PNGE 241

Making Investment Decisions Using Type Curve Analysis and Net Present Value Profile

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December 6, 1999

EXECUTIVE SUMMARY

The design project of the Fall 1999 semester in PNGE 241, Oil Property Evaluation, was to determine which lease our company should enter based on four months of production data and economic considerations for each well. The first well is located in Texas and requires an investment of $1,000,000. The investment required for the second well is $100,000 and can be found in Louisiana.

It was concluded that both wells are experiencing hyperbolic decline. This was made evident by constructing a chart of flow rates versus time on semi-log paper and analyzing the production data using Fetkovich's type curves for decline curve analysis.

Our group recommends that the company invest in the well located in Texas. The investment appears to be very large when compared to that of the well located Louisiana. However, when observing the Net Present Value profile it is clear that investing in the Texas well will be much more lucrative for a given number of interest rates including the 15.5% relative to our company.

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PROBLEM STATEMENT

The purpose of this project was to determine which investment opportunity, the Texas well or the Louisiana well, would generate a higher profit assuming that the time value of money for the company for the next three years is 15.5%. The projects were evaluated using decline curves, and a comparison was made using the Net Present Value Profile technique.

INTRODUCTION

"Oil wells usually reach their maximum daily output shortly after they are completed. From that time they decline in production, the rapidity of declining depending on the output of the wells and on other factors governing their productivity. The production curve of a well shows the amount of oil production per unit of time for several consecutive periods; if the conditions affecting the rate of production are not changed by outside influences, the curve will be fairly regular, and if projected, will furnish useful knowledge as to the future production of the well." The quote was taken from an article by J.O. Lewis and Carl H. Beal in 1918.

Predicting the production of a well is a key factor in determining the value of a well. An over prediction of the well's performance can cost a company tens to hundreds thousands of dollars. Decline curves are the most common means of forecasting production. Decline curves use data which is easy to obtain, they're easy to plot, they yield results on a time basis, and they're deceptively easy to analyze.

When plotted on a semi-log paper, sometimes the data will curve up or be concave upwards. The decline rate continuously decreaes with time according to a hyperbolic equation. An example of this is equation is (Thompson, p.5-1):

$$q = q_i (1 + b D_i t)^{-1/b}$$

where: q = producing rate at time t (vol/time)
q_i = producing rate at time 0 (vol/time)
D_i = initial nominal decline rate, t=0 (1/time)
b = hyperbolic exponent
t = time

METHODOLOGY

**Note: Each group member did a type curve analysis and the average of the three was used in the calculations. The calculations were done in Excel.*

Type Curve Matching

Place a sheet of tracing paper over the type curve. Mark the axis and grid lines on the tracing paper. (We made a transparency copy of the type curve.) Label the each axis with the appropriate scale for the given data (t on the x-axis, q on the y-axis). Plot the data on the tracing paper, but do not connect the dots. Remember that the scale is in log-log form.

Move the tracing paper over the type curve, keeping the x-axis and y-axis on the racing paper and type curve parallel to each other. Match the data points to a type curve. The later data points are usually more important than the earlier ones. Then, pick a match point anywhere on the paper. Be sure to mark it on both the tracing paper and the type curve. Record the values of the match point as follows:

q from the tracing paper = q
t from the tracing paper = t
q from the type curve = q_{Dd}
t from the type curve = t_{Dd}

If the data falls in the Analytical Region (upper left curves), the ensuing values can be found:

r_e/r_w = read from matched type curve

$$kh/\mu = \frac{q}{q_{Dd}} \quad \frac{141.2\ B\ [\ln (r_e/r_w) - ½)}{(P_i - P_{wf})}$$

where: q = bbl/d

$$\phi c = \frac{t}{t_{Dd}} \quad \frac{0.00634\ k}{\mu\ r_w 2\ ½\ [(r_e/r_w)2 - 1]\ [\ln (re/r_w) - ½]}$$

where: t = days

If the data falls in the Empirical Region (lower right curves), the ensuing values can be found:

b = read from matched type curve

$$q_i = \frac{q}{q_{Dd}}$$

$$D_i = \frac{t_{Dd}}{t}$$

The unit of q_i is the same as the flow rate unit used in the plot and the unit of D_i is the same as the inverse of the time unit used.

