GAS BUILDUP ANALYSIS REVIEW

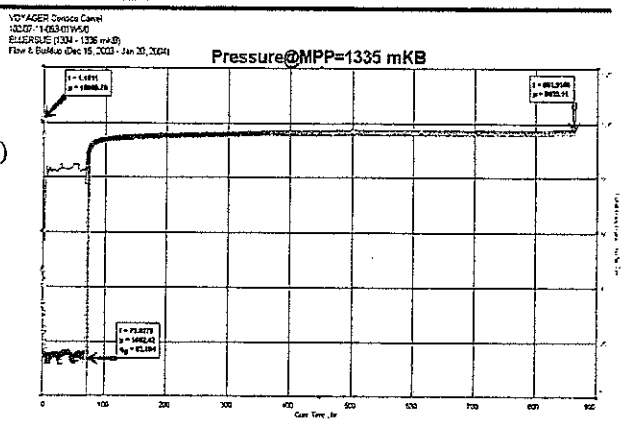
WELL LOCATION: **Voyager Conoco Carvel 102/07-11-053-01W5/0**

FIELD, ZONE: ELLERSLIE (1334–1336 mKB)

TEST DATE: Dec 15, 2003 Static Gradient
Dec 15 – Jan 20, 2004 FBU
Jan 20, 2004 Static Gradient

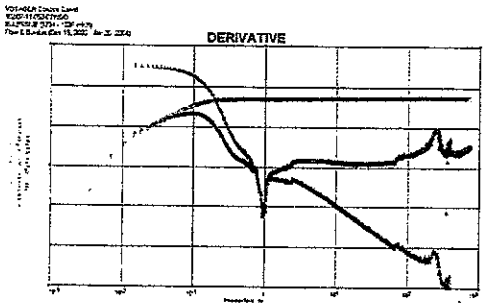
July 25 – Aug 13, 1998 FBU
Nov 20, 2002 Static Gradient

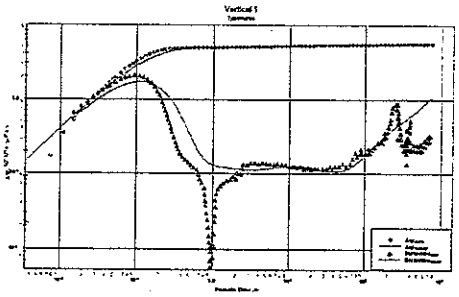
STAGE OF COMPLETION: Standing Well

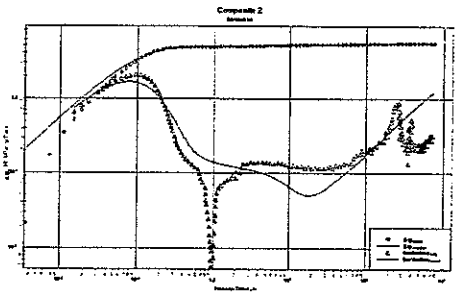


SUMMARY: Type/Size of Stimulation: N/A

Type of Analysis		Semi-Log		SYN (Homogeneous w/ 3 Near Wellbore Boundaries)
		Metric	Field	Metric
Tr=51.5 °C	kh:	146.8 md.m	481.6 md.ft	kh = 146.8 md.m
	k:	58.7 md	58.7 md	k = 58.7 md
	h:	2.5 m	8.2 ft	2.5 m
	s':	+ 14.3	+ 14.3	+ 14.3
	Pi:	10087 kPaa	1463.0 psia	10087 kPaa @ MPP=1335 mKB
	P*:	*9776* kPaa	*1418.0* psia	N/A
	Pr:	N/A	N/A	9996 kPaa (Pave – Vertical Model 1)







COMMENTS: The initial flow and buildup test conducted between July 25 to August 13, 1998, in addition with the static gradient data conducted on November 20th 2002, were analyzed and the observation and comments were presented in a separate report at that time.
Based on that review, it was concluded that the "*apparent*" depletion measured during the initial flow and buildup test could not be accounted for four years later, when a static gradient test was conducted. As such, it was indicated in the review that there is no evidence of pressure depletion due to a small size hydrocarbon accumulation.

With all these facts, since the depletion scenario could not be unanimously discounted, and in order to establish the reservoir model, it was decided by the BR engineers to conduct a second flow and buildup test. Therefore, the main objective of the second test became to determine with a high degree of confidence the final pressure derivative trend. A continuously increasing trend of the late-time pressure derivative would indicate that eventually the reservoir pressure would be capable of recharging over-time to values comparable with the measured initial reservoir pressure prior to the flow period. On the other hand, if the pressure derivative will exhibit a downward trend during the late-time buildup, pseudo steady-state flow conditions (depletion) will be evident and the original-gas-in-place could be calculated.

As such, special considerations were given to recorder selection and test sequence design. Tandem quartz electronic subsurface recorders were selected for their high resolution and accuracy and the well was produced on a single rate for 72 h and a subsequent long buildup was conducted for 861.9 h. Static gradient surveys were conducted before the flow period and at the end of the buildup, respectively, to determine the pressure corrections required from the recorder run depth to the mid point of the perforated interval.

As expected, the pressure transient response of the second flow and buildup was very similar with the buildup profile obtained during the initial test. The conventional Log-Log diagnostic plot was constructed to identify the flow regimes during the buildup period. During the initial 2.6 h of shut-in, wellbore storage was identified. Thereafter, the pressure transient appears

dominated by pseudo radial flow conditions, as indicated by the relatively flat region of the pressure derivative. Beyond 72 hours of shut-in, the pressure derivative started to developed an evident increasing trend, which eventually lasted for the remaining of the buildup. The increasing slope of the pressure derivative suggests near wellbore no-flow boundary detection, or the reduction of the formation flow capacity away from the wellbore. It should be noted that a downward trend of the pressure derivative was not observed during the buildup period recorded and therefore pseudo steady-state flow conditions could not be implied. Furthermore, the examination of the sandface flowing profile indicates relatively steady flow conditions for both gas rates and flowing pressures. Such flowing conditions are not characteristic of pseudo steady-state flow conditions.

The conventional semi-log straight-line analysis was conducted for the radial flow period identified, to calculate the formation permeability and the near wellbore skin. The results indicate good formation permeability and a high pressure drop in the near wellbore region (apparent skin). It should be noted that the near wellbore parameters obtained were in good agreement with the initial welltest results.

Pressure history matching was then employed to define the reservoir model. Based on the initial welltest review, a radial composite reservoir system with the formation flow capacity significantly degrading away from the wellbore was first attempted. Although the pressure history match was fairly good, the pressure derivative match was not considered satisfactory.

A homogeneous (storage and skin) reservoir model with 3 no-flow boundaries provided a better history match for both the pressure and the pressure derivative. It should be noted that the boundary solution is non-unique and due to the low sensitivity of the model to the fourth boundary, the length of the reservoir can not be indicated.

Based on all the evidence provided by all welltest data obtain over time for the subject well it can be concluded that the calculation of the gas-in-place using the material balance should not be based on the buildup pressures, since this will substantially underestimate the gas reserves that the wellbore is capable to capture.

