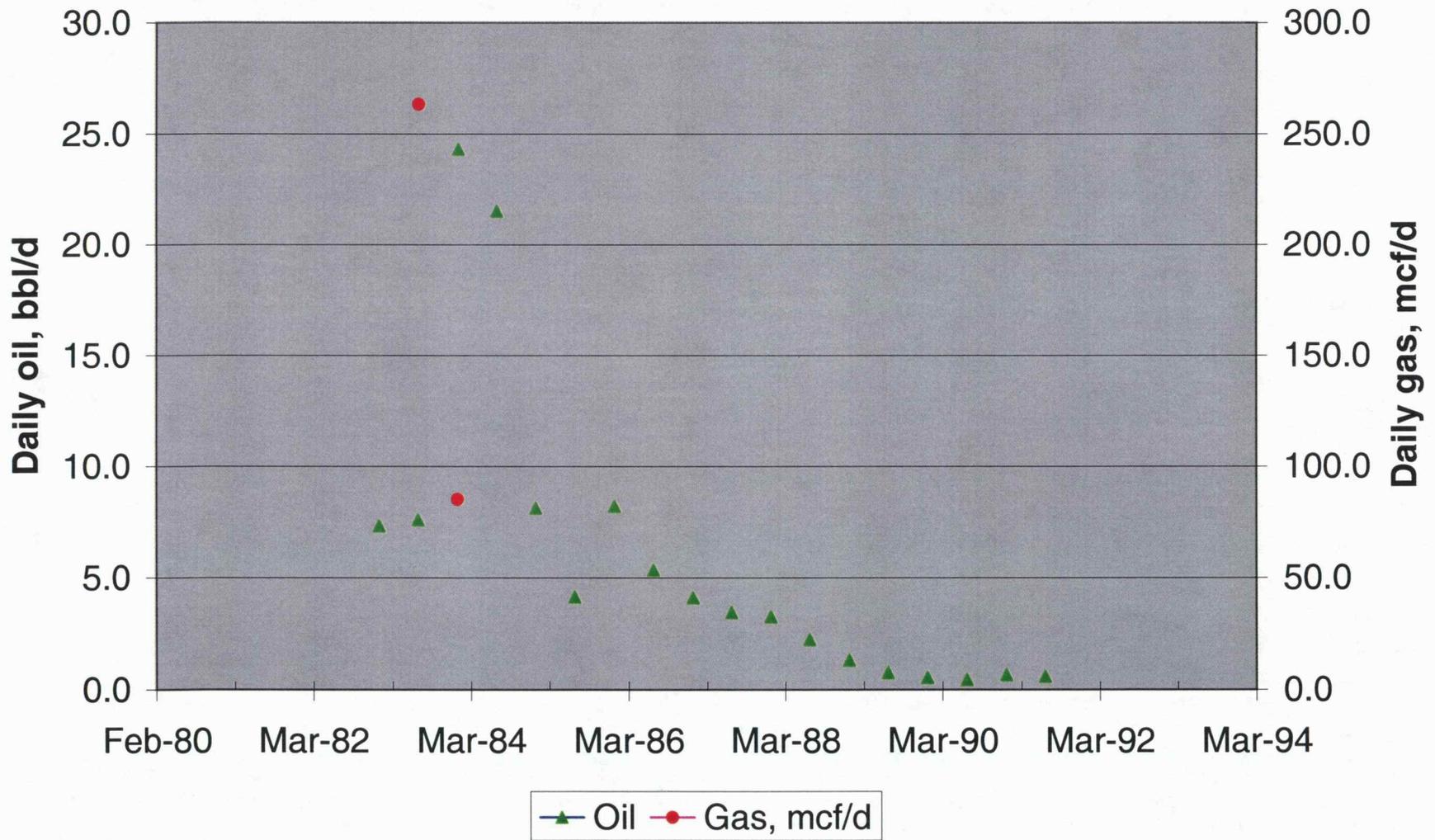
Legend: Oil, bbl — Gas, mcf

Norton 1-4 (Murfin)
Averaged over 6 months

Patton 1-3 & 2-3 (Murfin)
Averaged over 6 months
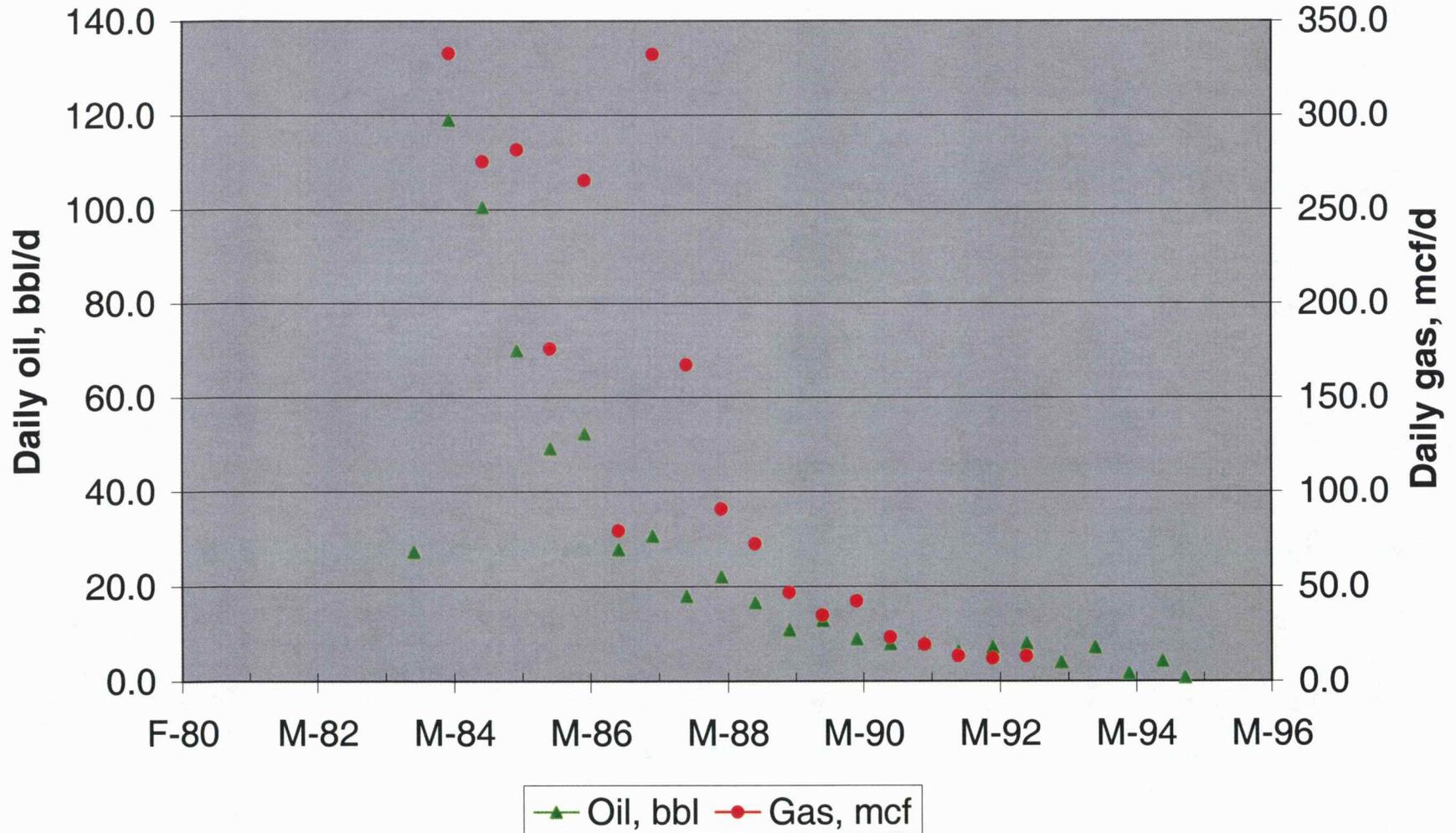
Patton 1 (Ladd)
Averaged over 6 months

Chart: Daily oil (bbl/d) on left axis (0.0–30.0) and Daily gas (mcf/d) on right axis (0.0–300.0) versus date (Feb-80 to Mar-94).