Net Present Value Profile

The q_i that was found was converted from BOPD to bbl/month and the D_i was changed from 1/day to 1/month. First, the q for each month was calculated:

$$q = q_i(1 + b\, D_i\, t)^{-1/b}$$

Then the cumulative oil produced is computed:

$$Np = \frac{q_i^b}{D_i\,(1-b)}\,(q_i^{1-b} - q^{1-b})$$

In order to calculate the Net Present Value for each month, the production per month must be found:

$$Np/month = Np_n - Np_{n-1}$$

The profit per month is now figured:

Profit = Np/month * price of oil

where: price of oil increases 5% per year

The operating cost is:

Op. Cost = Np/month * cost/bbl

where: the cost is fixed and the investment is the cost for time=0

Finally the Net Present Value (NPV) can be calculated:

$$NPV = \frac{(Profit - Op.\ Cost)}{(1 + interest\ rate)^t}$$

where: interest rate = 0%, 5%, 10%, 15.5%, 20%, and 25% to to create a graph.

Now a semi-log plot of q vs t can be graphed to determine if the decline is hyperbolic (q is the semi-log value). A linear plot of NPV vs discount rate (interest rate) can be used to compare the two investment opportunities. The objective is the determine which well is more profitable at an interest rate of 15.5%.

RESULTS

The results of analyzing the production data from the Texas and Louisiana wells using decline curve analysis shows that both wells are hyperbolically declining (Appendix A). The Texas well has a b of 0.5, a q_i equal to 109,300 BOPD, and a D_i of 0.11/day, while the Louisiana well has a b of 0.2, a q_i equal to 102,000 BOPD, and a D_i of 0.0975/day. Using these values of b, q_i, and D_i , a monthly Net Cash Flow and Net Present Value Profile were generated for both wells for three years. The results of these calculations are summarized in Table 1, below, and the complete results for each well are found in Table 2 – Texas, and Table 3 – Louisiana. The Net Present Value Profile for each well can be seen in Graph 1. The semilog graphs of flow rate versus time show that the wells are hyperbolically declining, which supports the decline curve analysis (Graphs 2 & 3).

Table 1 – Net Present Value

Discount Rate	Texas NPV, $	Louisiana NPV, $
0%	21,527,302.80	18,234,073.12
5.0%	21,289,835.04	18,140,245.75
10.0%	21,061,657.58	18,047,444.37
15.5%	20,820,539.49	17,946,525.07
20.0%	20,630,380.03	17,864,843.68
25.0%	20,426,058.07	17,775,007.88

