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Valuing Oil & Gas Properties

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39th Annual Natural Resources Law Institute
Hot Springs, Arkansas
February 23-26, 2000

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Introduction

The purpose of this paper is to review procedures to value oil and gas properties. It is important to know not only how to determine the value of oil and gas properties but the methods used in arriving at property values. This paper will provide a quick look at property valuation to enable Natural Resources Law Institute participants to discern the reasonableness of oil and gas property values as presented from prospective buyers and sellers alike. Per the October 1992 Uniform Appraisal Standards - Section A "Under established law the criterion for just compensation is the fair market value of the property at the time of the taking. Fair Market Value is defined as the amount in cash, or on terms reasonably equivalent to cash, for which in all probability the property would be sold by a knowledgeable owner willing but not obligated to sell to a knowledgeable purchaser who desired but is not obligated to buy." Valuation methods will be discussed and reviewed. A review of reserve definitions, methodology, and economic factors will follow the valuation method discussion. The property sale results of 1998 will be summarized and oil and gas valuation examples will be presented.

Valuation Methods

We can make several approaches to place a value on oil and gas properties. Most of the methods require that reserves be determined and scheduled annually with resultant annual net cash flow streams after expenses. All of the valuation methods require, at the least, oil and gas reserves to be determined. Reserve classification and categories will be discussed later in this paper. The reserve classification does affect value as reserves with more risk are discounted accordingly. The valuation methods are as follows:

1. Rate of return or present worth at a specified discount rate (15 - 25%)
2. Payout time (2-5 years with 1/3 of the remaining life being the maximum payout time)
3. Income to investment ratio (2-1 or a 3-1 ratio)
4. Specified fraction of present worth of future net income (2/3)
5. Price per barrel of reserves in ground (1/3 of well head price)

Rate of Return Method

This method calculates Fair Market Value as that purchase that provides for an acceptable rate-of-return on investment. The remaining reserves of the properties in question need to be determined and scheduled annually. Using reasonable product prices and cost, annual net cash flows are calculated. The yearly net cash flow amounts are discounted at a present worth rate that yields an acceptable rate of return. Present worth is by definition the value of future cash projected income applied to the present. The normal discount rate used for oil and gas properties is the cost of money. The present worth equation is $PW = CF(1+i)^{-n}$ where CF is annual net cash flow, i is annual decimal interest rate and n is number of years. Depending on the evaluating entity, the discount rate will range from fifteen to twenty five percent and be closer to the higher rate. This method is the most used, most reliable, and most accurate. It also requires the longest time to determine as compared to some of the other methods.

Payout Time Method

Using the payout time method, the Fair Market Value would be equal to the cumulative undiscounted future net cash flow for the first two to five years after the property is purchased. A rule of thumb for the maximum time length considered in this type of valuation method would usually be no more than one-third of the remaining life. The cash flow needs to be calculated based on projected oil and gas production. Another variation of this approach is the monthly multiplier technique. An example of this is some number of months times current monthly net income. The number of months used range from 12 to 54 depending on the property type. This method provides a quick way to determine a Fair Market Value range for further review.

Income to Investment Ratio Method

This method calculates Fair Market Value by dividing the expected income by the purchase price of the property. Purchasers would typically seek a ratio of two or three to one or better. This technique requires reserves to determined and scheduled annually and resultant net cash flow to be calculated. The income to investment ratio method should be used in conjunction with other methods to fine tune Fair Market Value.

Specified Fraction of Present Worth of Future Net Income

Fair Market Value is estimated by use of a specified percent of present worth. A common rule of thumb approach in using this method is two-thirds of present worth. The remaining reserves of the properties in question need to be determined and scheduled on an annual basis. Using reasonable product prices and costs annual net cash flows are calculated. The yearly net cash flow amounts are discounted at a present worth rate that represents the current cost of money and ranges from seven to ten percent. This method should also be used in conjunction with other methods to fine tune Fair Market Value.