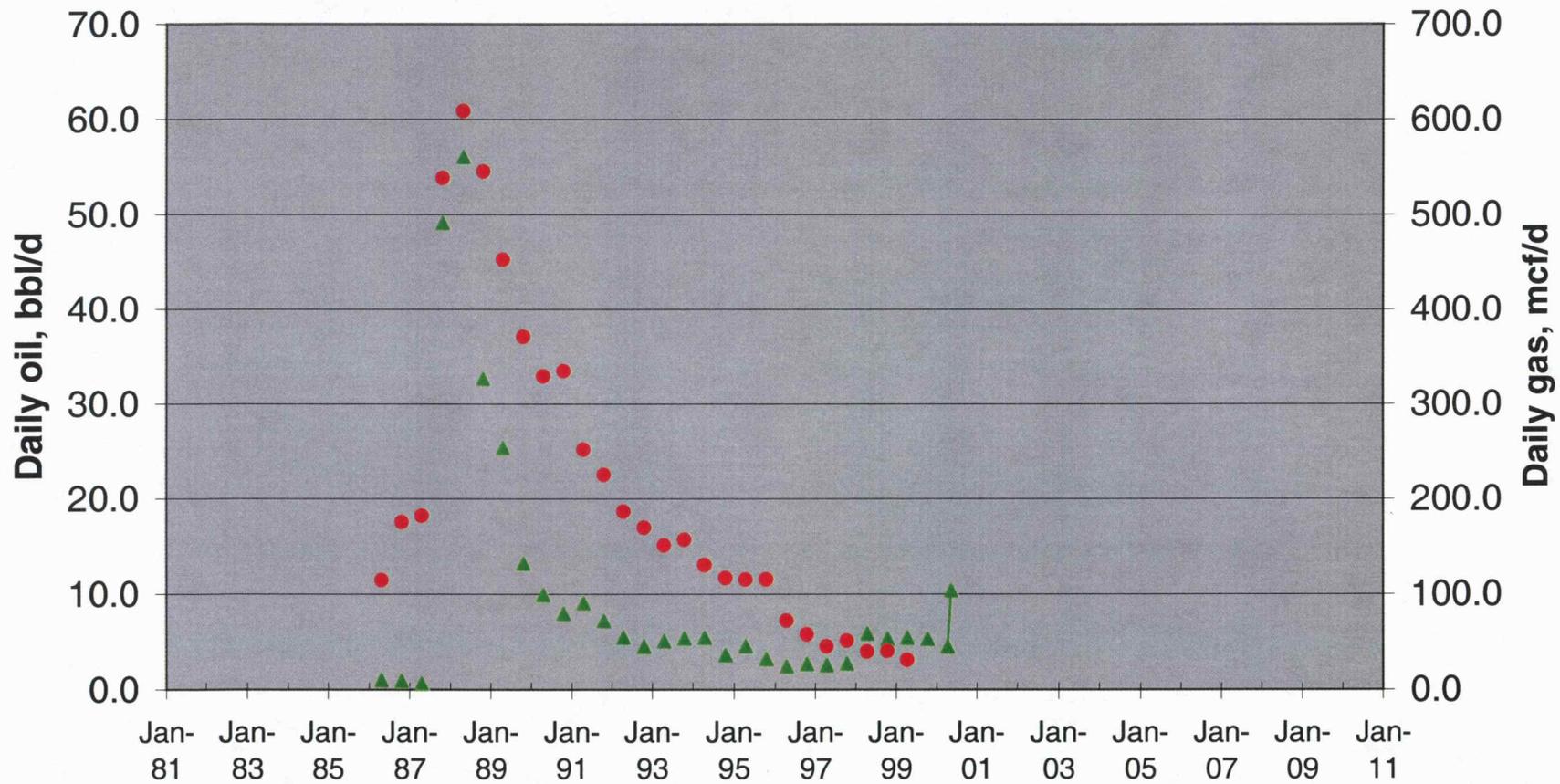
Legend: ▲ Oil   ● Gas, mcf/d

Rooney 1 (Vern Jones)
Averaged over 6 months
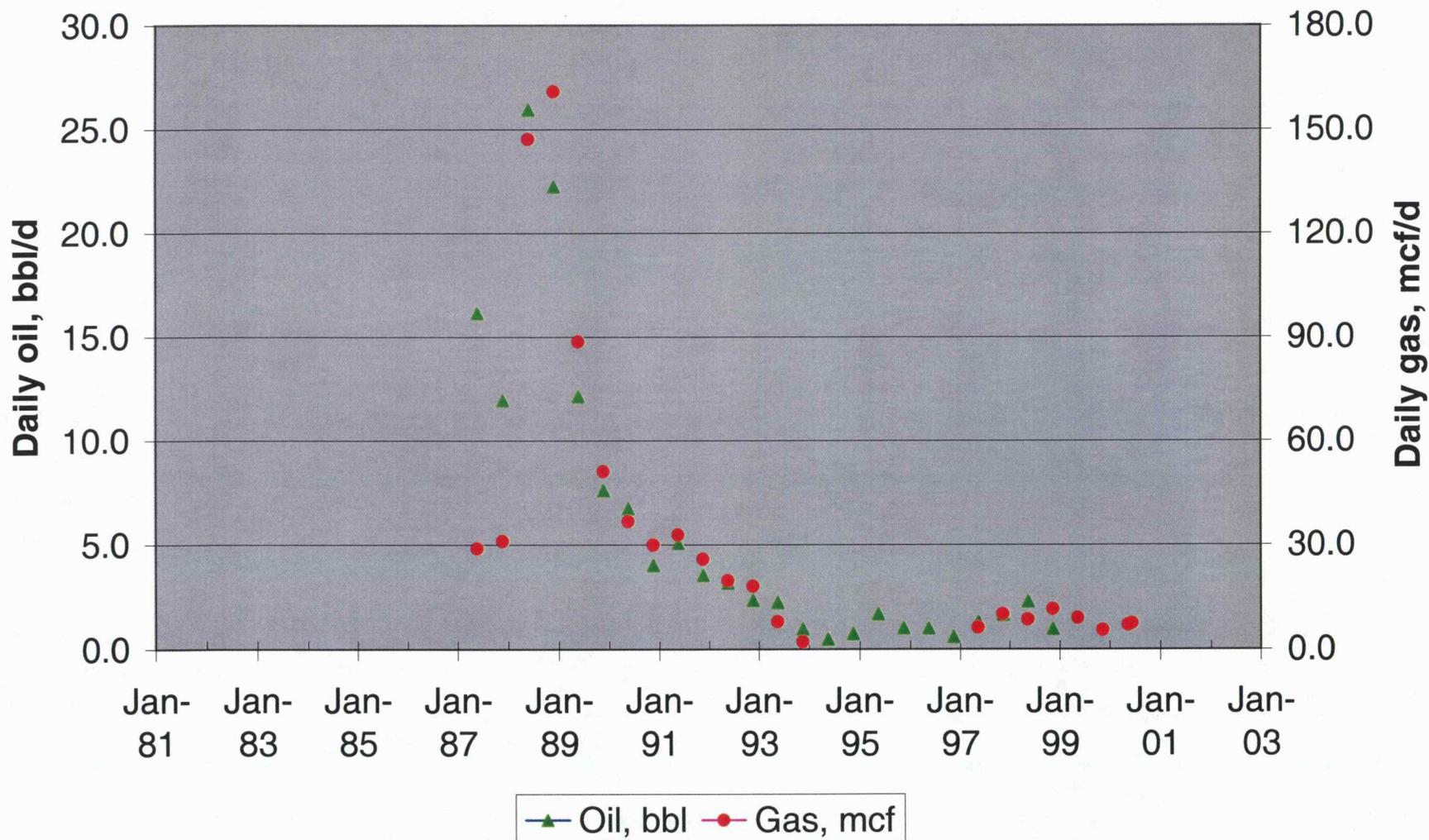