Florin Hategan

Copy:	Kevin MacArthur	Daryl Stepanic	Joe Foose
	John Woolley	Pierre Gagnon	Joe Lam
	Paris Hill	Donny Johnson	Cam Winters
	Bob Thompson	Well file	Michael Dragonetti

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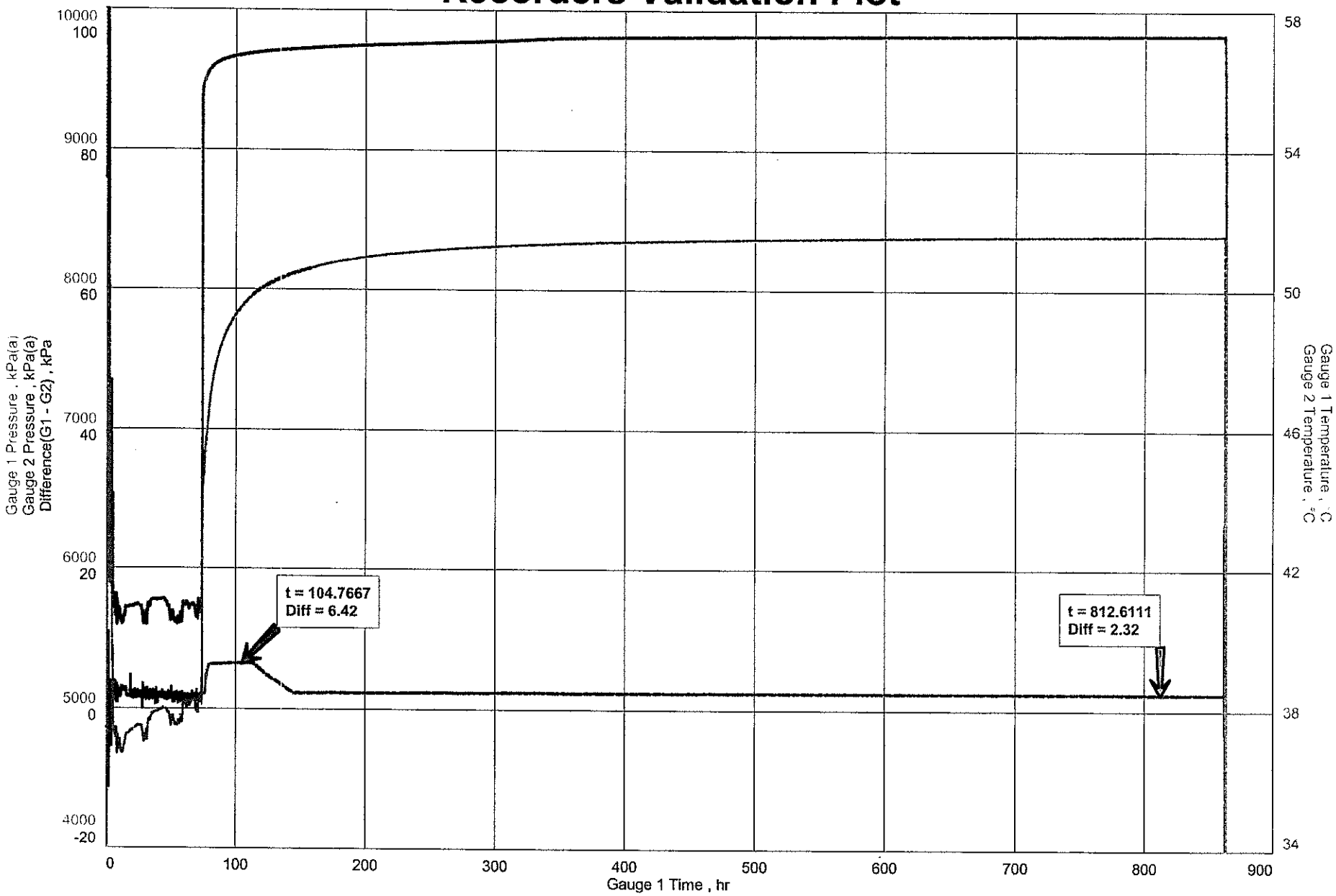
102/07-11-053-01W5/2

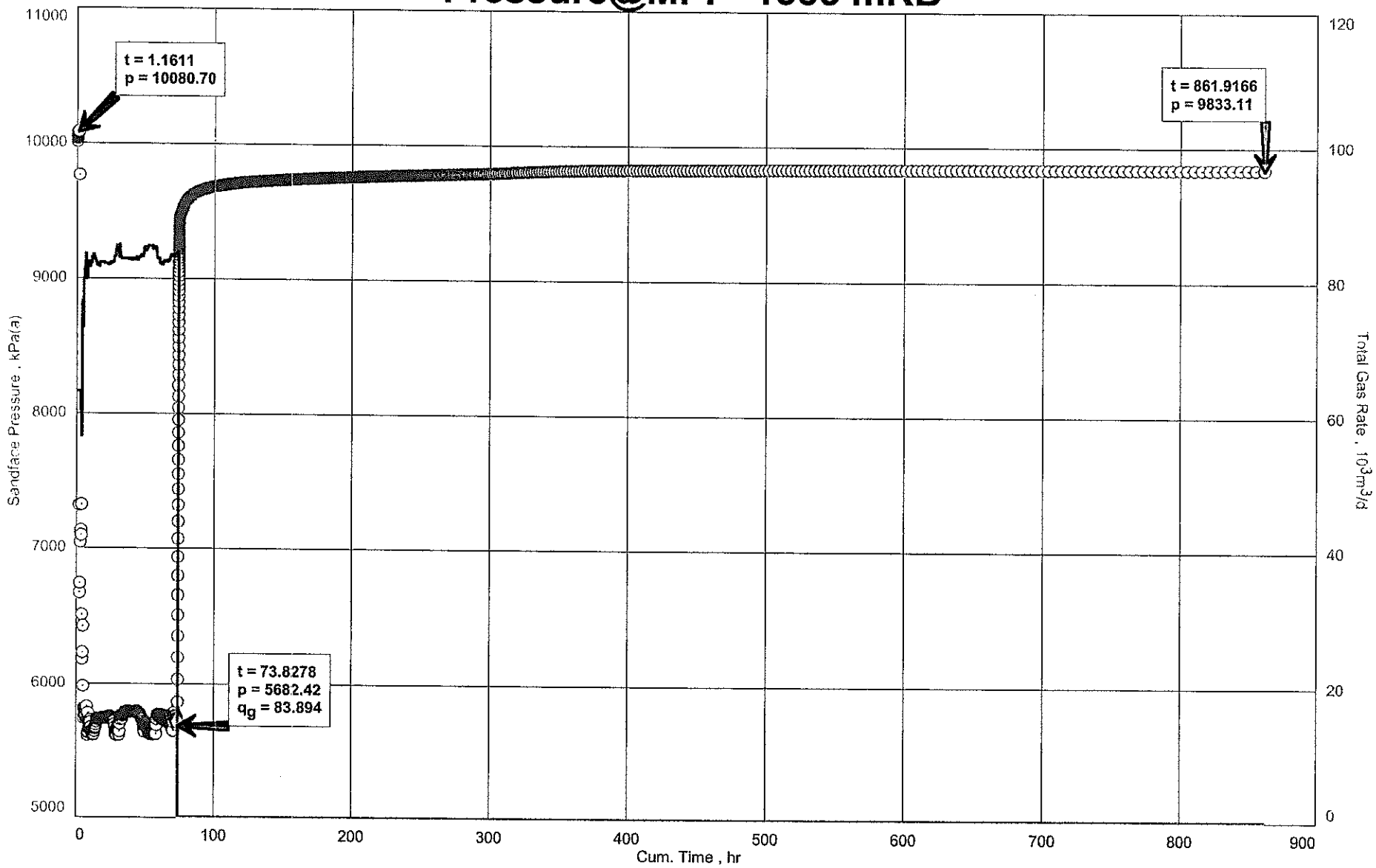
Recorders Validation Plot

Formation: ELLERSLIE



VOYAGER Conoco Carvel
102/07-11-053-01W5/0
ELLERSLIE (1334 - 1336 mKB)
Flow & Buildup (Dec 15, 2003 - Jan 20, 2004)