Table 2- TEXAS

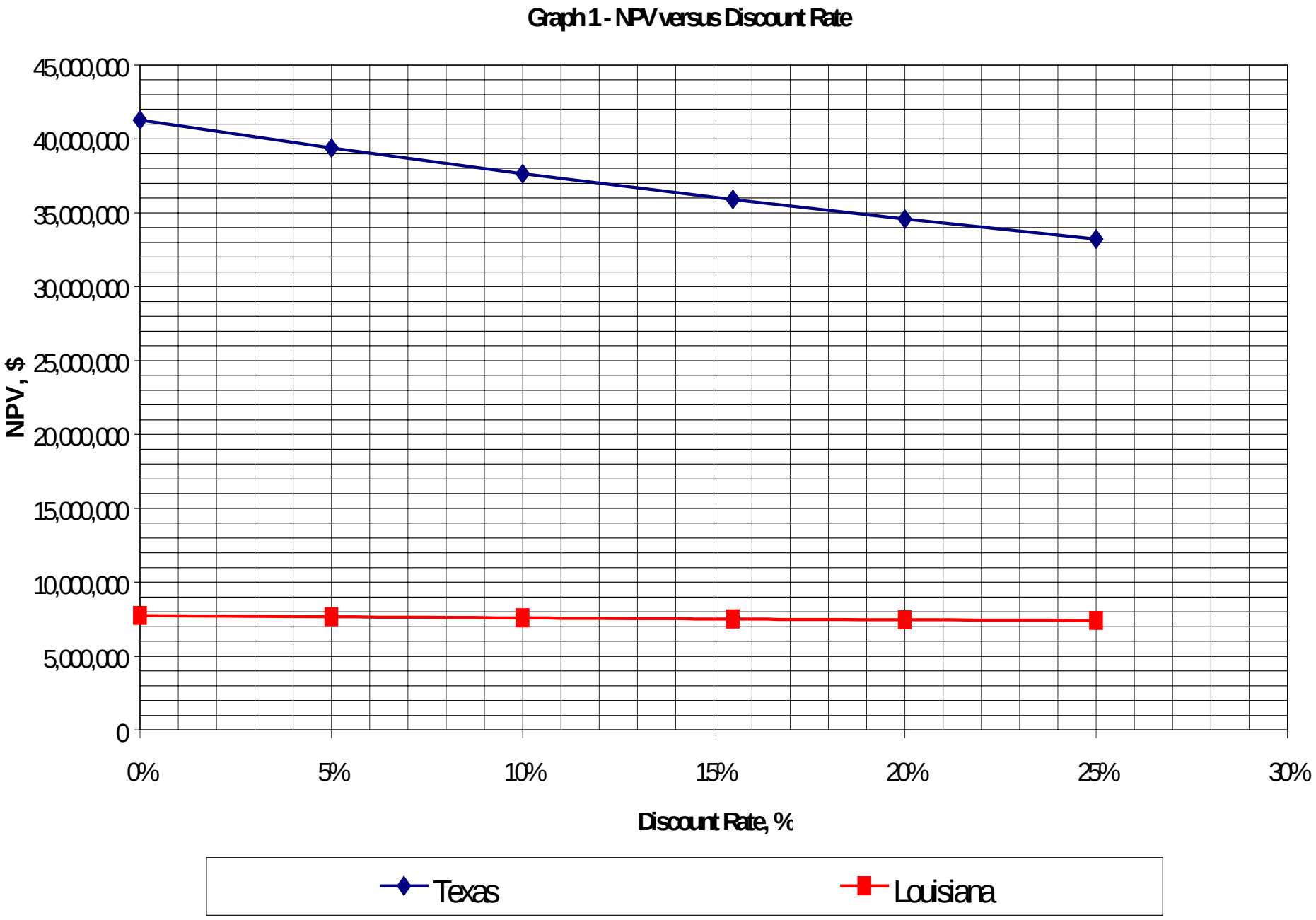
Months	Flow Rate, bbl/month	Np, bbl	Np/month, bbl	Profit, $	Operating Cost, $	NPV @ 0.0%	NPV @ 5.0%	NPV @ 10.0%	NPV @ 15.5%
0	0.00	0.00	0.00	0.00	-1,000,000.00	-1,000,000.00	-1,000,000.00	-1,000,000.00	-1,000,000.00
1	465,394.06	1243532.93	1,243,532.93	21,140,059.88	6,851,866.47	14,288,193.41	14,228,906.30	14,170,109.17	14,105,991.03
2	176,081.66	1529797.42	286,264.49	4,866,496.29	1,577,317.33	3,289,178.96	3,261,939.50	3,235,037.02	3,205,826.91
3	91,807.49	1656941.49	127,144.07	2,161,449.15	700,563.81	1,460,885.34	1,442,775.40	1,424,963.56	1,405,707.55
4	56,216.91	1728782.52	71,841.03	1,221,297.49	395,844.07	825,453.42	811,837.99	798,502.12	784,147.39
5	37,926.44	1774957.26	46,174.75	784,970.69	254,422.85	530,547.84	519,631.59	508,983.76	497,572.04
6	27,301.42	1807135.61	32,178.34	547,031.79	177,302.66	369,729.13	360,619.22	351,770.10	342,327.17
7	20,587.93	1830843.83	23,708.22	403,039.79	130,632.31	272,407.48	264,593.05	257,033.76	249,002.10
8	16,077.47	1849037.28	18,193.46	309,288.75	100,245.94	209,042.81	202,203.57	195,615.03	188,645.08
9	12,901.85	1863439.68	14,402.40	244,840.74	79,357.21	165,483.54	159,405.24	153,573.99	147,431.86
10	10,581.96	1875124.15	11,684.47	198,636.03	64,381.44	134,254.59	128,786.73	123,562.84	118,084.25
11	8,835.85	1884793.73	9,669.58	164,382.79	53,279.36	111,103.43	106,136.23	101,410.30	96,475.40
12	7,488.80	1892928.22	8,134.49	138,286.32	44,821.04	93,465.28	88,916.16	84,605.94	80,124.57
13	6,427.85	1899866.29	6,938.07	123,844.60	38,228.78	85,615.82	81,110.78	76,860.00	72,459.56
14	5,577.37	1905853.82	5,987.53	106,877.36	32,991.27	73,886.08	69,707.81	65,781.67	61,734.88
15	4,885.16	1911073.62	5,219.80	93,173.45	28,761.10	64,412.35	60,517.66	56,873.15	53,132.88
16	4,314.25	1915664.46	4,590.84	81,946.44	25,295.51	56,650.93	53,004.68	49,606.78	46,134.68
