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Advanced Reservoir Characterization and Horizontal Laterals
in a Class I Reservoir – East Binger (Marchand) Unit”**

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Abstract

The reservoir characterization and investigation of the benefits of horizontal wells in the East Binger Unit miscible nitrogen flood has been completed. A significant work program was implemented from 2002 to 2005 in an effort to reduce gas cycling and economically increase ultimate oil recovery. Horizontal and vertical infill wells were drilled and existing producers were converted to injection. Due to successful infill drilling based on the improved flow characterization, more drilling was done than originally planned, and further drilling will occur after the project is completed.

Through the drilling of wells and reservoir characterization work, it was determined that poor areal sweep efficiency is the primary factor causing nitrogen cycling and limiting oil recovery. This is in contrast to the perception prior to the initiation of development, which was that gravity segregation was causing poor *vertical* sweep efficiency.

Although not true of all infill wells, most were drilled in areas with little sweep and came online producing gas with much lower nitrogen contents than previously drilled wells in the field and in the pilot area. Seven vertical and three horizontal wells were drilled in the pilot area throughout the project. As previously reported, the benefits of horizontal drilling were found to be insufficient to justify their increased cost.

Nitrogen recycle, defined as nitrogen production as a percentage of injection, decreased from 72% prior to initiation of the project to about 25% before rising back to a current rate of 40%. Injection into the pilot area, despite being limited at times by problems in the Air Separation Unit of the Nitrogen Management Facility, increased 60% over levels prior to the project. Meanwhile, gas production and nitrogen content of produced gas both decreased.

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Quarterly Technical Progress Report – 2nd Quarter 2006

Introduction

The DOE-sponsored project in the East Binger Unit (“EBU”) miscible nitrogen injection project has been completed. A significant work program was implemented from 2002 to 2005 in an effort to reduce gas cycling and economically increase ultimate oil recovery. Horizontal and vertical infill wells were drilled and existing producers were converted to injection. Overall project results have been encouraging, with reductions in nitrogen production and cycling, and fluid flow in the reservoir is better understood. Due to successful infill drilling based on the improved flow characterization, more drilling was done than originally planned, and further drilling will occur after the project is completed. Data gathering, specifically in the form of produced gas analyses from producers in the project area, continued throughout the project.

Executive Summary

The reservoir characterization and investigation of the benefits of horizontal wells in the East Binger Unit miscible nitrogen flood as been completed. A significant work program was implemented from 2002 to 2005 in an effort to reduce gas cycling and economically increase ultimate oil recovery. Horizontal and vertical infill wells were drilled and existing producers were converted to injection. Due to successful infill drilling based on the improved flow characterization, more drilling was done than originally planned, and further drilling will occur after the project is completed.

Through the drilling of wells and reservoir characterization work, it was determined that poor areal sweep efficiency is the primary factor causing nitrogen cycling and limiting oil recovery. This is in contrast to the perception prior to the initiation of development, which was that gravity segregation was causing poor *vertical* sweep efficiency.

Although not true of all infill wells, most were drilled in areas with little sweep and came online producing gas with much lower nitrogen contents than previously drilled wells in the field and in the pilot area. Seven vertical and three horizontal wells were drilled in the pilot area throughout the project. As previously reported, the benefits of horizontal drilling were found to be insufficient to justify their increased cost.

Nitrogen recycle, defined as nitrogen production as a percentage of injection, decreased from 72% prior to initiation of the project to about 25% before rising back to a current rate of 40%. Injection into the pilot area, despite being limited at times by problems in the Air Separation Unit of the Nitrogen Management Facility, increased 60% over levels prior to the project. Meanwhile, gas production and nitrogen content of produced gas both decreased.

Experimental

There were no experimental methods used in the work completed during this reporting period.

Results and Discussion

The following is a detailed review of the work conducted in this reporting period.

Task 1.3.1 – Continue Monitoring Program

Binger Operations, LLC (“BOL”) continues to monitor new well and overall pilot area performance. Figure 1 shows the well work implemented during the project. For the second quarter of 2006, pilot area production averaged 478 bopd, a net increase of 235 bopd over the projected current rate without development, and an increase of 27 bopd over the previous quarter. Overall, production from new wells in the project area added 277 bopd but was offset by the loss of 42 bopd from wells converted to injection. See Figures 2 (all wells in pilot area), 3 (pre-existing wells), and 4 (new wells).

Figure 4 shows the component rate streams of various wells and packages of wells that have been brought on line throughout the project. The recent increase of 27 bopd over the average rate of the prior quarter was largely driven by increases at two wells, EBU 46-3 and EBU 64-3H. EBU 46-3 increased following a period of lower than expected production associated with poor wellbore hydraulics, which was resolved by installing and lining out a rod pump. The increase at EBU 64-3H is a classical injection response; in addition to the increase in oil rate (from 40 to 60 bopd over a seven month period), the associated hydrocarbon gas has caused the overall nitrogen content in the well’s produced gas to drop from 52% to 31%.

Gas cycling is increasing but is still well below pre-project levels, as shown in Figure 2. Injection has leveled off at about 6.3 MMscf/d, about 58% higher than before the project began. Meanwhile, total nitrogen produced from the pilot area has declined from 2.9 MMscf/d (4.2 MMscf/d total gas with a nitrogen content of 69%) to 2.5 MMscf/d (4.3 MMscf/d total gas with a nitrogen content of 59%). As shown in the table that follows, this represents a total change in gas recycle from 72% prior to development to about 40% over the past six months. Gas production and gas nitrogen content will continue rise, but this clearly represents an improvement in flood performance.