Pressure@MPP=1335 mKB



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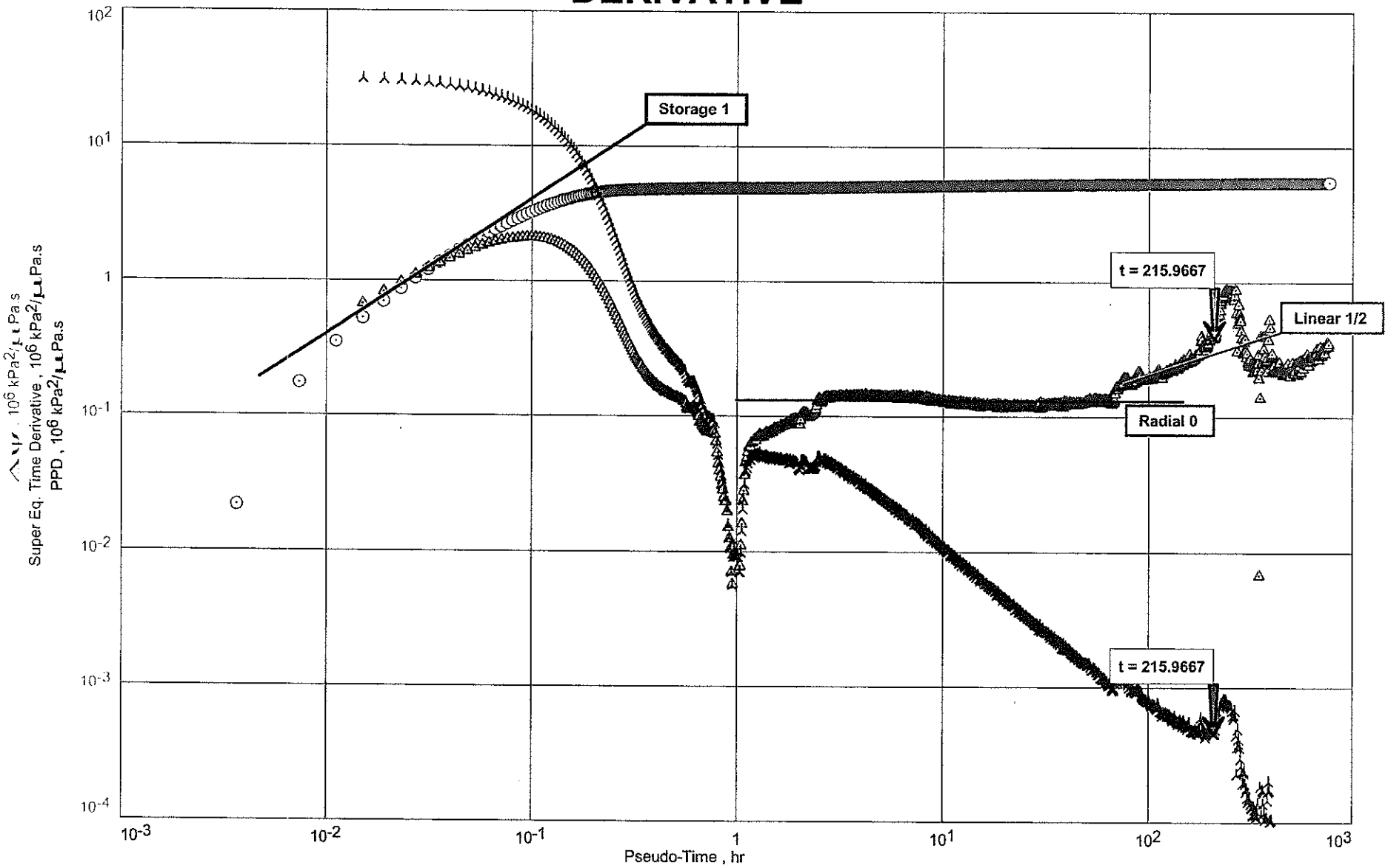
ELLERSLIE (1334 - 1336 mKB)
Flow & Buildup (Dec 15, 2003 - Jan 20, 2004)

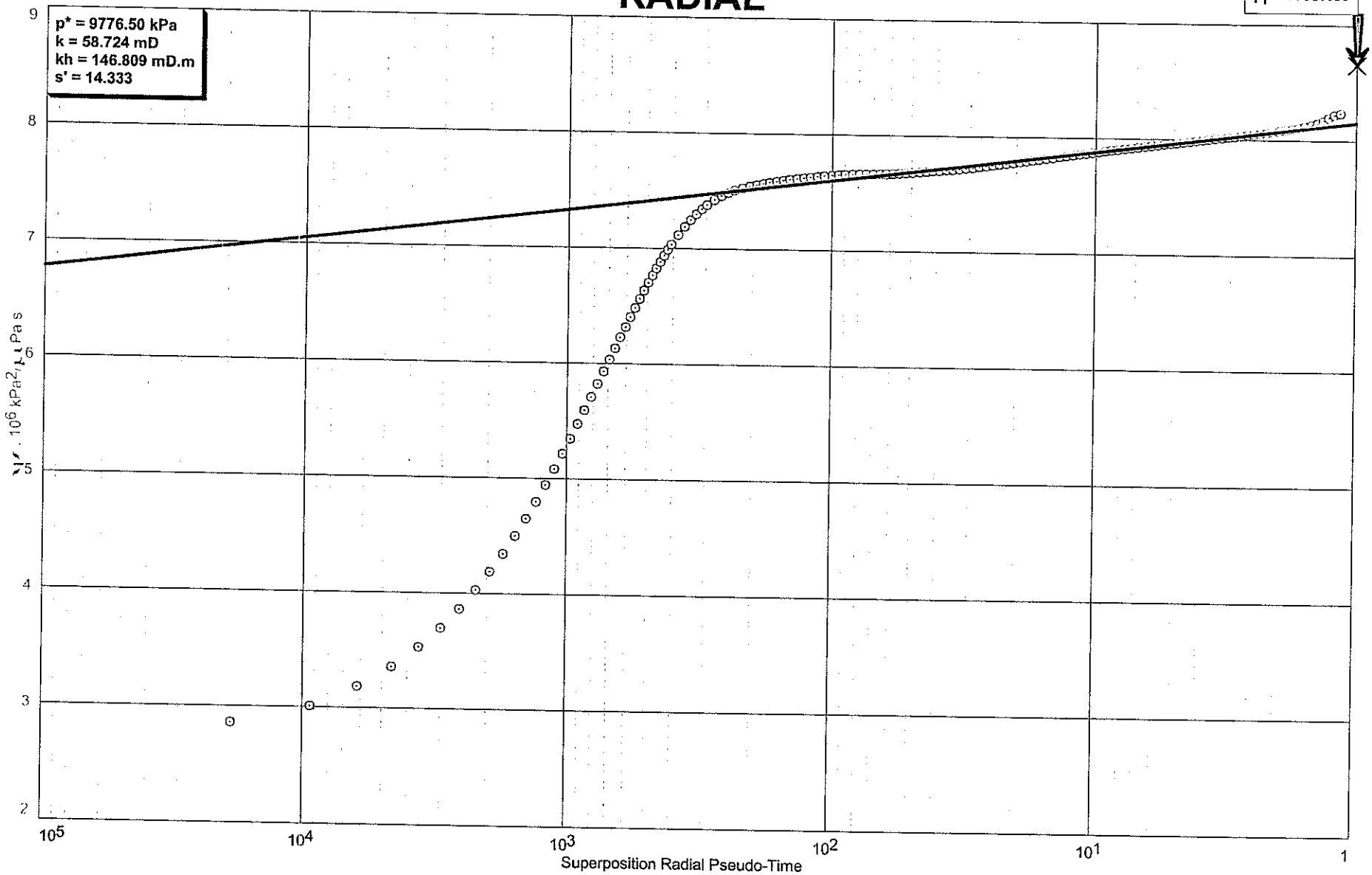
DERIVATIVE



Fast

VOYAGER Conoco Carvel
102/07-11-053-01W5/0
ELLERSLIE (1334 - 1336 mKB)
Flow & Buildup (Dec 15, 2003 - Jan 20, 2004)