Price Per Barrel of Reserves in Ground (1/3 of Well head Price)

For this method, gas volumes are converted to equivalent barrels of oil on either a heating value (1 Bbl = 6 MCF) or price ratio basis. The oldest and truest rule of thumb in the oil industry is that oil reserves in the ground are worth one-third the current market value. This method, in my opinion, is one that is after the fact. By that I mean that after Fair Market Value is determined then the price per barrel of in ground reserves can be calculated. If reserves are known, then this is a quick way to estimate Fair Market Value.

Reserve Analysis

Definitions

The above described valuation methods require an understanding and explanation of reserve determination. Reserves are classified as proved, probable, and possible. The lower the category, the less certain are the reserve estimates assigned to the property. Proved reserves are further classified as: proved producing, proved shut-in, proved behind-pipe, and proved undeveloped. An accepted definition of reserves is the Society of Petroleum Engineer's Definitions of Oil and Gas Reserves which is included in the Appendix as Exhibit A.

Reserve Risk Factors

Reserve risk factors are applied to reserves to account for risk associated with producing the reserves. The risk factors increase with the uncertainty that the reserves will be produced. The risk factors have been determined from the Society of Petroleum Evaluation Engineers Survey of Economic Parameters Used in Property Evaluation, June 1999 which is in the Appendix as Exhibit B.

Methodology

Decline Analysis

A number of methods are used in determining reserves depending on the producing time and available pressure and production data of the evaluated properties. The methods are decline analysis, volumetric analysis, material balance and analogy. Decline analysis is a method in which future production is estimated based on past performance. This method is best suited for properties that have been producing for some time with production declines that represent true reservoir behavior and not market capacity problems. This method represents the quickest way to evaluate a large number of properties and is very reliable in terms of results.

Volumetric Analysis

Volumetric analysis is a method to determine reserves assuming a reservoir volume to be drained by the well evaluated. This method is used primarily for wells that have been producing for a short time and there is limited well history to predict future production. This method utilizes log and core analyses to estimate productive pore volumes in the vicinity of the evaluated well. The drainage volume also has to be estimated based on well spacing or analogy to offset wells. This method has a greater chance of being incorrect and is usually high.

Material Balance

A third method is material balance. This is an analysis of pressure and production data to determine the original in-place hydrocarbon volumes. As oil or gas is withdrawn from the reservoir there is a change in reservoir pressure. A calculation is performed that examines reservoir withdrawals as compared to reservoir pressure changes to determine original oil or gas in place. This method is the most accurate in determining reserves but requires complete well data. It is not used as often as other methods due the lack of sufficient well data.

Analogy

Analogy is the fourth method used to determine reserves when other methods are not applicable or it is used in conjunction with other methods. This technique compares recoveries from similar producing properties to the properties being examined. The analogy method is not very accurate and is used when other methods do not yield good results. It provides an order of magnitude range of reserves. This method does provide a way to differentiate realistic reserves from pie in the sky reserves.

Economic Factors

One of the more important factors used in valuing oil and gas properties is the economic assumptions. There is considerable risk associated with pricing, costs, and escalations in determining Fair Market Value. This section of the paper will deal with my best guess on how to arrive at economic assumptions that will provide reasonable market values.

Pricing

In an attempt to obtain proper prices to use in valuing properties a number of sources need to be considered. Current prices, an average of the last twelve month prices, and NYMEX future twelve month averages adjusted to spot gas prices and posted oil prices are three sources to review. The NYMEX futures price approach will probably provide the best estimate of the price in the coming year. Depending on the criteria of the evaluator, property values should be considered with different prices to provide a range of values that are price sensitive.

Costs

Operating and capital costs used should be actual average costs over the last six to twelve months. These numbers are not always available but are critical to the accuracy of the evaluation. If cost estimates are necessary, base them an analogy to similar properties. Any liabilities associated with producing properties must also be considered and include plug and abandon costs and environmental clean up costs.

Escalations

Price and cost escalations are moving targets and depend on the economic perception at the time of the analysis to value the oil and gas properties. The commonly used escalation rates track the consumer price index. An annual escalation rate of between two and three percent is reasonable to use. Price ceilings should also be applied that do not exceed one and one-half times the currently used initial prices. Please see Exhibit B in the Appendix.