17	3,837.87	1919733.55	4,069.09	72,633.33	22,420.71	50,212.62	46,785.82	43,605.65	40,370.09
18	3,436.25	1923365.06	3,631.51	64,822.49	20,009.63	44,812.86	41,581.32	38,594.77	35,569.34
19	3,094.52	1926625.98	3,260.91	58,207.31	17,967.63	40,239.67	37,182.98	34,369.73	31,532.17
20	2,801.35	1929570.27	2,944.29	52,555.59	16,223.04	36,332.55	33,433.34	30,776.08	28,107.45
21	2,547.95	1932241.91	2,671.65	47,688.90	14,720.77	32,968.12	30,211.51	27,695.40	25,179.45
22	2,327.44	1934677.11	2,435.20	43,468.28	13,417.94	30,050.34	27,423.43	25,035.64	22,658.32
23	2,134.36	1936905.92	2,228.81	39,784.23	12,280.73	27,503.50	24,995.08	22,724.43	20,473.52
24	1,964.35	1938953.51	2,047.59	36,549.49	11,282.22	25,267.27	22,867.52	20,704.24	18,569.02
25	1,813.87	1940841.12	1,887.61	35,373.82	10,400.73	24,973.09	22,507.50	20,294.07	18,118.79
26	1,680.04	1942586.80	1,745.67	32,713.94	9,618.67	23,095.28	20,728.71	18,612.98	16,542.70
27	1,560.50	1944205.96	1,619.17	30,343.20	8,921.61	21,421.59	19,146.75	17,121.44	15,148.21
28	1,453.27	1945711.90	1,505.93	28,221.16	8,297.68	19,923.48	17,733.84	15,792.45	13,909.16
29	1,356.73	1947116.07	1,404.17	26,314.20	7,736.99	18,577.21	16,466.91	14,603.63	12,803.91
30	1,269.50	1948428.46	1,312.39	24,594.21	7,231.28	17,362.94	15,326.72	13,536.28	11,814.40
31	1,190.42	1949657.78	1,229.32	23,037.52	6,773.57	16,263.95	14,297.04	12,574.71	10,925.49
32	1,118.50	1950811.68	1,153.90	21,624.09	6,357.99	15,266.10	13,364.19	11,705.67	10,124.40
33	1,052.91	1951896.90	1,085.21	20,336.87	5,979.52	14,357.35	12,516.50	10,917.88	9,400.30
34	992.93	1952919.37	1,022.48	19,161.26	5,633.86	13,527.40	11,744.03	10,201.74	8,743.96
35	937.92	1953884.41	965.03	18,084.73	5,317.34	12,767.40	11,038.23	9,549.00	8,147.46
36	887.37	1954796.71	912.30	17,096.44	5,026.76	12,069.69	10,391.71	8,952.57	7,604.00
					Total	**$ 21,527,302.80**	**$ 21,289,835.04**	**$ 21,061,657.58**	**$20,820,539.49**