RADIAL



Vertical 1

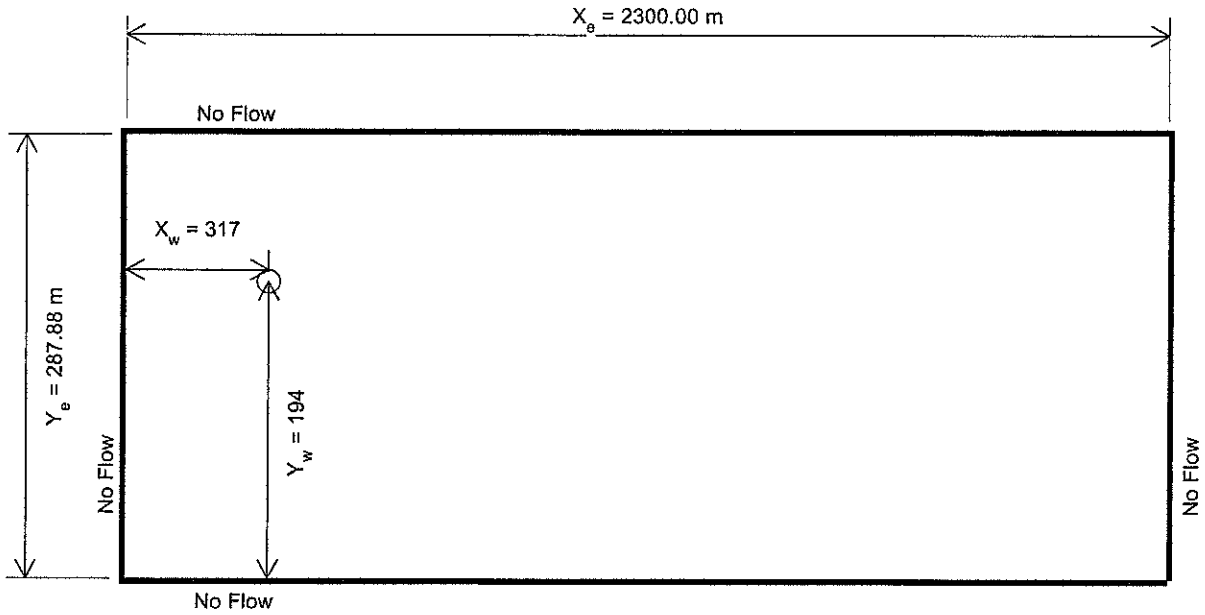
VOYAGER Conoco Carvel
102/07-11-053-01W5/0
ELLERSLIE (1334 - 1336 mKB)
Flow & Buildup (Dec 15, 2003 - Jan 20, 2004)

k = 58.724 mD
s = 14.333
GIP_{model} = 24.345 $10^6 m^3$

0 834 bcf

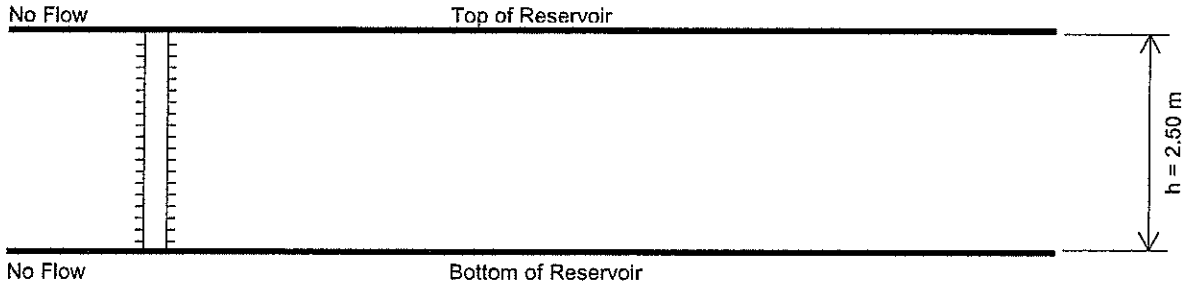
Plan View

(Not to scale)



Side View

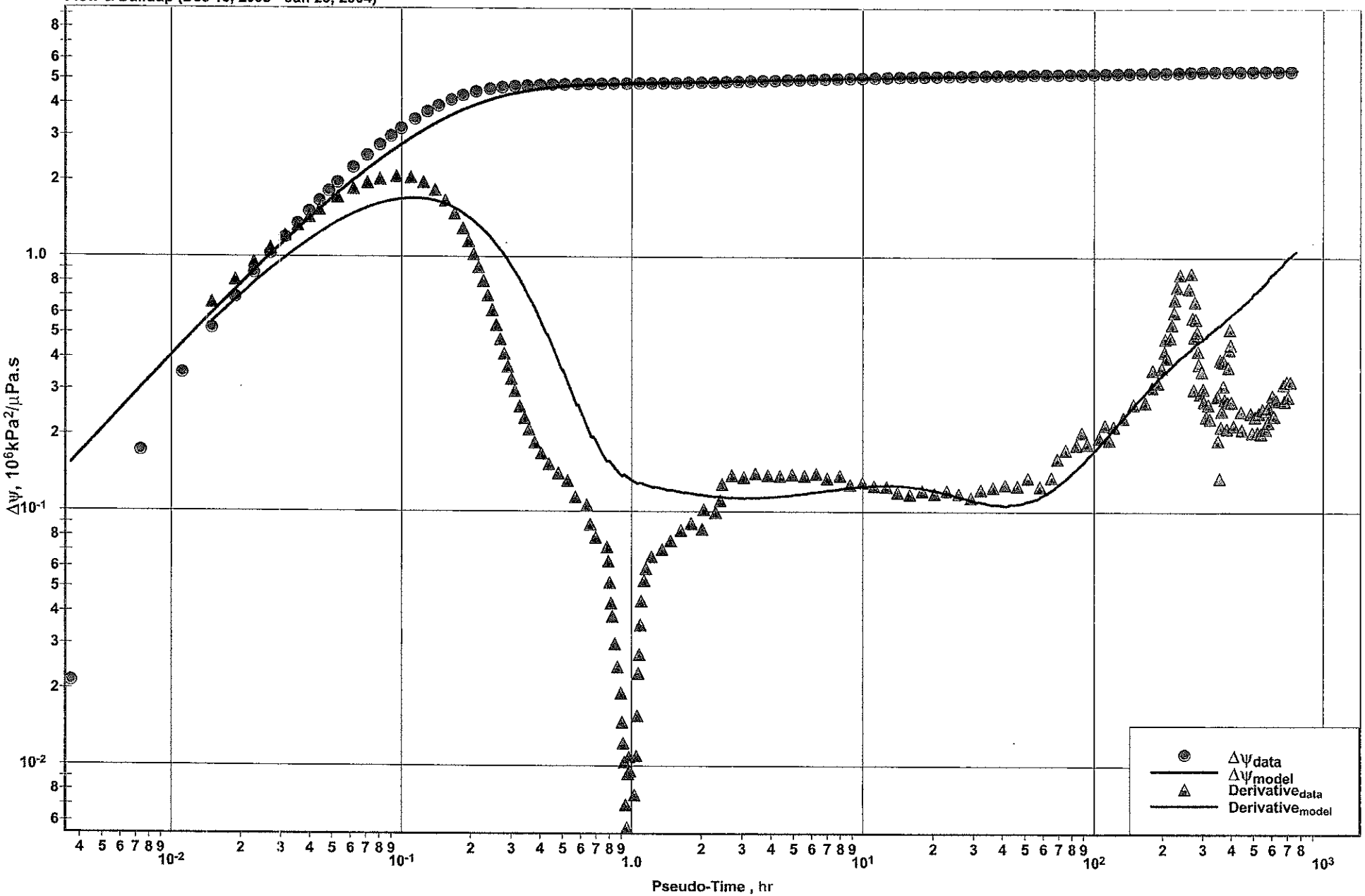
(Not to scale)



VOYAGER Conoco Carvel
102/07-11-053-01W5/0
ELLERSLIE (1334 - 1336 mKB)
Flow & Buildup (Dec 15, 2003 - Jan 20, 2004)