Property Sales Results Summary

Volume 97, Number 11 of The Oil and Gas Journal, reported that the asset sales of 1998 reached a record $82.1 billion. The median reserves value for the 133 deals in 1998 for which transaction values were disclosed was $4.94/boe. Gas dominated transactions accounted for 85.4% of the disclosed transactions in the fourth quarter of 1998 with the median price paid of $0.83/Mcfe. The average prices received in 1998 were $11.72/Bbl for oil and $2.08/MMBTU for gas. The market value price in 1998 represents 42% of the wellhead oil price and 40% of the wellhead gas price. These results are close to the 1/3 wellhead price of the in ground reserves valuation method.

Valuation of Oil and Gas Property Example

Reserves and resultant economic analyses were prepared for oil and gas producing properties for the purpose of finding the Fair Market Value by the various methods discussed in this paper. Cash flow projections have been prepared by reserve classification and category and are shown on the following pages.

TOTAL COMPOSITE PROJECTION OF FUTURE REVENUE
PROVED
DEVELOPED - PRODUCING

EVALUATION OF THE INTEREST IN OIL AND GAS PROPERTIES

EFFECTIVE DATE: NOVEMBER 1, 1999

PROVED
DEVELOPED - PRODUCING
REPORT TOTAL

COUTRET & ASSOCIATES, INC.
PETROLEUM RESERVOIR ENGINEERS
810 LOUISIANA TOWER
401 EDWARDS STREET
SHREVEPORT, LOUISIANA

12 MONS. ENDING 12 / 31	GROSS PRODUCTION OIL ---BBL--	GROSS PRODUCTION GAS -----MCF----	NET PRODUCTION OIL ----BBL--	NET PRODUCTION GAS ------MCF----	EFFECTIVE PRICES OIL -$/BBL--	EFFECTIVE PRICES GAS ---$/MCF--	NET REVENUE OIL ----$-----	NET REVENUE GAS ---$-----	TOTAL ----$-----
2000	145,840	1,391,300	5,172	50,645	20.87	2.43	107,935	123,304	231,239
2001	604,640	6,687,350	21,974	241,927	21.49	2.51	472,317	606,721	1,079,038
2002	376,490	5,384,100	13,632	193,642	22.14	2.58	301,791	500,233	802,024
2003	240,510	4,110,250	8,574	151,693	22.81	2.66	195,584	403,746	599,330
2004	148,140	2,813,400	5,152	100,999	23.50	2.74	121,052	276,885	397,937
2005	99,230	1,924,150	3,420	68,718	24.20	2.82	82,773	194,038	276,812
2006	54,170	1,463,250	2,024	53,809	24.93	2.91	50,453	156,498	206,951
2007	37,780	1,188,800	1,390	44,792	25.00	3.00	34,748	134,181	168,929
2008	17,240	859,900	547	32,126	25.00	3.09	13,669	99,125	112,794
2009	4,860	424,800	186	17,373	25.00	3.18	4,642	55,213	59,854
THERE-AFTER	10,480	918,200	468	41,823	25.00	3.41	11,701	142,749	154,450
TOTAL	1,739,380	27,165,500	62,539	997,547	22.33	2.70	1,396,665	2,692,693	4,089,358