Pilot Area Gas Recycle

	[A] Total Gas Production Rate (MMscf/d)	[B] Percent Nitrogen (%)	[C] = [A]*[B] Nitrogen Production Rate (MMscf/d)	[D] Nitrogen Injection Rate (MMscf/d)	[C] / [D] Percent Recycle (%)
Pre-Development Baseline (1H 2001)	4.2	69	2.9	4.0	72
Fourth Quarter 2003	3.1	55	1.7	6.9	25
First Quarter 2004	2.9	56	1.6	6.0	27
Second Quarter 2004	3.4	53	1.8	6.2	29
Third Quarter 2004	3.6	54	1.9	7.0	28
Fourth Quarter 2004	3.7	56	2.1	5.1 *	40
First Quarter 2005	3.4	58	2.0	4.4 *	46
Second Quarter 2005	3.7	60	2.2	6.8	33
Third Quarter 2005	4.3	62	2.6	6.1	44
Fourth Quarter 2005	4.2	64	2.7	6.4	42
First Quarter 2006	3.8	65	2.5	6.4	39
Second Quarter 2006	4.3	59	2.5	6.3	40

* Plant problems limited the supply of nitrogen for injection from November 2004 through February 2005.

Based on the pre-project decline and the rate at the end of the reporting period, the project has added 1.9 million barrels of oil reserves, 0.8 million barrels of NGL reserves, and 3.1 BCF of residue gas reserves. See Figure 5.

A secondary aspect of Pilot Area performance monitoring is the comparison of the performances of horizontal wells to vertical wells. Figure 6 is a plot of the rate performances of the new wells drilled in the project, excluding EBU 37-3H, the horizontal well drilled in Budget Period 1, and EBU 43-2 and EBU 60-2, two recently completed vertical wells. As previously reported, these three wells were drilled in areas with much higher gas saturation. EBU 37 G-3H and EBU 43-2 have been converted to injection and EBU 60-2 is awaiting conversion.

Comparisons of wells in similar reservoir environments (thickness and gas saturation) show that vertical wells have performed nearly as well as the horizontal wells.

Figure 7 shows the averages of the following horizontal and vertical wells:

<u>Well</u>	<u>Net Pay</u>	<u>Average GOR & %N2 @ 6 - 9 Months (reflect gas saturation)</u>	<u>Average GOR & %N2 @ 15 - 18 Months (reflect gas saturation)</u>
<i>Horizontal</i>			
EBU 63-2H	70' - 75'	4.3 Mcf/bbl & 21%	4.9 Mcf/bbl & 24%
EBU 64-3H	55' - 60'	5.6 Mcf/bbl & 17%	3.9 Mcf/bbl & 29%
<i>Average Horizontal</i>	65'	<i>5.0 Mcf/bbl & 19%</i>	<i>4.4 Mcf/bbl & 27%</i>
<i>Vertical</i>			
EBU 44-3	66'	2.4 Mcf/bbl & 3%	2.9 Mcf/bbl & 4%
EBU 46-3	80'	1.6 Mcf/bbl & 3%	1.3 Mcf/bbl & 4%
EBU 47-2	69'	5.9 Mcf/bbl & 54%	Not there yet
EBU 67-2	62'	11.6 Mcf/bbl & 50%	15.9 Mcf/bbl & 52%
EBU 74-2	45'	1.6 Mcf/bbl & 10%	1.7 Mcf/bbl & 17%
<i>Average Vertical</i>	63'	<i>4.6 Mcf/bbl & 24%</i>	<i>5.5 Mcf/bbl & 19%</i>

Most of the new wells have low GORs and nitrogen contents in produced gas, as indicated above and shown in Figure 8. The relative lack of nitrogen at the infill well locations indicates poor areal sweep – EBU 60-2 being a significant exception to this. For most new wells, current trends of nitrogen content data suggest it will be years before the nitrogen contents in their produced gas approach the current field average.

Task 1.3.3 – Technology Transfer Activities – Continue Updating Web Site

Additional technical progress reports have been posted on the project web site, www.eastbingerunit.com. A review of the project was presented to the Big Horn Section of the Society of Petroleum Engineers in Cody, Wyoming on May 4, 2006.

Conclusion

The reservoir characterization and investigation of the benefits of horizontal wells in the East Binger Unit miscible nitrogen flood as been completed. Through the drilling of wells and reservoir characterization work, it was determined that poor areal sweep efficiency is the primary factor causing nitrogen cycling and limiting oil recovery. This is in contrast to the perception prior to the initiation of development, which was that gravity segregation was causing poor *vertical* sweep efficiency.

Although not true of all infill wells, most were drilled in areas with little sweep and came online producing gas with much lower nitrogen contents than previously drilled wells in the field and in the pilot area. Seven vertical and three horizontal wells have been drilled in the pilot area

throughout the project. As previously reported, the benefits of horizontal drilling were found to be insufficient to justify their increased cost.

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References

There are no references for this report.