NPV @ 20.0%	NPV @ 25.0%
-1,000,000.00	-1,000,000.00
14,053,960.73	13,996,597.63
3,182,220.98	3,156,296.68
1,390,209.90	1,373,256.31
772,641.86	760,104.32
488,462.95	478,575.36
334,820.60	326,704.12
242,643.66	235,795.30
183,149.84	177,254.18
142,609.20	137,455.21
113,800.27	109,239.75
92,632.42	88,557.26
76,649.14	72,978.04
69,060.93	65,484.88
58,622.25	55,359.84
50,267.86	47,276.63
43,486.02	40,731.42
37,912.02	35,365.56
33,280.37	30,918.29
29,394.18	27,196.46
26,105.03	24,054.65
23,299.36	21,381.71
20,889.14	19,091.62
18,805.31	17,116.96
16,993.08	15,404.30
16,519.91	14,914.24
15,027.27	13,511.30
13,709.76	12,276.40
12,541.94	11,184.83
11,502.74	10,216.21
10,574.64	9,353.58
9,742.94	8,582.74
8,995.25	7,891.75
8,321.11	7,270.51
7,711.57	6,710.42
7,158.99	6,204.16
6,656.82	5,745.42
$ 20,630,380.03	**$ 20,426,058.07**

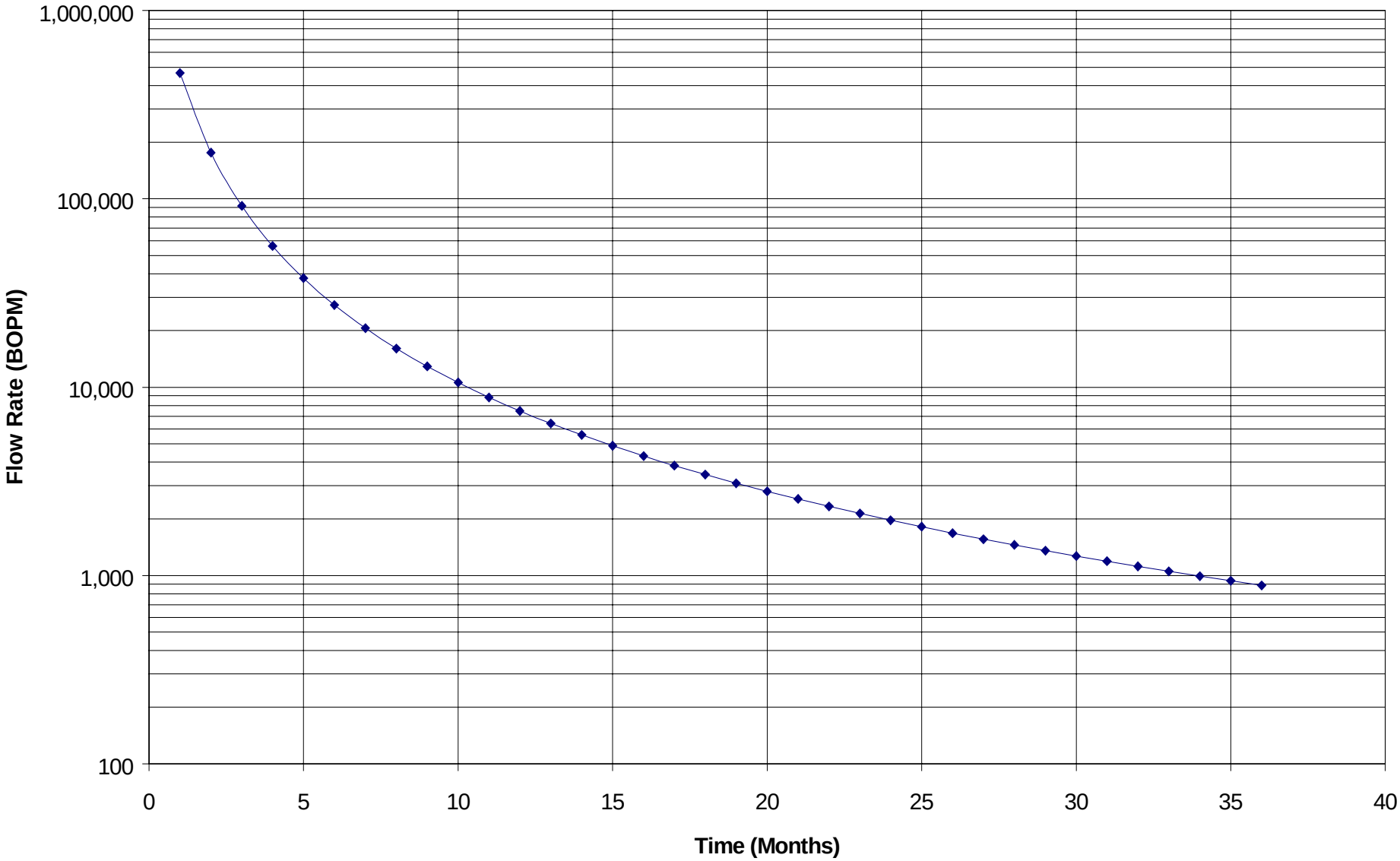
Table 3 - LOUISIANA

Months	Flow Rate, bbl/month	Np, bbl	Np/month, bbl	Profit, $	Operating Cost, $	NPV @ 0%	NPV @ 5%	NPV @ 10%	NPV @ 15.5%	NPV @ 20%
0	0.00	0.00	0.00	0.00	-100,000.00	-100,000.00	-100,000.00	-100,000.00	-100,000.00	-100,000.00
1	302,459.70	1,104,521.84	1,104,521.84	20,930,688.86	5,445,292.67	15,485,396.19	15,421,141.44	15,357,417.71	15,287,927.13	15,231,537.24
2	62,175.65	1,250,383.31	145,861.47	2,764,074.79	719,097.03	2,044,977.76	2,028,042.20	2,011,316.15	1,993,155.38	1,978,478.89
3	18,728.37	1,285,747.77	35,364.46	670,156.54	174,346.79	495,809.74	489,663.41	483,618.25	477,082.96	471,823.21
4	7,121.17	1,297,567.95	11,820.18	223,992.45	58,273.50	165,718.96	162,985.51	160,308.18	157,426.31	155,116.45
5	3,168.15	1,302,396.03	4,828.08	91,492.07	23,802.42	67,689.65	66,296.90	64,938.41	63,482.45	62,320.27
6	1,578.24	1,304,659.35	2,263.33	42,890.06	11,158.20	31,731.85	30,950.00	30,190.52	29,380.09	28,735.84
7	856.26	1,305,832.74	1,173.39	22,235.69	5,784.80	16,450.89	15,978.97	15,522.46	15,037.42	14,653.43
8	496.60	1,306,489.68	656.94	12,448.95	3,238.70	9,210.25	8,908.92	8,618.63	8,311.54	8,069.43
9	303.86	1,306,880.48	390.80	7,405.68	1,926.65	5,479.03	5,277.78	5,084.71	4,881.35	4,721.68