YEAR	TOTAL INCOME ---$------	PRODUCTION TAXES -----$---	OPERATING EXPENSE ---$------	TOTAL EXPENSE ---$-----	NET OPERATING INCOME ---$-----	CAPITAL COSTS ----$------	NET CASH FLOW ----$-----	PRESENT WORTH @ 10 % YEAR -----$----	PRESENT WORTH @ 10 % CUMULATIVE ------$---
2000	231,239	16,920	150,811	167,730	63,508	0	63,508	60,553	60,553
2001	1,079,038	75,782	151,502	227,284	851,754	0	851,754	738,287	798,840
2002	802,024	51,455	133,568	185,023	617,001	0	617,001	486,188	1,285,027
2003	599,330	35,707	115,592	151,299	448,031	0	448,031	320,947	1,605,974
2004	397,937	22,581	87,242	109,824	288,114	0	288,114	187,628	1,793,602
2005	276,812	15,099	72,502	87,601	189,210	0	189,210	112,017	1,905,619
2006	206,951	9,916	55,881	65,797	141,153	0	141,153	75,969	1,981,589
2007	168,929	7,384	51,671	59,055	109,875	0	109,875	53,759	2,035,348
2008	112,794	4,588	40,622	45,210	67,584	0	67,584	30,061	2,065,409
2009	59,854	2,133	21,653	23,787	36,068	0	36,068	14,584	2,079,993
THERE-AFTER	154,450	5,248	77,455	82,704	71,746	0	71,746	22,967	2,102,960
TOTAL	4,089,358	246,814	958,500	1,205,314	2,884,044	0	2,884,044	2,102,960	

RECOVERY SUMMARY

	GROSS OIL, BBL.	GROSS GAS, MCF
CUMULATIVE	2,507,050	26,220,400
ULTIMATE	4,246,430	53,385,900

YEARS IN THEREAFTER 8.00

PRESENT WORTH PROFILE

PRESENT WORTH @ 5%	$2,439,731
PRESENT WORTH @ 10%	$2,102,960
PRESENT WORTH @ 15%	$1,840,161
PRESENT WORTH @ 20%	$1,630,144
PRESENT WORTH @ 25%	$1,458,962
PRESENT WORTH @ 30%	$1,317,100
PRESENT WORTH @ 35%	$1,197,864

TOTAL COMPOSITE PROJECTION OF FUTURE REVENUE
PROVED
DEVELOPED - NONPRODUCING - BEHIND PIPE

EVALUATION OF THE INTEREST IN OIL AND GAS PROPERTIES

EFFECTIVE DATE: NOVEMBER 1, 1999

PROVED
DEVELOPED - NONPRODUCING - BEHIND PIPE
REPORT TOTAL

COUTRET & ASSOCIATES, INC.
PETROLEUM RESERVOIR ENGINEERS
810 LOUISIANA TOWER
401 EDWARDS STREET
SHREVEPORT, LOUISIANA

12 MONS. ENDING 12 / 31	GROSS PRODUCTION OIL ---BBL--	GROSS PRODUCTION GAS -----MCF----	NET PRODUCTION OIL ----BBL--	NET PRODUCTION GAS ------MCF----	EFFECTIVE PRICES OIL -$/BBL--	EFFECTIVE PRICES GAS ---$/MCF--	NET REVENUE OIL ----$-----	NET REVENUE GAS ---$-----	TOTAL ----$-----
2002	54,000	41,000	1,469	1,116	22.15	2.58	32,544	2,883	35,427
2003	105,200	372,400	2,717	7,963	22.81	2.66	61,971	21,195	83,167
2004	74,825	1,095,100	1,896	29,065	23.50	2.74	44,557	79,679	124,236
2005	84,275	557,900	2,210	20,270	24.20	2.82	53,479	57,235	110,714
2006	70,080	1,601,200	1,632	36,054	24.93	2.91	40,684	104,860	145,543
2007	67,360	1,221,400	1,682	27,916	25.00	3.00	42,049	83,627	125,676
2008	121,540	776,200	4,299	19,378	25.00	3.09	107,473	59,790	167,263
2009	81,520	1,641,100	2,881	49,508	25.00	3.18	72,023	157,340	229,364
2010	71,300	1,636,300	2,418	42,885	25.00	3.27	60,461	140,382	200,843
2011	47,600	1,152,200	1,709	29,579	25.00	3.37	42,728	99,729	142,457
THERE-AFTER	68,700	5,077,500	2,057	164,267	25.00	3.50	51,430	574,181	625,612
TOTAL	846,400	15,172,300	24,971	428,000	24.40	3.23	609,399	1,380,902	1,990,301