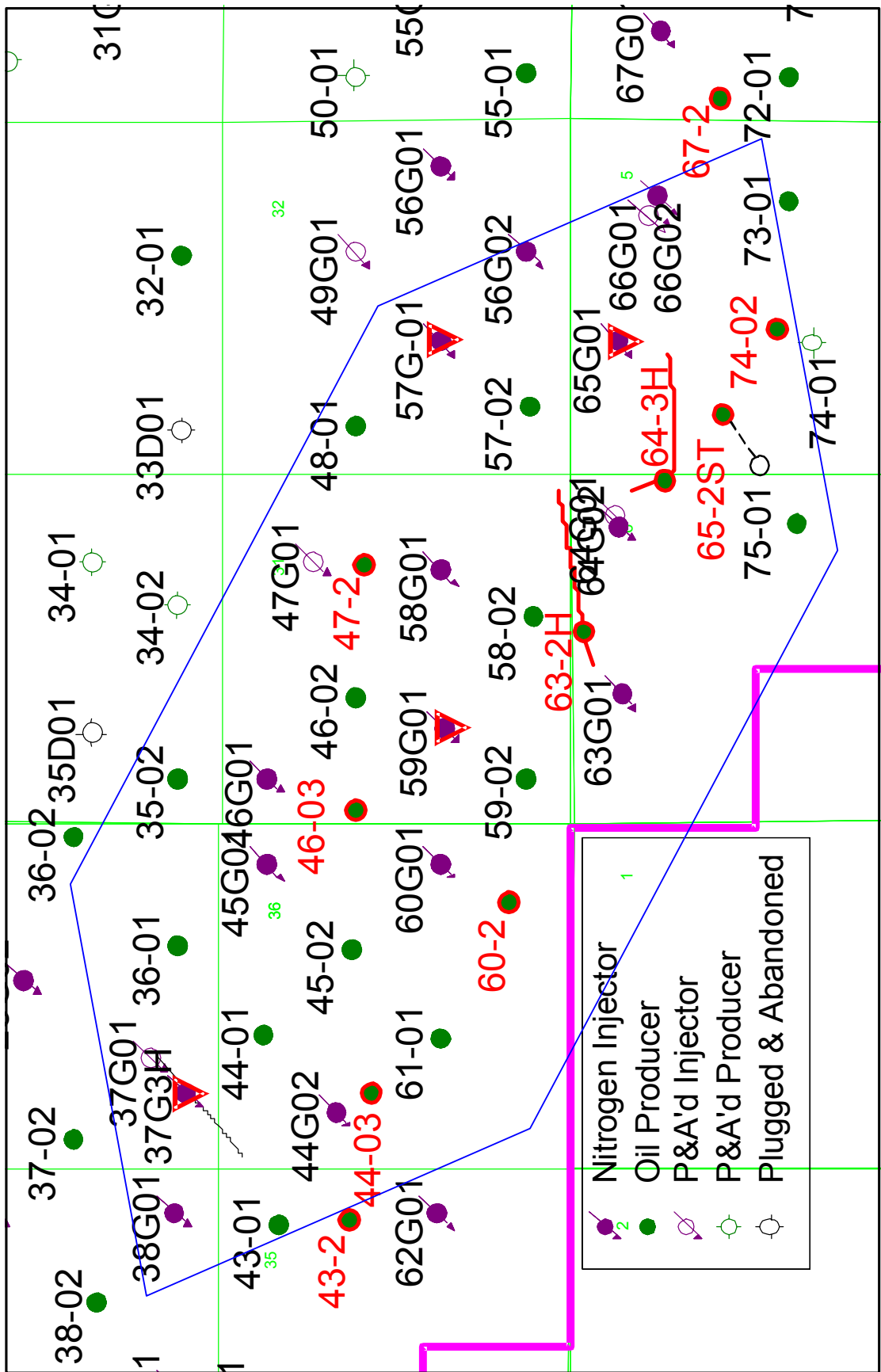


Figure 1. Map of the central portion of the East Binger Unit. The Pilot Area is indicated by the blue polygon. Well work implemented in the Project is highlighted in red.