Vertical 1

Typecurve



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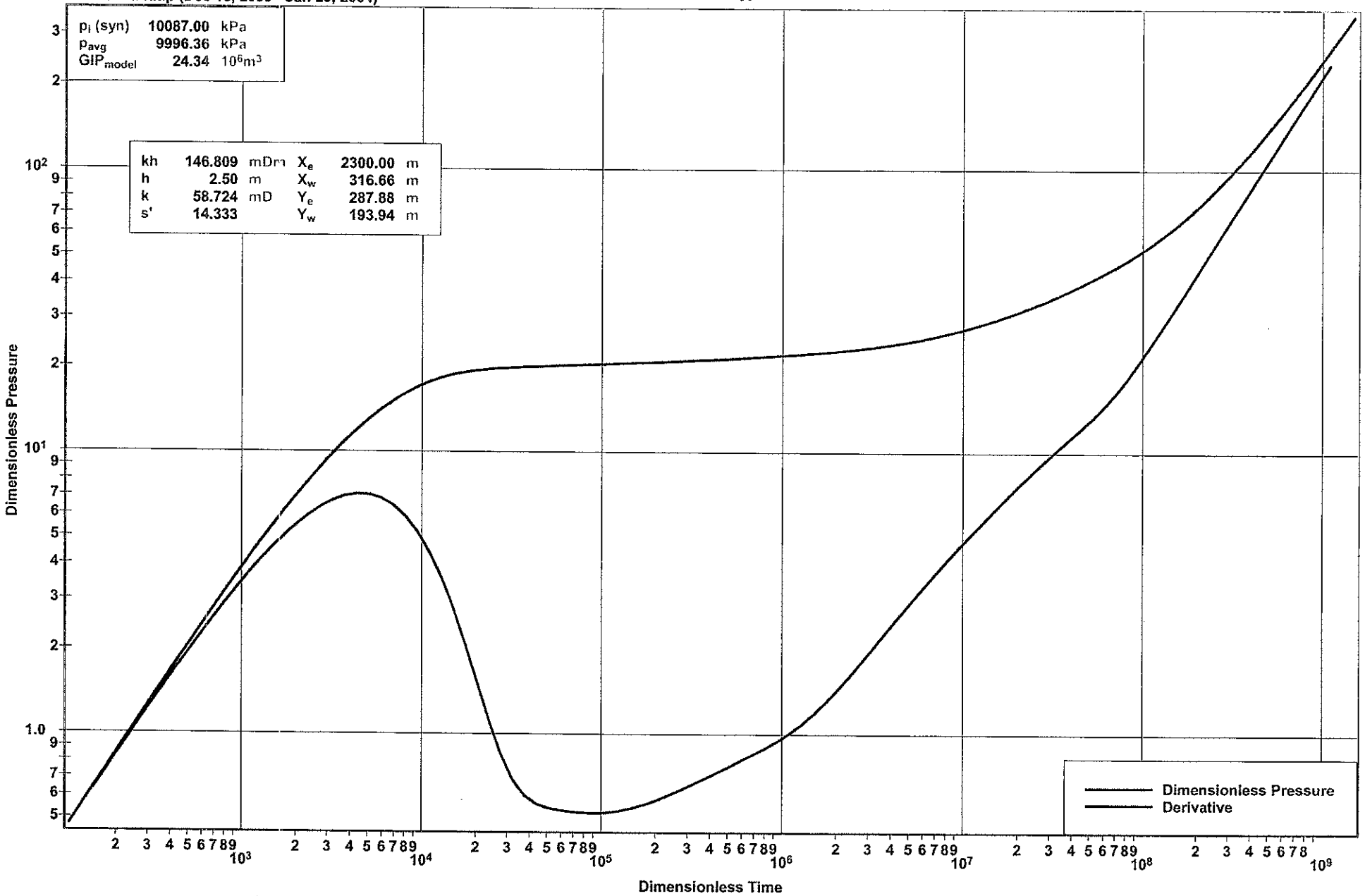
VOYAGER Conoco Carvel
102/07-11-053-01W5/0
ELLERSLIE (1334 - 1336 mKB)
Flow & Buildup (Dec 15, 2003 - Jan 20, 2004)

Vertical 1

Dimensionless Typecurve



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Vertical Gas Well Model

Case Name : Vertical 1

VOYAGER Conoco Carvel

102/07-11-053-01W5/0

ELLERSLIE (1334 - 1336 mKB)

Flow & Buildup (Dec 15, 2003 - Jan 20, 2004)

Model Parameters

Permeability (k)	58.724 mD	Reservoir Length (X_e)	2300.00 m
Apparent Wellbore Storage Dim. (C_{aD})		Reservoir Width (Y_e)	287.88 m
Wellbore Storage Constant Dim. (C_D)	230.59	Active Well At (X_w)	316.66 m
Storage Pressure Param Dim. (C_{pD})		Active Well At (Y_w)	193.94 m
Skin (s)	14.333		
Turbulence Factor (D)	0.00 $(10^3\ m^3/d)^{-1}$		

Formation Parameters

Net Pay (h)	2.50 m
Total Porosity (Φ_t)	20.00 %
Gas Saturation (S_g)	70.00 %
Water Saturation (S_w)	30.00 %
Oil Saturation (S_o)	0.00 %
Wellbore Radius (r_w)	0.150 m
Formation Temperature (T)	51.5 °C
Formation Compressibility (c_f)	5.289e-7 kPa^{-1}
Total Compressibility (c_t)	7.830e-5 kPa^{-1}

Fluid Properties

Gas Gravity (G)	0.678
N_2	3.48 %
H_2S	0.00 %
CO_2	1.78 %
Critical Pressure (P_c)	4595.30 kPa
Critical Temperature (T_c)	207.90 K
PVT Reference Pressure (p_{PVT})	10087.00 kPa
Gas Compressibility (c_g)	1.10910e-4 kPa^{-1}
Gas Compressibility Factor (z)	0.841
Gas Viscosity (μ_g)	14.679 μPa.s
Gas Formation Volume Factor (B_g)	0.009519 m^3/m^3

Production and Pressure

Final Gas Rate	83.894 $10^3 m^3/d$
Cumulative Gas Production	247.222 $10^3 m^3$
Final Measured Pressure	9833.11 kPa

Synthesis Results

Average Error	1.34 %
Synthetic Initial Pressure (p_i)	10087.00 kPa
Average Reservoir Pressure	9996.36 kPa
Pressure Drop Due To Skin (Δp_s)	2789.22 kPa
Flow Efficiency (FE)	0.323
Damage Ratio (DR)	3.092