Schlicting 1-2 (Ladd)
Averaged over 6 months
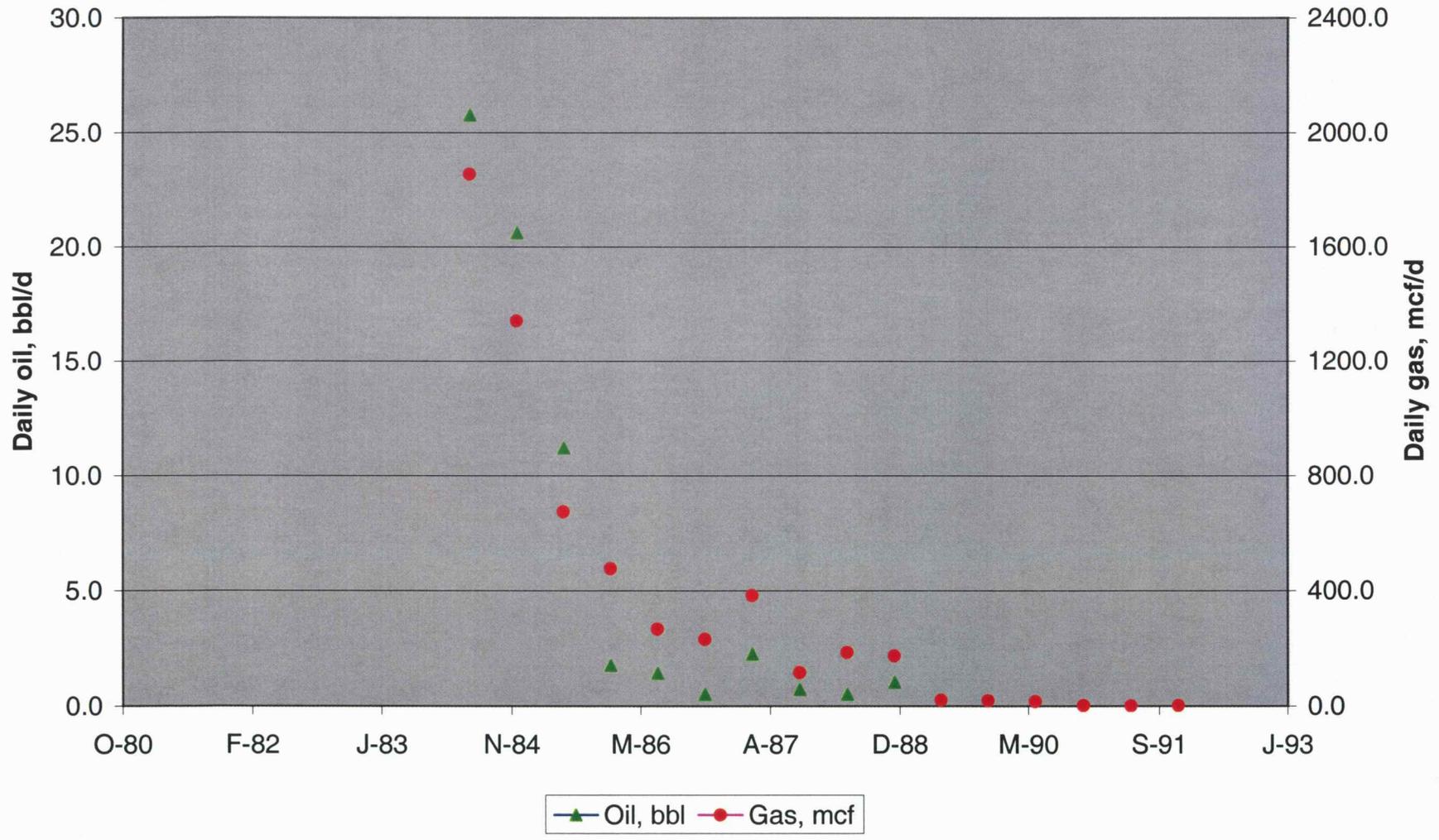
Statton 1-12 & 2-12 (Murfin)
Averaged over 6 months

Tefdford 1 (Ladd)