YEAR	TOTAL INCOME ---$------	PRODUCTION TAXES -----$---	OPERATING EXPENSE ---$------	TOTAL EXPENSE ---$-----	NET OPERATING INCOME ---$-----	CAPITAL COSTS ----$-----	NET CASH FLOW ----$----	PRESENT WORTH @ 10 % YEAR -----$----	PRESENT WORTH @ 10 % CUMULATIVE ------$---
2002	35,427	4,155	1,406	5,561	29,865	2,930	26,935	21,225	21,225
2003	83,167	8,446	7,240	15,686	67,481	4,194	63,287	45,336	66,561
2004	124,236	8,244	16,734	24,978	99,258	6,869	92,390	60,167	126,727
2005	110,714	8,542	14,508	23,050	87,664	8,165	79,499	47,081	173,809
2006	145,543	8,421	17,108	25,529	120,015	2,174	117,840	63,426	237,235
2007	125,676	7,623	13,413	21,036	104,640	4,529	100,111	48,982	286,217
2008	167,263	15,038	16,614	31,652	135,611	7,774	127,837	56,861	343,078
2009	229,364	13,319	29,823	43,142	186,222	15,089	171,133	69,217	412,295
2010	200,843	11,308	30,088	41,396	159,447	2,447	157,000	57,713	470,009
2011	142,457	7,889	27,264	35,153	107,304	0	107,304	35,859	505,868
THERE-AFTER	625,612	21,163	182,863	204,027	421,585	49,805	371,780	87,487	593,355
TOTAL	1,990,301	114,147	357,062	471,209	1,519,092	103,976	1,415,116	593,355	

RECOVERY SUMMARY

	GROSS OIL, BBL.	GROSS GAS, MCF
CUMULATIVE	400	26,300
ULTIMATE	846,800	15,198,600

YEARS IN THEREAFTER 13.00

PRESENT WORTH PROFILE

PRESENT WORTH @ 5%	$890,189
PRESENT WORTH @ 10%	$593,355
PRESENT WORTH @ 15%	$414,310
PRESENT WORTH @ 20%	$300,523
PRESENT WORTH @ 25%	$225,019
PRESENT WORTH @ 30%	$173,061
PRESENT WORTH @ 35%	$136,175

TOTAL COMPOSITE PROJECTION OF FUTURE REVENUE
PROVED
UNDEVELOPED - UNDRILLED

EVALUATION OF THE INTEREST IN OIL AND GAS PROPERTIES

EFFECTIVE DATE: NOVEMBER 1, 1999

PROVED
UNDEVELOPED - UNDRILLED
REPORT TOTAL

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2001	132,000	116,500	5,587	4,931	21.50	2.51	120,142	12,372	132,514
2002	269,000	197,000	11,386	8,339	22.15	2.58	252,180	21,548	273,728
2003	269,000	209,000	11,386	8,847	22.81	2.66	259,745	23,546	283,291
2004	237,000	176,000	10,032	7,450	23.50	2.74	235,711	20,423	256,134
2005	194,000	143,500	8,212	6,074	24.20	2.82	198,732	17,151	215,883
2006	140,000	109,000	5,926	4,614	24.93	2.91	147,718	13,419	161,137
2007	126,531	90,000	5,356	3,810	25.00	3.00	133,896	11,412	145,308
2008	74,000	398,000	3,132	16,847	25.00	3.09	78,307	51,980	130,287
2009	54,000	338,000	2,286	14,307	25.00	3.18	57,143	45,469	102,611
2010	25,000	16,000	1,058	677	25.00	3.27	26,455	2,217	28,672
THERE-AFTER	21,000	17,500	889	741	25.00	3.41	22,222	2,525	24,748
TOTAL	1,541,531	1,810,500	65,250	76,635	23.48	2.90	1,532,251	222,061	1,754,313