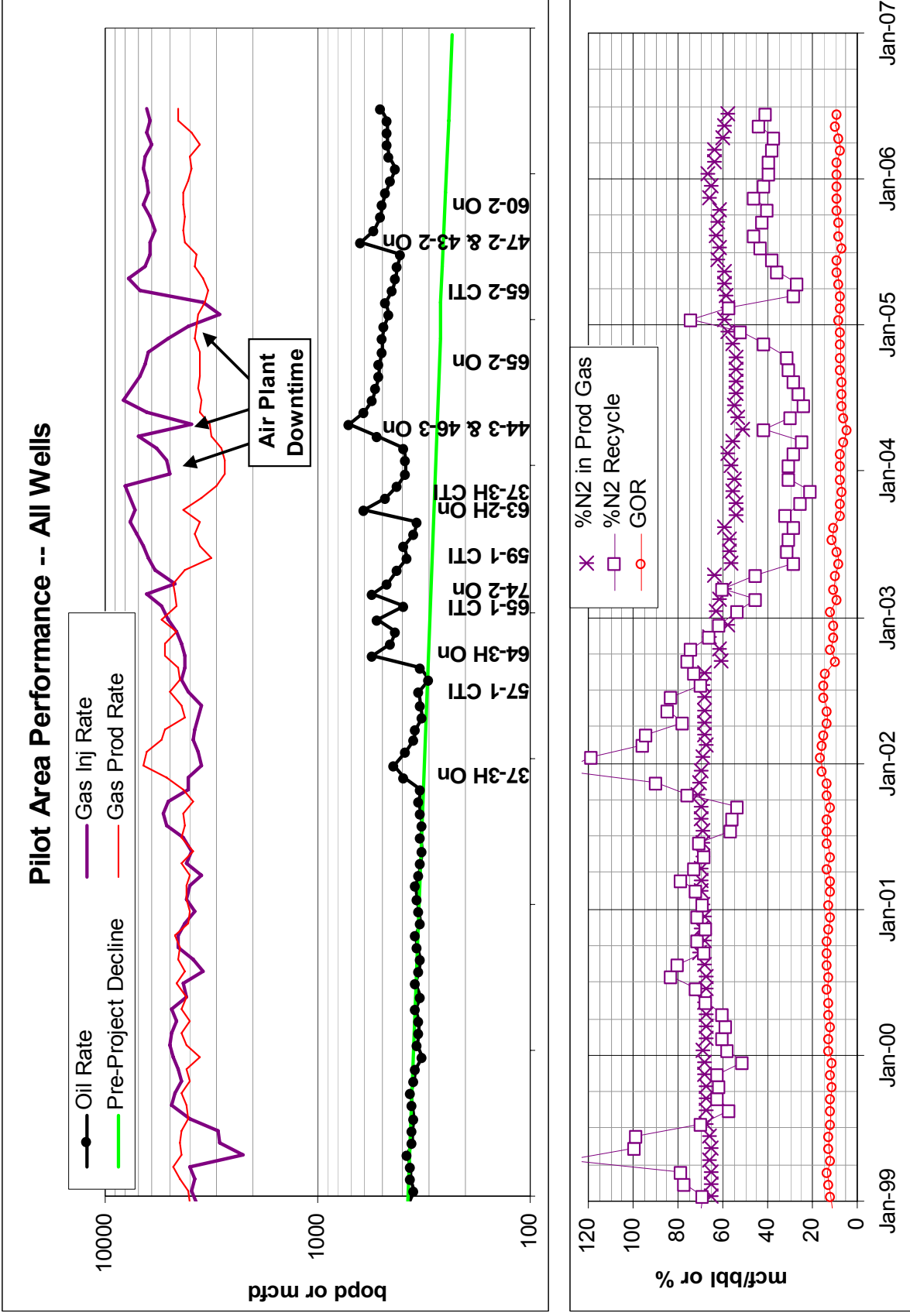


Figure 2. Production data for all wells in the pilot area.

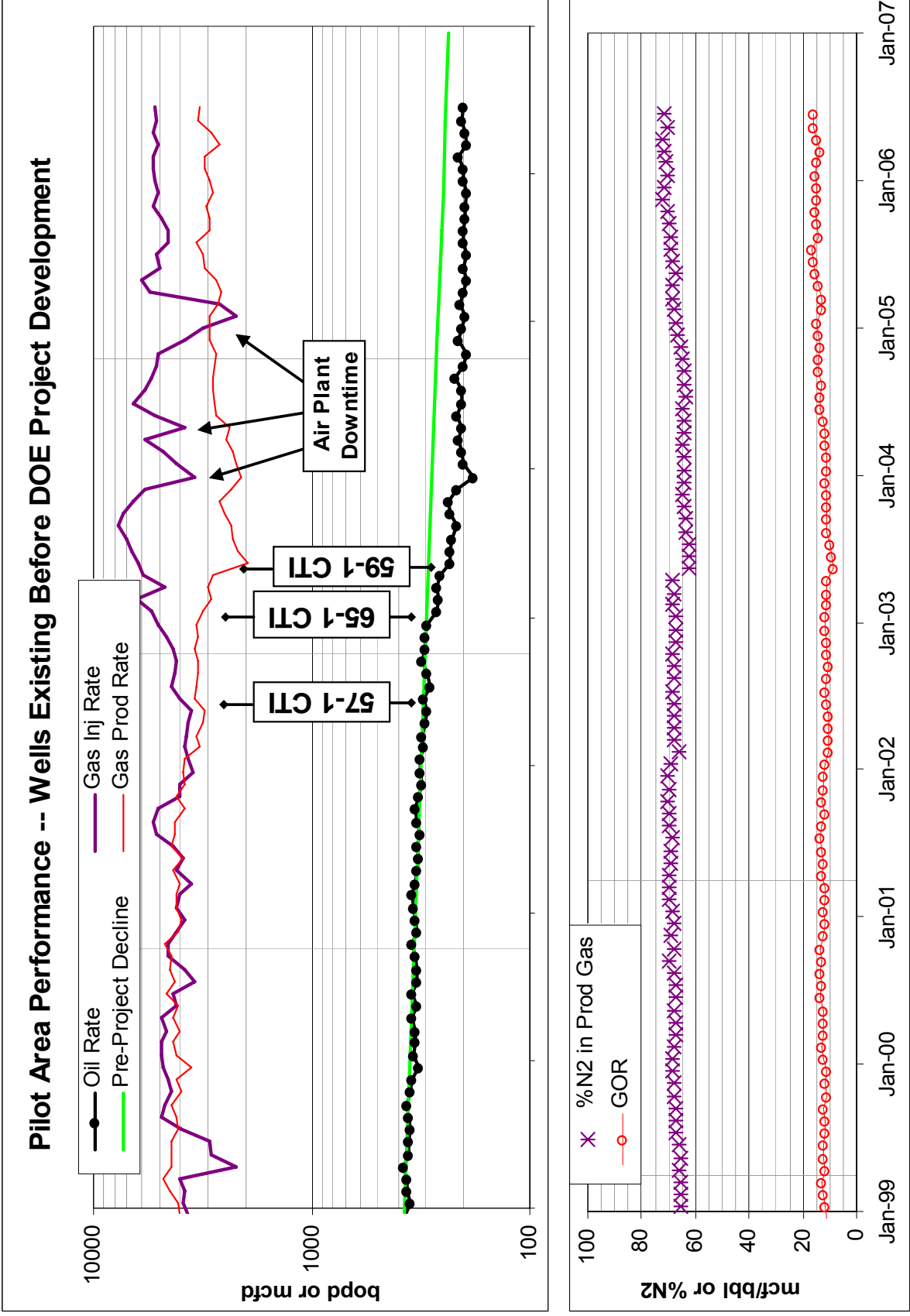


Figure 3. Production data for wells in the pilot area that existed before DOE Project development.