10	194.28	1,307,124.67	244.19	4,627.34	1,203.84	3,423.50	3,284.07	3,150.86	3,011.16	2,901.92
11	128.87	1,307,283.57	158.90	3,011.14	783.37	2,227.77	2,128.17	2,033.41	1,934.46	1,857.40
12	88.19	1,307,390.55	106.99	2,027.45	527.46	1,499.99	1,426.98	1,357.81	1,285.89	1,230.12
13	61.98	1,307,464.72	74.16	1,475.86	365.63	1,110.23	1,051.81	996.69	939.63	895.55
14	44.59	1,307,517.43	52.72	1,049.04	259.89	789.15	744.53	702.59	659.37	626.13
15	32.74	1,307,555.73	38.30	762.15	188.81	573.33	538.67	506.23	472.94	447.43
16	24.47	1,307,584.10	28.36	564.46	139.84	424.62	397.29	371.82	345.80	325.95
17	18.59	1,307,605.47	21.37	425.24	105.35	319.89	298.06	277.80	257.19	241.53
18	14.32	1,307,621.81	16.34	325.26	80.58	244.68	227.04	210.73	194.21	181.71
19	11.18	1,307,634.49	12.67	252.21	62.48	189.73	175.32	162.05	148.67	138.59
20	8.83	1,307,644.44	9.95	198.00	49.05	148.95	137.06	126.17	115.23	107.02
21	7.05	1,307,652.33	7.90	157.18	38.94	118.24	108.36	99.33	90.31	83.56
22	5.68	1,307,658.67	6.33	126.06	31.23	94.83	86.54	79.01	71.50	65.92
23	4.62	1,307,663.80	5.13	102.05	25.28	76.77	69.77	63.43	57.15	52.49
24	3.79	1,307,667.98	4.19	83.32	20.64	62.68	56.73	51.36	46.06	42.16
25	3.13	1,307,671.43	3.45	71.98	16.99	55.00	49.57	44.69	39.90	36.38
26	2.60	1,307,674.29	2.86	59.68	14.08	45.59	40.92	36.74	32.66	29.67
27	2.18	1,307,676.67	2.38	49.81	11.76	38.05	34.01	30.42	26.91	24.36
28	1.84	1,307,678.67	2.00	41.84	9.87	31.96	28.45	25.34	22.32	20.12
29	1.56	1,307,680.37	1.69	35.35	8.34	27.01	23.94	21.23	18.61	16.72
30	1.33	1,307,681.80	1.44	30.03	7.09	22.94	20.25	17.89	15.61	13.97
31	1.14	1,307,683.03	1.23	25.64	6.05	19.59	17.22	15.15	13.16	11.74
32	0.98	1,307,684.08	1.05	22.01	5.19	16.81	14.72	12.89	11.15	9.91
33	0.84	1,307,684.99	0.91	18.97	4.48	14.49	12.63	11.02	9.49	8.40
34	0.73	1,307,685.78	0.79	16.42	3.88	12.55	10.89	9.46	8.11	7.15
35	0.64	1,307,686.46	0.68	14.27	3.37	10.90	9.43	8.16	6.96	6.11
36	0.56	1,307,687.06	0.60	12.45	2.94	9.51	8.19	7.06	5.99	5.25
					Total	**$ 18,234,073.12**	**$ 18,140,245.75**	**$ 18,047,444.37**	**$ 17,946,525.07**	**$ 17,864,843.68**