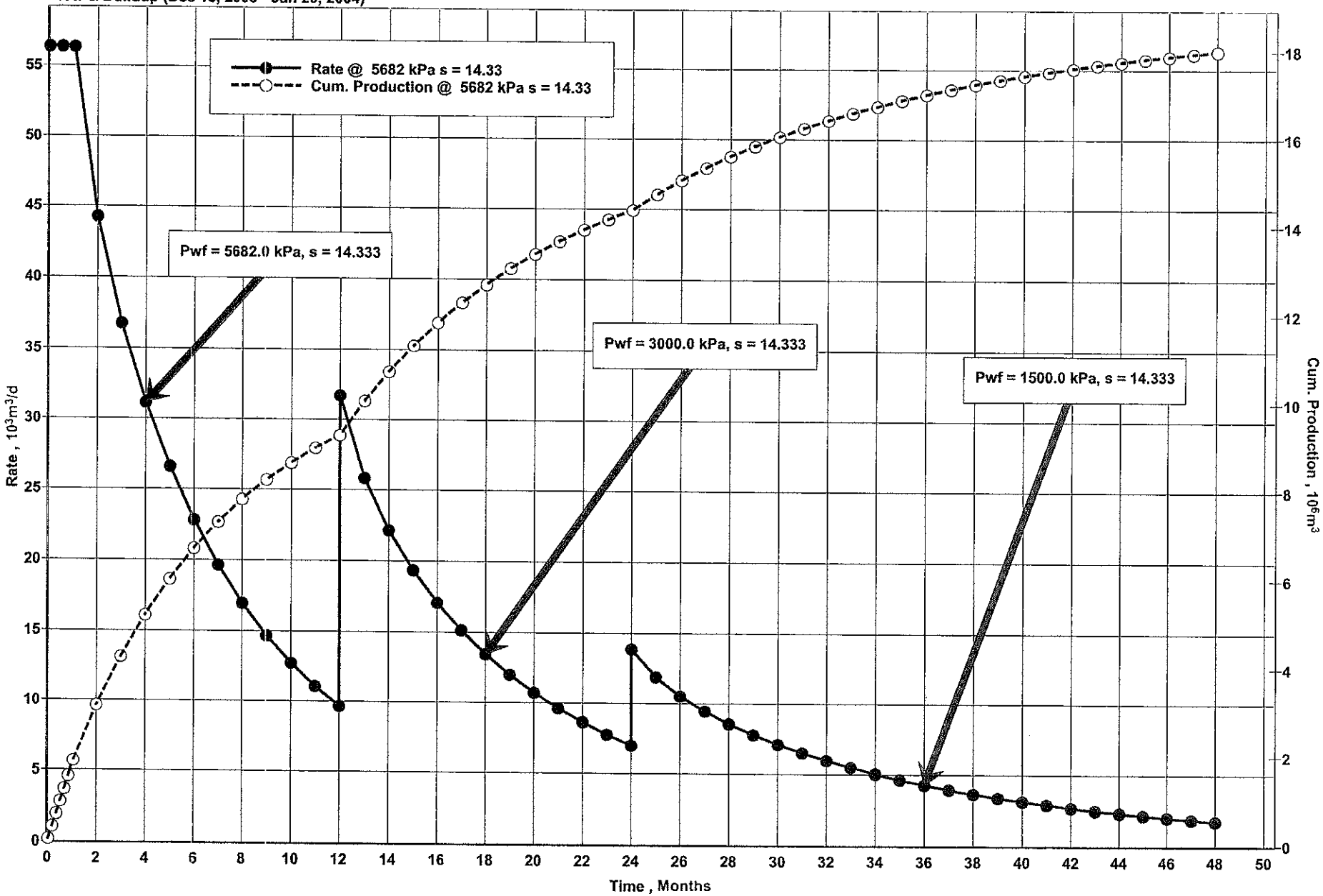
Forecasts

Forecast Flowing Pressure (P_{flow})	5682.42 kPa
3 - Month Constant Rate Forecast @ Curr. Skin	39.641 $10^3 m^3/d$
6 - Month Constant Rate Forecast @ Curr. Skin	28.613 $10^3 m^3/d$
Forecast Flow Duration (t_{flow})	12.00 month
Constant Rate Forecast @ Curr. Skin	18.451 $10^3 m^3/d$
Constant Rate Forecast @ Skin=0	21.289 $10^3 m^3/d$
Constant Rate Forecast @ Skin=-4	22.237 $10^3 m^3/d$

VOYAGER Conoco Carvel
102/07-11-053-01W5/0
ELLERSLIE (1334 - 1336 mKB)
Flow & Buildup (Dec 15, 2003 - Jan 20, 2004)

Vertical 1

Transient Forecast



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VOYAGER Conoco Carvel
102/07-11-053-01W5/0
ELLERSLIE (1334 - 1336 mKB)
Flow & Buildup (Dec 15, 2003 - Jan 20, 2004)

Vertical 1

Item	Time @ 5682 kPa s = 14.33 Months	Rate @ 5682 kPa s = 14.33 $10^3m^3/d$	Cum. Prod. @ 5682 kPa s = 14.33 10^6m^3	P_R @ 5682 kPa s = 14.33 kPa	P_{wf} @ 5682 kPa s = 14.33 kPa
1	0.000	56.348	0.000	9996.4	9996.4
2	0.033	56.348	0.056	9975.8	7556.8
3	0.066	56.348	0.113	9955.1	7456.9
4	0.099	56.348	0.169	9934.5	7372.5
5	0.131	56.348	0.225	9913.9	7294.5
6	0.164	56.348	0.282	9893.2	7219.7
7	0.197	56.348	0.338	9872.5	7147.8
8	0.230	56.348	0.394	9851.9	7077.9
9	0.263	56.348	0.451	9831.2	7010.2
10	0.296	56.348	0.507	9810.5	6944.1
11	0.329	56.348	0.563	9789.8	6879.9
12	0.361	56.348	0.620	9769.1	6817.6
13	0.394	56.348	0.676	9748.5	6757.0
14	0.427	56.348	0.733	9727.8	6696.8
15	0.460	56.348	0.789	9707.1	6638.1
16	0.493	56.348	0.845	9686.4	6580.1
17	0.526	56.348	0.902	9665.7	6522.9
18	0.559	56.348	0.958	9645.0	6466.8
19	0.591	56.348	1.014	9624.3	6411.4
20	0.624	56.348	1.071	9603.5	6357.1
21	0.657	56.348	1.127	9582.8	6302.8
22	0.690	56.348	1.183	9562.1	6249.3
23	0.723	56.348	1.240	9541.4	6196.6
24	0.756	56.348	1.296	9520.6	6143.8
25	0.789	56.348	1.352	9499.9	6092.2
26	0.821	56.348	1.409	9479.2	6041.0
27	0.854	56.348	1.465	9458.4	5990.0
28	0.887	56.348	1.521	9437.7	5939.7
29	0.920	56.348	1.578	9416.9	5889.3
30	0.953	56.348	1.634	9396.1	5839.2
31	0.986	56.348	1.690	9375.3	5789.9
32	1.000	56.348	1.715	9366.2	5768.3
33	1.059	56.322	1.817	9328.6	5682.0
34	2.000	44.263	3.084	8859.4	5682.0
35	3.000	36.741	4.202	8442.1	5682.0
36	4.000	31.141	5.150	8085.9	5682.0
37	5.000	26.594	5.960	7779.5	5682.0
38	6.000	22.812	6.654	7515.0	5682.0
39	7.000	19.637	7.252	7285.9	5682.0
40	8.000	16.957	7.768	7087.0	5682.0
41	9.000	14.679	8.215	6914.0	5682.0
42	10.000	12.737	8.602	6763.2	5682.0
43	11.000	11.075	8.939	6631.6	5682.0
44	12.000	9.650	9.233	6516.5	5682.0
45	12.000	31.687	9.233	6516.5	3000.0
46	13.000	25.835	10.020	6206.4	3000.0
47	14.000	22.133	10.693	5938.5	3000.0
48	15.000	19.358	11.283	5702.3	3000.0
49	16.000	17.076	11.802	5492.6	3000.0
50	17.000	15.135	12.263	5305.4	3000.0
51	18.000	13.457	12.673	5138.0	3000.0
52	19.000	12.000	13.038	4988.0	3000.0
53	20.000	10.728	13.364	4853.2	3000.0
54	21.000	9.613	13.657	4731.8	3000.0
55	22.000	8.632	13.920	4622.5	3000.0
56	23.000	7.764	14.156	4523.8	3000.0
57	24.000	6.996	14.369	4434.6	3000.0
58	24.000	13.864	14.369	4434.6	1500.0
59	25.000	11.890	14.731	4282.3	1500.0
60	26.000	10.511	15.051	4147.0	1500.0
61	27.000	9.445	15.338	4024.8	1500.0
62	28.000	8.560	15.599	3913.5	1500.0
63	29.000	7.793	15.836	3811.8	1500.0
64	30.000	7.112	16.052	3718.6	1500.0
65	31.000	6.510	16.251	3633.1	1500.0
66	32.000	5.966	16.432	3554.5	1500.0
67	33.000	5.478	16.599	3482.2	1500.0
68	34.000	5.037	16.752	3415.5	1500.0
69	35.000	4.638	16.893	3353.9	1500.0
70	36.000	4.273	17.023	3297.1	1500.0
71	37.000	3.946	17.144	3244.5	1500.0
72	38.000	3.644	17.255	3195.8	1500.0
73	39.000	3.370	17.357	3150.7	1500.0
74	40.000	3.121	17.452	3108.9	1500.0
75	41.000	2.891	17.540	3070.0	1500.0
76	42.000	2.677	17.622	3034.0	1500.0