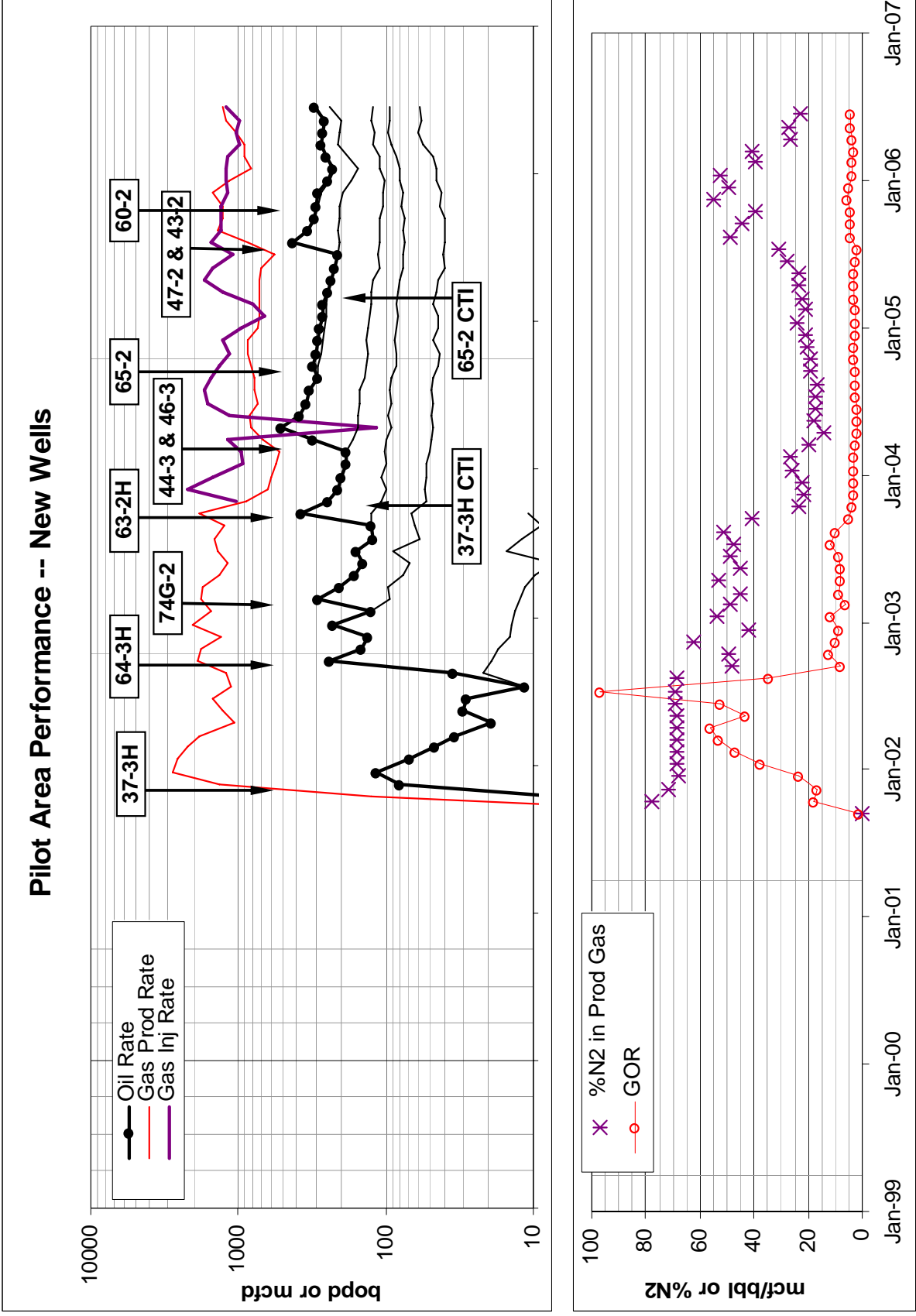


Figure 4. Production data for new wells in the pilot area.