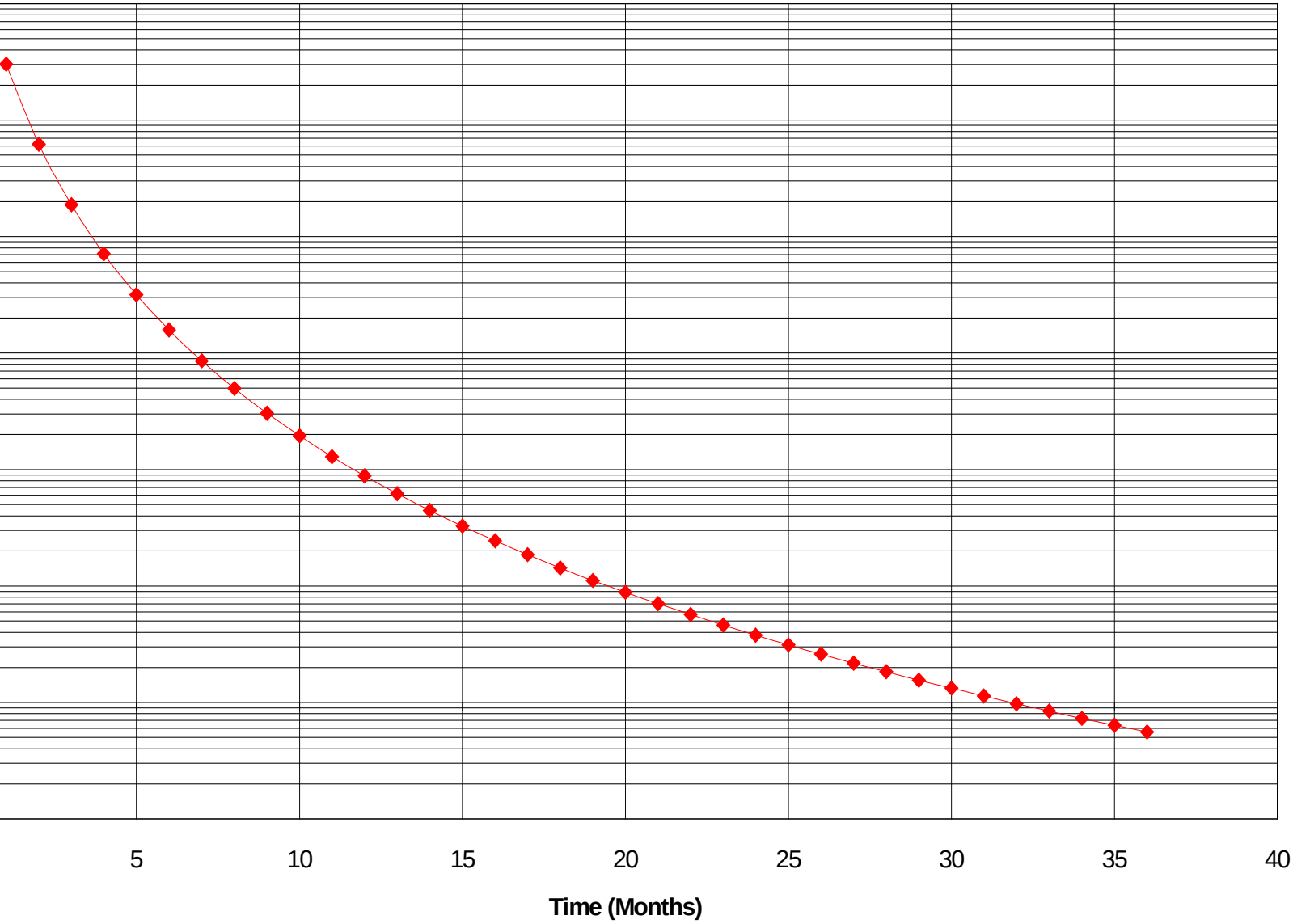
NPV @ 25%
-100,000.00
15,169,367.70
1,962,361.00
466,069.34
152,599.40
61,058.77
28,039.25
14,239.85
7,809.67
4,551.03
2,785.62
1,775.69
1,171.20
849.18
591.28
420.81
305.30
225.30
168.82
128.23
98.61
76.69
60.25
47.78
38.21
32.84
26.67
21.81
17.94
14.85
12.36
10.34
8.69
7.34
6.22
5.30
4.53
$ 17,775,007.88