Vertical 1

Item	Time @ 5682 kPa s = 14.33 Months	Rate @ 5682 kPa s = 14.33 $10^3m^3/d$	Cum. Prod. @ 5682 kPa s = 14.33 10^6m^3	P_R @ 5682 kPa s = 14.33 kPa	P_{wf} @ 5682 kPa s = 14.33 kPa
77	43.000	2.487	17.697	3000.6	1500.0
78	44.000	2.310	17.768	2969.4	1500.0
79	45.000	2.146	17.833	2940.4	1500.0
80	46.000	1.993	17.894	2913.5	1500.0
81	47.000	1.853	17.950	2888.4	1500.0
82	48.000	1.727	18.003	2865.1	1500.0

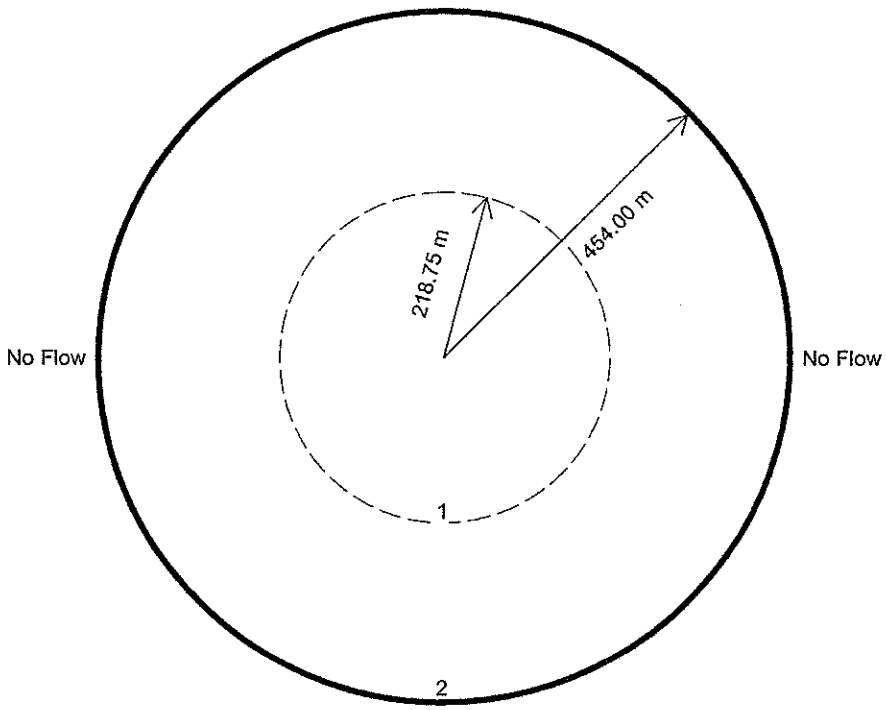
Composite 2

VOYAGER Conoco Carvel
102/07-11-053-01W5/0
ELLERSLIE (1334 - 1336 mKB)
Flow & Buildup (Dec 15, 2003 - Jan 20, 2004)

s = 14.702
k_1 = 58.724 mD
k_2 = 0.827 mD

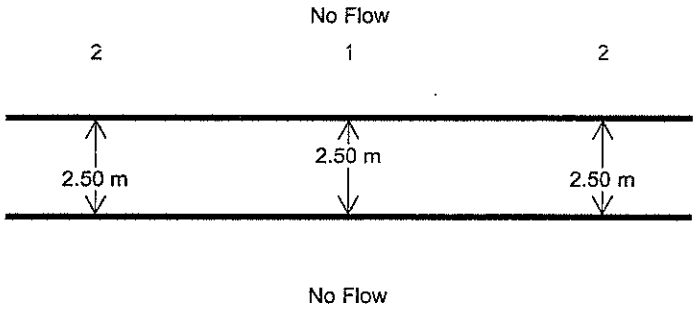
Plan View

(Not to scale)



Side View

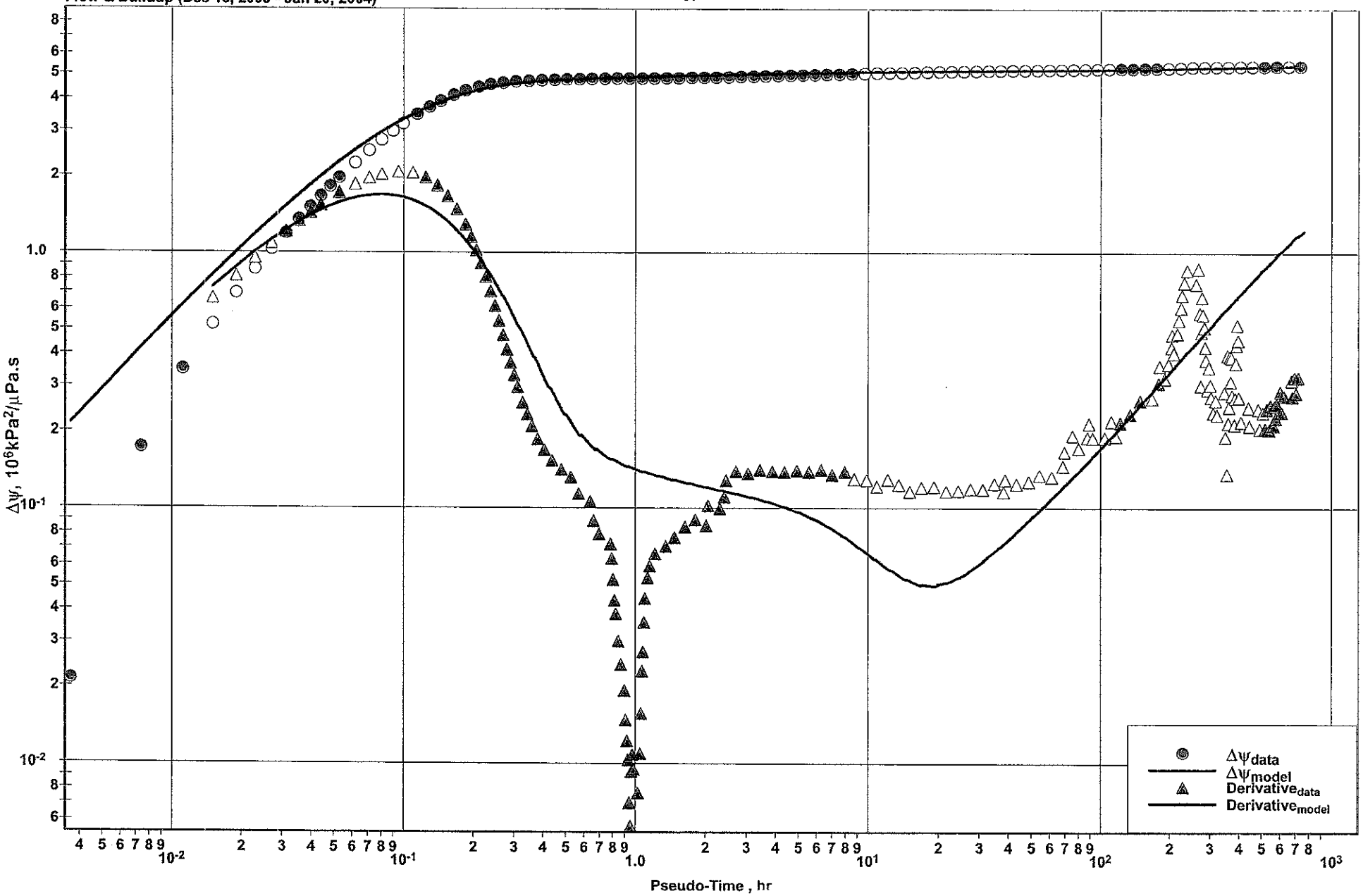
(Not to scale)