Averaged over 6 months

Daily oil, bbl/d (left axis): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Daily gas, mcf/d (right axis): 0, 3, 6, 9, 12, 15, 18, 21, 24, 27, 30

X-axis: Feb-80, Mar-82, Mar-84, Mar-86, Mar-88, Mar-90
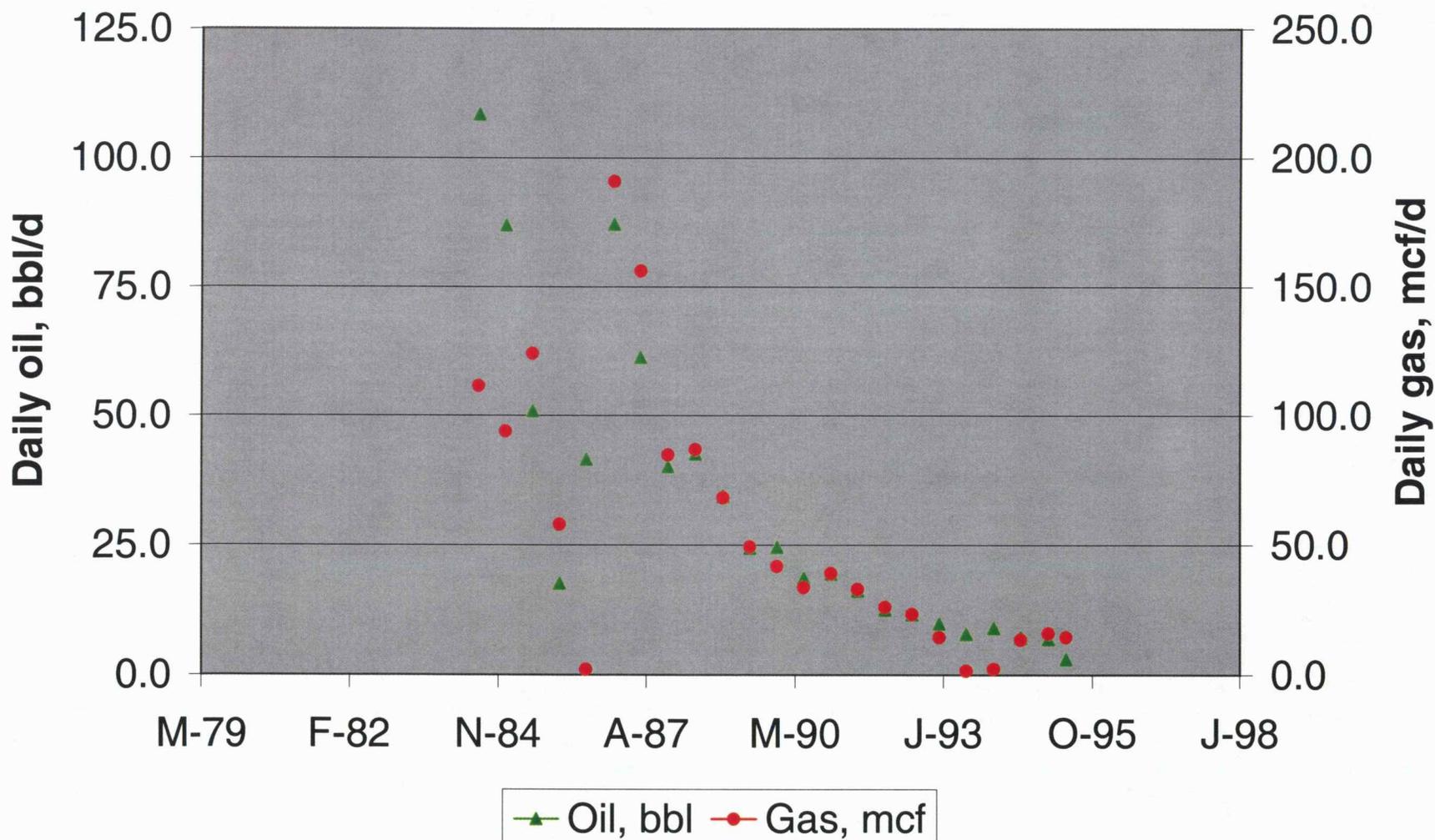
▲ Oil, bbl   ● Gas, mcf

Tedford 2-10 (Ladd)