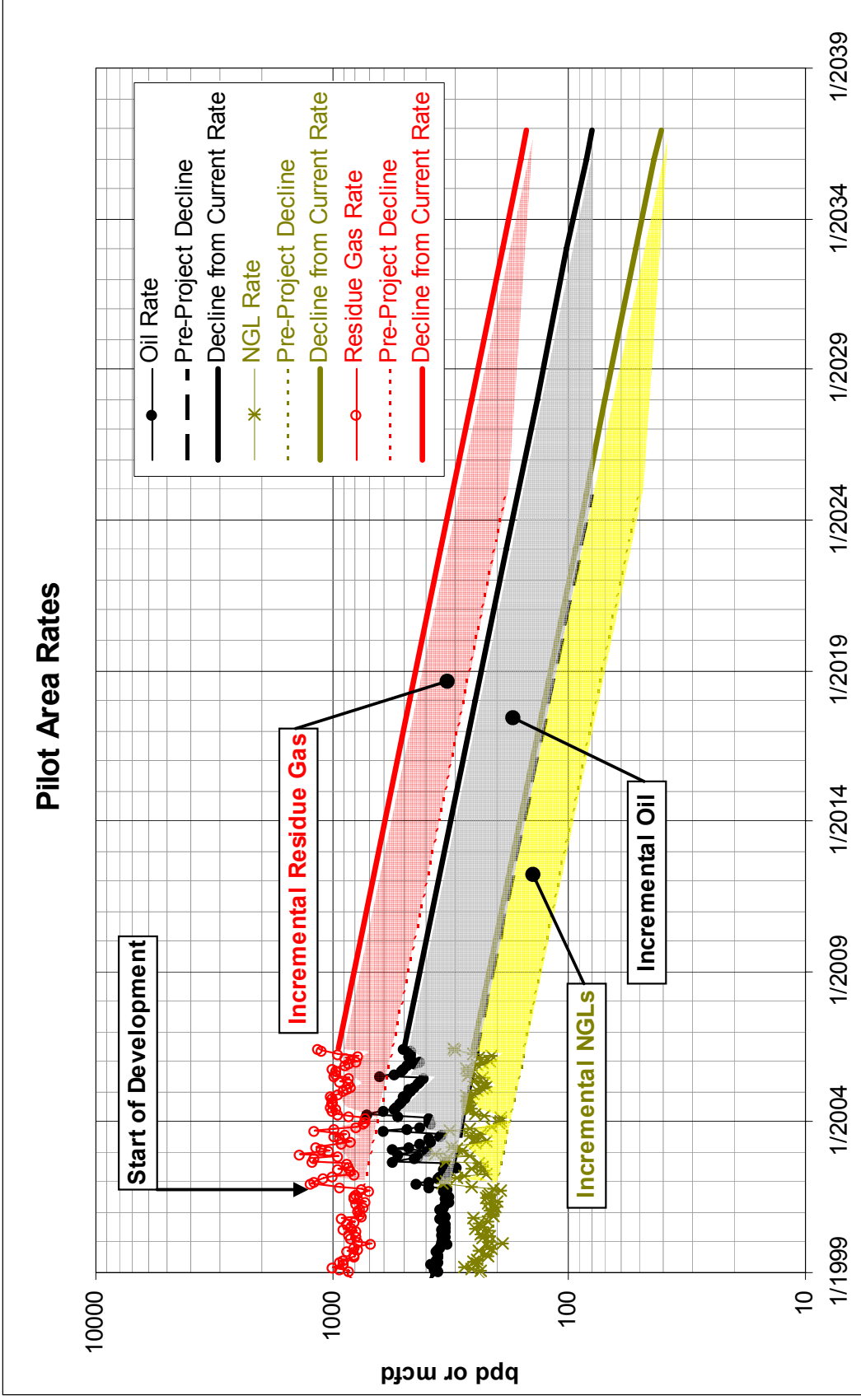


Figure 5. Oil, NGL, and Residue Gas forecasts without and with development. Shaded “wedges” reflect incremental reserves developed with the project.