Graph 1 - NPV versus Discount Rate
45,000,000
40,000,000
35,000,000
30,000,000
25,000,000
20,000,000
15,000,000
10,000,000
5,000,000
0
NPV, $
0%
5%
10%
15%
20%
25%
30%
Discount Rate, %
Texas
Louisiana

Graph 2 - Texas
Flow Rate vs. Time



Grpah 3 - Louisiana
Flow Rate vs. Time



DISCUSSION

After careful analysis of both wells it is recommended that the company invest in the oil well in Texas. Even though the operation investment in Texas is $900,000 more than in Louisiana, the Texas well is selected over the Louisiana well for several reasons.

First of all, the results show that the Texas well will produce 647,110 more barrels of crude than the Louisiana well in three years. The Texas crude is worth only $17.00 per barrel while the Louisiana crude is worth $18.95 a barrel, but in three years, including the operation investment, the Texas well will make $3,293,230 more than the Louisiana well at a 0% discount rate. The Net Present Value Profile also shows that with a time value of money of 15.5% for the company the Texas well should be selected over the Louisiana well.

The Net Present Value and Decline Curve Analysis were used for this project because of the characteristics of the data. Decline curve Analysis was done in order to determine the values of b, q_i, and D_i , so that the future production of the wells could be predicted. Once the production was predicted for three years the Net Present Value was calculated so that a Net Present Value Profile could be generated and the two projects could be visually compared.

The results of this project could be improved in a few ways. For this project the Decline Curve Analysis was done three times by three different people, which resulted in the same value of b but different values of q_i and D_i. Therefore, the results of the Decline Curve Analysis are subject to personal judgement. An average of the three different q_i and D_i values were taken but perhaps the values would be more precise is the analysis was done more accurately. Also, the values found for b, q_i , and D_l were initially in days but were converted to months. This conversion from days to months could have caused the results to be less accurate. Another place where rounding and calculations could have affected the results is when calculating the Net Present Value. However, in this project when dealing with such large numbers the errors should not affect the results so much that the better project can not be distinctly selected.

CONCLUSION

The results of the project with all of the given data and using Net Present Value and Decline Curve Analysis show that the Texas well should be selected over the Louisiana well. After a complete analysis of both wells it is recommended that investing in the Texas well will be the most profitable choice for the company. The company may have to invest more for the Texas well but in the long run it is the most profitable choice.

REFERENCES

1. Thompson, Robert S. and John D. Wright, Oil Property Evaluation. 2nd Edition. Thompson-Wright Associates, 1996.

2. PNGE 241 Class Notes, Shahab Mohaghegh, West Virginia University, Fall 1999.

APPENDIX A