Averaged over 6 months
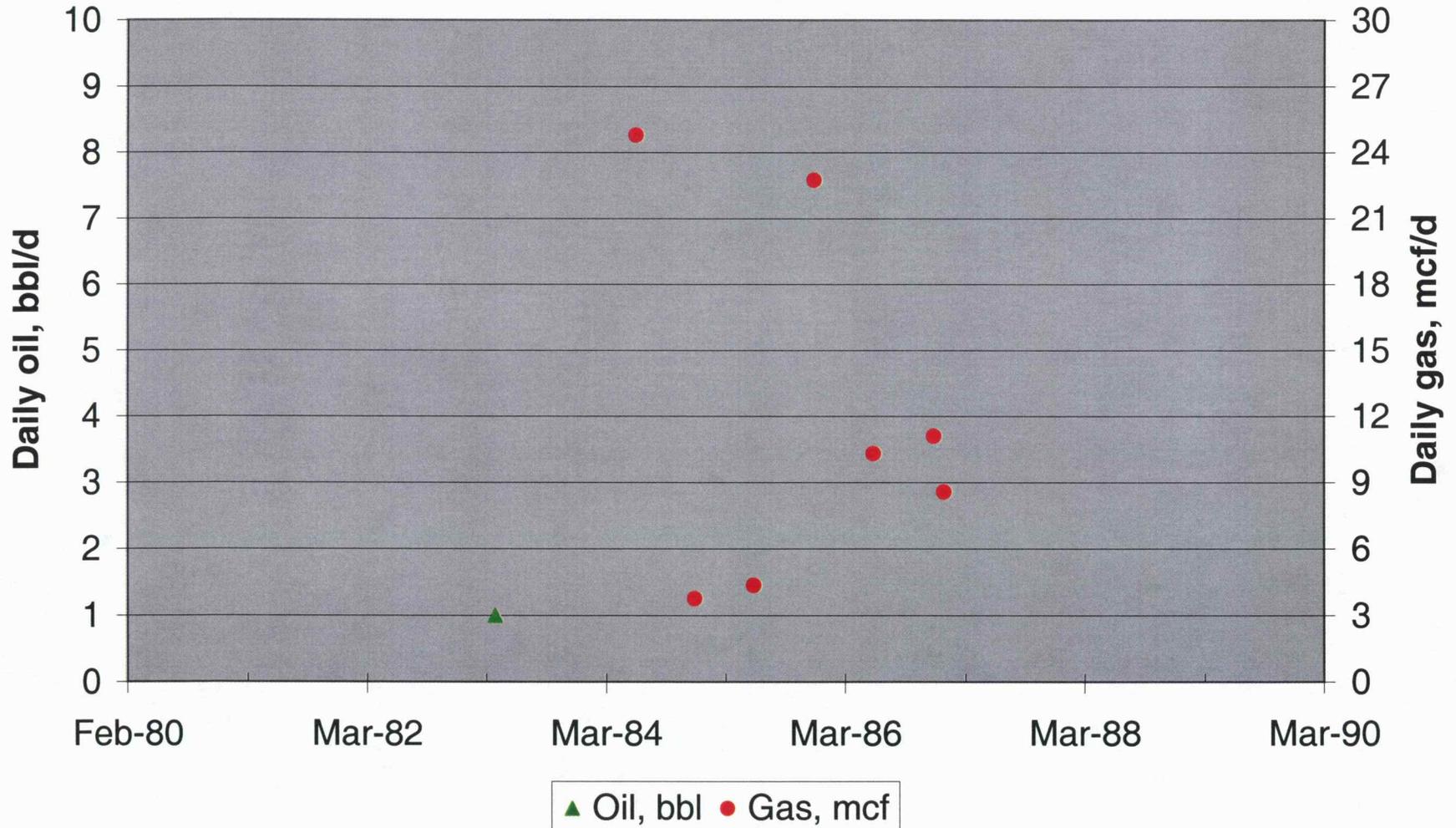
Tedford 4-10 & 1-10 (Murfin)
Averaged over 6 months

Tedford B1-10 (Murfin)
Averaged over 6 months