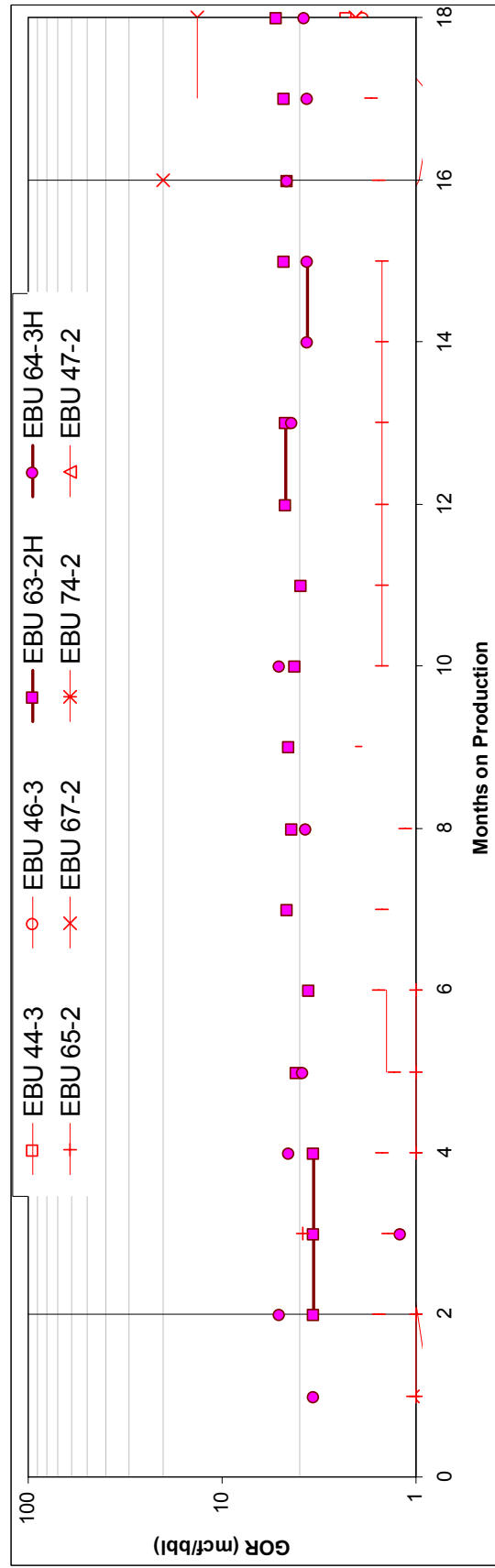
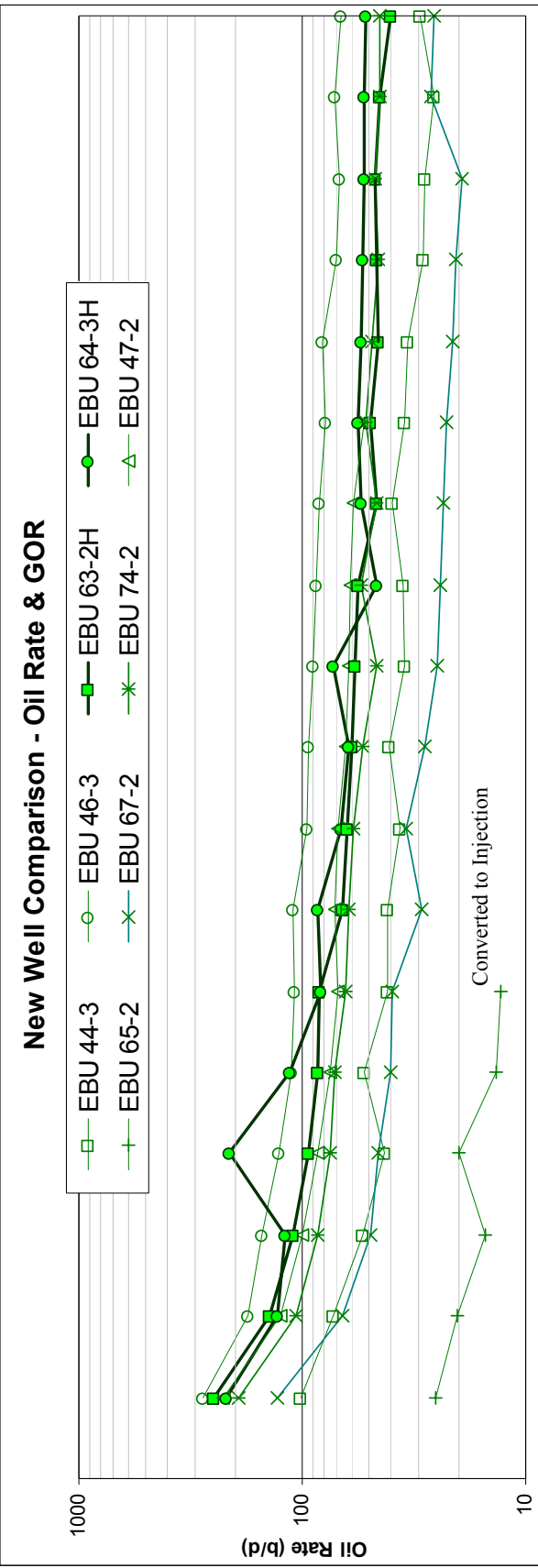


Figure 6. Comparison of production data for recent horizontal and vertical wells in or near the Pilot Area. Horizontal wells are designated with an “H” in their names.