VOYAGER Conoco Carvel
102/07-11-053-01W5/0
ELLERSLIE (1334 - 1336 mKB)
Flow & Buildup (Dec 15, 2003 - Jan 20, 2004)

Composite 2

Typecurve



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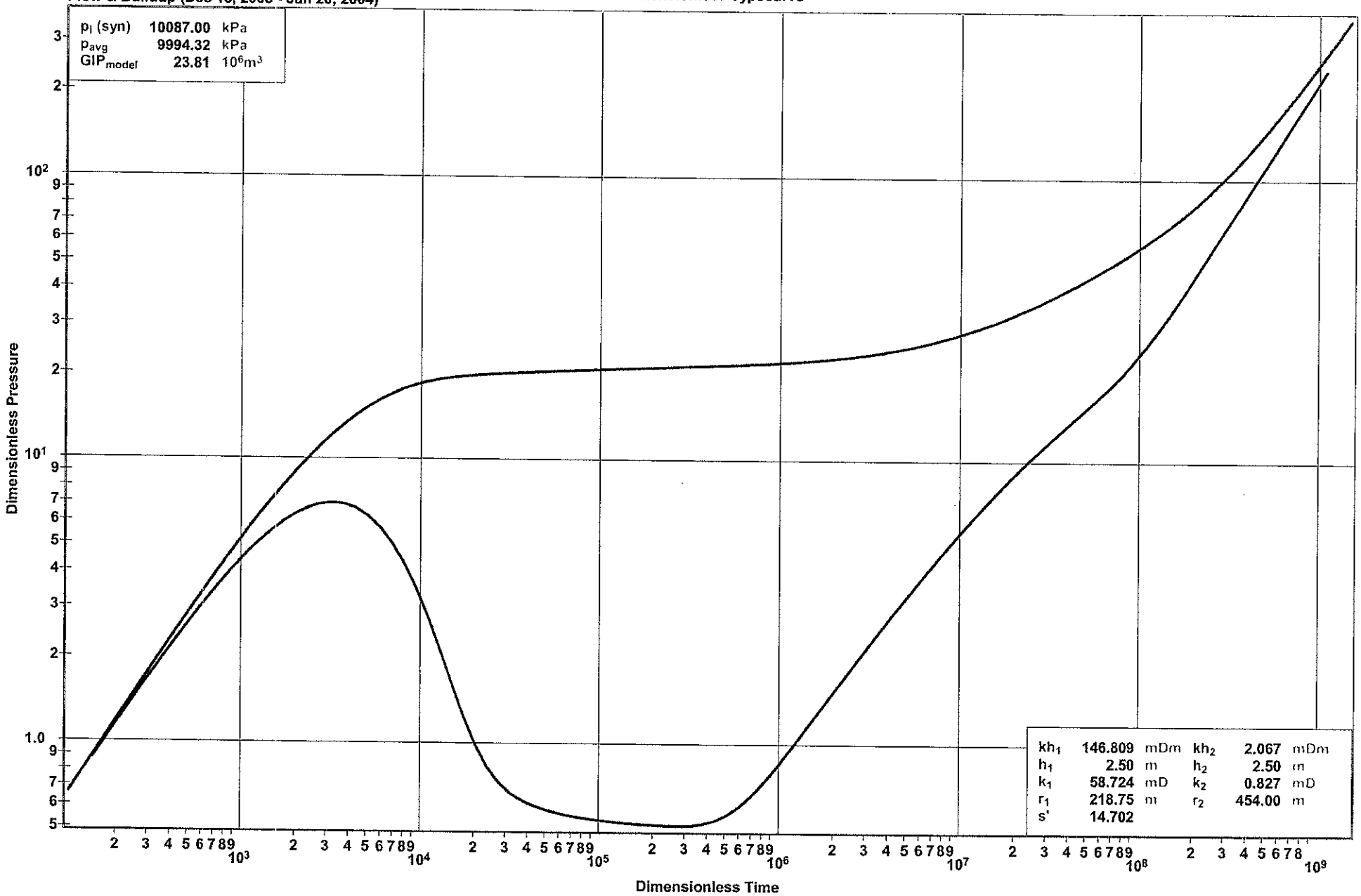
VOYAGER Conoco Carvel
102/07-11-053-01W5/0
ELLERSLIE (1334 - 1336 mKB)
Flow & Buildup (Dec 15, 2003 - Jan 20, 2004)

Composite 2

Dimensionless Typecurve



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Composite Gas Well Model

Case Name : Composite 2

VOYAGER Conoco Carvel

102/07-11-053-01W5/0

ELLERSLIE (1334 - 1336 mKB)

Flow & Buildup (Dec 15, 2003 - Jan 20, 2004)

Model Parameters

	Region 1		Region 2	
Permeability	k_1=	58.724 mD	k_2=	0.827 mD
Viscosity	μ_1=	0.015 mPa.s	μ_2=	0.015 mPa.s
Net Pay	h_1=	2.50 m	h_2=	2.50 m
Total Porosity	Φ_{t1}=	20.00 %	Φ_{t2}=	20.00 %
Total Compressibility	c_{t1}=	7.830e-5 kPa^{-1}	c_{t2}=	7.830e-5 kPa^{-1}
Region Radius	r_1=	218.75 m	r_2=	454.00 m

Skin (s)	14.702
Turbulence Factor (D)	0.00 $(10^3\ m^3/d)^{-1}$
Apparent Wellbore Storage Dim. (C_{aD})	
Wellbore Storage Constant Dim. (C_D)	193.88
Storage Pressure Param. Dim. (C_{pD})	

Formation Parameters

Gas Saturation (S_g)	70.00 %
Water Saturation (S_w)	30.00 %
Oil Saturation (S_o)	0.00 %
Wellbore Radius (r_w)	0.150 m
Formation Temperature (T)	51.5 °C

Fluid Properties

Gas Gravity (G)	0.678
N_2	3.48 %
H_2S	0.00 %
CO_2	1.78 %
Critical Pressure (P_c)	4595.30 kPa
Critical Temperature (T_c)	207.90 K
PVT Reference Pressure (p_{PVT})	10087.00 kPa
Gas Compressibility (c_g)	1.10910e-4 kPa^{-1}
Gas Compressibility Factor (z)	0.841
Gas Viscosity (μ_g)	14.679 μPa.s
Gas Formation Volume Factor (B_g)	0.009519 m^3/m^3

Production and Pressure

Final Gas Rate	83.894 $10^3 m^3/d$
Cumulative Gas Production	247.222 $10^3 m^3$
Final Measured Pressure	9833.11 kPa

Synthesis Results

Average Error	-0.97 %
Synthetic Initial Pressure (p_i)	10087.00 kPa
Average Reservoir Pressure	9994.32 kPa
Pressure Drop Due To Skin (Δp_s)	2860.72 kPa
Flow Efficiency (FE)	0.312
Damage Ratio (DR)	3.210

Forecasts

Forecast Flowing Pressuer (P_{flow})	5682.42 kPa
3 - Month Constant Rate Forecast @ Curr. Skin	36.289 $10^3 m^3/d$
6 - Month Constant Rate Forecast @ Curr. Skin	26.419 $10^3 m^3/d$
Forecast Flow Duration (t_{flow})	12.00 month
Constant Rate Forecast @ Curr. Skin	17.369 $10^3 m^3/d$
Constant Rate Forecast @ Skin=0	19.938 $10^3 m^3/d$
Constant Rate Forecast @ Skin=-4	20.776 $10^3 m^3/d$