YEAR	TOTAL INCOME ---$------	PRODUCTION TAXES -----$---	OPERATING EXPENSE ---$------	TOTAL EXPENSE ---$-----	NET OPERATING INCOME ---$-----	CAPITAL COSTS ----$------	NET CASH FLOW ----$---	PRESENT WORTH @ 10 % YEAR -----$----	PRESENT WORTH @ 10 % CUMULATIVE ------$---
2001	132,514	15,402	9,861	25,263	107,250	115,991	-8,741	-7,576	-7,576
2002	273,728	32,173	20,313	52,486	221,241	0	221,241	174,335	166,759
2003	283,291	33,158	20,923	54,081	229,210	0	229,210	164,195	330,954
2004	256,134	30,045	21,550	51,595	204,539	0	204,539	133,202	464,155
2005	215,883	25,315	22,197	47,512	168,371	0	168,371	99,680	563,835
2006	161,137	18,825	22,863	41,687	119,449	0	119,449	64,288	628,123
2007	145,308	17,034	23,549	40,583	104,725	0	104,725	51,239	679,363
2008	130,287	11,102	18,191	29,294	100,994	7,774	93,220	41,464	720,827
2009	102,611	8,259	18,737	26,996	75,616	0	75,616	30,576	751,403
2010	28,672	3,360	12,866	16,226	12,446	0	12,446	4,575	755,978
THERE-AFTER	24,748	2,836	13,451	16,286	8,461	0	8,461	2,810	758,788
TOTAL	1,754,313	197,509	204,500	402,009	1,352,303	123,765	1,228,538	758,788	

RECOVERY SUMMARY

	GROSS OIL, BBL.	GROSS GAS, MCF
CUMULATIVE	0	0
ULTIMATE	1,541,531	1,810,500

YEARS IN THEREAFTER 1.00

PRESENT WORTH PROFILE

PRESENT WORTH @ 5%	$954,934
PRESENT WORTH @ 10%	$758,788
PRESENT WORTH @ 15%	$614,440
PRESENT WORTH @ 20%	$505,736
PRESENT WORTH @ 25%	$422,193
PRESENT WORTH @ 30%	$356,824
PRESENT WORTH @ 35%	$304,854

TOTAL COMPOSITE PROJECTION OF FUTURE REVENUE
PROVED
ALL CATEGORIES

EVALUATION OF THE INTEREST IN OIL AND GAS PROPERTIES

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PROVED
ALL CATEGORIES
REPORT TOTAL

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2000	145,840	1,391,300	5,172	50,645	20.87	2.43	107,935	123,304	231,239
2001	736,640	6,803,850	27,561	246,859	21.50	2.51	592,459	619,093	1,211,552
2002	699,490	5,622,100	26,488	203,096	22.14	2.58	586,514	524,664	1,111,178
2003	614,710	4,691,650	22,677	168,503	22.81	2.66	517,301	448,487	965,788
2004	459,965	4,084,500	17,080	137,514	23.50	2.74	401,321	376,987	778,308
2005	377,505	2,625,550	13,842	95,062	24.20	2.82	334,985	268,425	603,409
2006	264,250	3,173,450	9,582	94,477	24.93	2.91	238,854	274,776	513,630
2007	231,671	2,500,200	8,428	76,518	25.00	3.00	210,693	229,220	439,913
2008	212,780	2,034,100	7,978	68,350	25.00	3.09	199,449	210,895	410,344
2009	140,380	2,403,900	5,352	81,188	25.00	3.18	133,808	258,022	391,830
THERE-AFTER	244,080	8,817,700	8,600	279,972	25.00	3.44	214,997	961,784	1,176,782
TOTAL	4,127,311	44,148,300	152,760	1,502,182	23.16	2.86	3,538,315	4,295,656	7,833,972