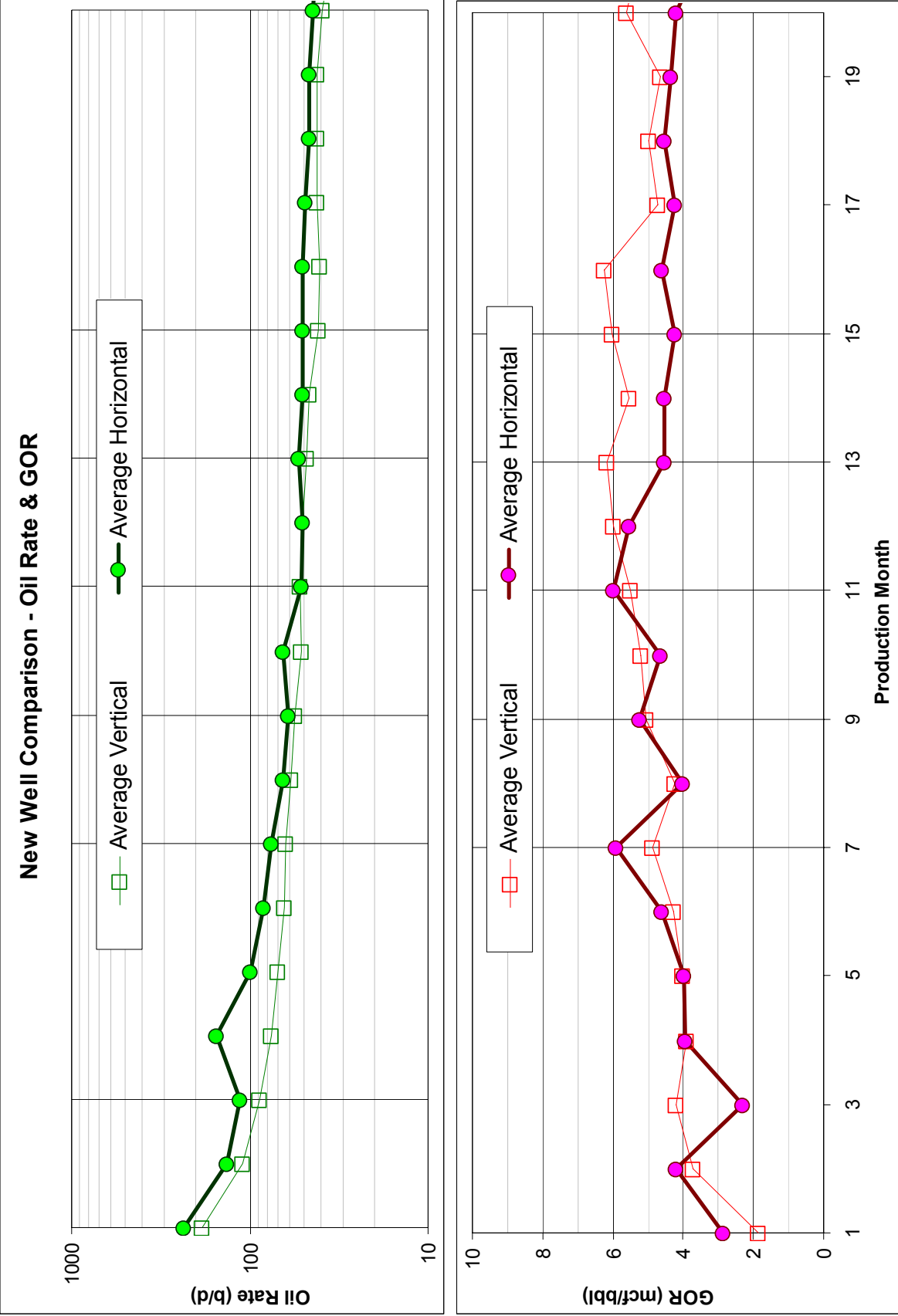


Figure 7. Comparison of average production data for two horizontal and five vertical wells in or near the Pilot Area.

East Binger Unit Pilot Area Nitrogen Content in Produced Gas Pilot Area Sample Data															
Well	4th Qtr 2001	1st Qtr 2003	2nd Qtr 2003	3rd Qtr 2003	4th Qtr 2003	1st Qtr 2004	2nd Qtr 2004	3rd Qtr 2004	4th Qtr 2004	1st Qtr 2005	2nd Qtr 2005	3rd Qtr 2005	4th Qtr 2005	1st Qtr 2006	2nd Qtr 2006
35-2	58%	-	63%	67%	63%	-	66%	-	67%	-	70%	-	-	68%	75%
36-1	65%	46%	47%	44%	45%	50%	58%	70%	74%	77%	80%	86%	-	82%	83%
36-2	25%	-	20%	-	18%	-	22%	-	18%	-	20%	-	-	23%	17%
37-2	83%	80%	79%	80%	81%	81%	83%	84%	83%	83%	85%	85%	-	85%	86%
43-1	9%	7%	-	6%	-	4%	4%	12%	11%	20%	27%	31%	-	33%	32%
44-1	69%	68%	71%	66%	68%	67%	69%	65%	66%	73%	68%	67%	-	70%	74%
45-2	56%	57%	59%	60%	61%	62%	64%	64%	65%	64%	67%	67%	-	69%	69%
46-2	62%	68%	64%	61%	62%	64%	62%	62%	61%	63%	66%	66%	-	69%	68%
48-1	83%	84%	85%	86%	87%	87%	87%	87%	87%	87%	87%	86%	-	86%	86%
57-2	37%	41%	45%	47%	40%	37%	39%	40%	43%	45%	45%	48%	-	51%	52%
58-2	8%	6%	5%	-	-	12%	6%	6%	17%	5%	5%	-	-	6%	12%
59-2	44%	48%	45%	43%	39%	45%	48%	49%	52%	54%	55%	53%	-	56%	54%
61-1	56%	-	56%	-	59%	-	63%	61%	-	60%	-	63%	-	63%	63%
73-1	13%	21%	-	21%	-	19%	-	24%	-	18%	-	11%	-	11%	-
Avg	48%	48%	53%	53%	57%	48%	52%	52%	54%	54%	56%	60%	-	55%	59%
43-2	-	-	-	-	-	-	-	-	-	-	-	91%	93%	CTI	-
44-3	-	-	-	-	-	4%	3%	3%	3%	4%	4%	4%	-	5%	6%
46-3	-	-	-	-	-	-	2%	3%	4%	4%	-	5%	-	4%	5%
47-2	-	-	-	-	-	-	-	-	-	-	-	42%	54%	54%	54%
60-2	-	-	-	-	-	-	-	-	-	-	-	-	91%	94%	95%
63-2H	-	-	-	16%	19%	22%	20%	19%	23%	26%	20%	18%	-	29%	21%
64-3H	-	17%	16%	23%	25%	36%	36%	30%	43%	45%	-	52%	-	18%	31%
65-2	-	-	-	-	-	-	-	25%	22%	CTI	-	-	-	-	-
74-2	-	8%	10%	10%	10%	19%	16%	16%	18%	24%	25%	28%	-	33%	33%
Avg	-	13%	13%	16%	18%	20%	15%	16%	19%	21%	16%	34%	-	34%	35%

Figure 8. Pilot Area gas sample data – percent nitrogen in produced gas. New wells are shown in blue at the bottom of the table. Limited data was obtained in the fourth quarter of 2005 due to a sampling problem.