YEAR	TOTAL INCOME ---$------	PRODUCTION TAXES -----$---	OPERATING EXPENSE ---$------	TOTAL EXPENSE ---$-----	NET OPERATING INCOME ---$-----	CAPITAL COSTS ----$----	NET CASH FLOW ----$---	PRESENT WORTH @ 10 % YEAR -----$----	PRESENT WORTH @ 10 % CUMULATIVE ------$---
2000	231,239	16,920	150,811	167,730	63,508	0	63,508	60,553	60,553
2001	1,211,552	91,185	161,363	252,547	959,004	115,991	843,013	730,711	791,263
2002	1,111,178	87,783	155,288	243,071	868,107	2,930	865,177	681,747	1,473,011
2003	965,788	77,311	143,755	221,066	744,722	4,194	740,528	530,478	2,003,488
2004	778,308	60,871	125,527	186,397	591,911	6,869	585,042	380,996	2,384,484
2005	603,409	48,957	109,207	158,163	445,246	8,165	437,081	258,779	2,643,263
2006	513,630	37,161	95,852	133,013	380,617	2,174	378,443	203,684	2,846,947
2007	439,913	32,041	88,632	120,673	319,240	4,529	314,711	153,981	3,000,928
2008	410,344	30,728	75,427	106,155	304,189	15,548	288,641	128,387	3,129,314
2009	391,830	23,711	70,213	93,924	297,905	15,089	282,816	114,377	3,243,691
THERE-AFTER	1,176,782	51,804	343,988	395,792	780,990	52,252	728,738	211,411	3,455,102
TOTAL	7,833,972	558,469	1,520,063	2,078,533	5,755,439	227,741	5,527,698	3,455,102	

RECOVERY SUMMARY

	GROSS OIL, BBL.	GROSS GAS, MCF
CUMULATIVE	2,507,450	26,246,700
ULTIMATE	6,634,761	70,395,000

YEARS IN THEREAFTER 15.00

PRESENT WORTH PROFILE

PRESENT WORTH @ 5%	$4,284,854
PRESENT WORTH @ 10%	$3,455,103
PRESENT WORTH @ 15%	$2,868,911
PRESENT WORTH @ 20%	$2,436,403
PRESENT WORTH @ 25%	$2,106,174
PRESENT WORTH @ 30%	$1,846,984
PRESENT WORTH @ 35%	$1,638,894

A summary of the Fair Market Value results for the different valuation methods is shown below:

1) **Rate of Return Method - 20%**

Reserve Classification-Category	$M PW@20%	Risk Factor	$M Risk Adjusted
Proved Dev Producing	1,630	.97	1,581
Proved Dev Non Prod Behind Pipe	301	.75	226
Proved Undrilled	506	.56	283
Total			2,090

2) **Payout Time Method**

By examining the composite revenue projection on page P-4, it will take 32 months to recover $2,090,000. So the payout time to recover the rate of return market value is 32 months. This is between the stated 2-5 year estimate in the text.

3) **Income to Investment Ratio Method**

The total net cash flow to recover from the evaluated properties is $5,527,698. Using the rate of return FMV of $2,090,000, the income to investment ratio is 2.64-1. This is between the range of 2-1 to 3-1 as listed in the text.

4) **Specified Fraction of Present Worth Method**

Reserve Classification-Category	$M PW@10%	Risk Factor	$M Risk Adjusted
Proved Dev Producing	2,130	.97	2,040
Proved Dev Non Prod Behind Pipe	593	.75	445
Proved Undrilled	759	.56	425
Total	3,455		2,910
Specified Fraction			.72
Total PW @10% multiplied by the specified fraction			2,090

The specified fraction was calculated to be .72 to determine a FMV of $2,090,000. This fraction is similar to the text stated fraction of .667.

5) **Price per Barrel in Ground Method**

Proved net oil reserves - 152,760 Bbl
Proved net gas reserves - 1,502,182 MCF
Oil/Gas price ratio - $20.87/Bbl/2.43/MCF = 8.1 MCF/Bbl
Proved net reserves, BOE - 152,760 Bbl + (1,502,182 MCF/8.1 MCF/Bbl) = 338,215 BOE

FMV = \$2,090,000/338,215 BOE = \$6.18/Bbl
Fraction of FMV \$/Bbl to current price \$/Bbl = \$6.18/Bbl/\$20.87/Bbl = .30
The calculated fraction of the wellhead oil price is 30% which is very close to the rule of thumb of 33.33%.

These various valuation methods point out how each method yields the same approximate answer. The quickest method to determine a Fair Market Value range with some degree of confidence would be the in ground method. This method does require total net remaining reserves. The rate of return method is the most reliable and requires a full evaluation of remaining reserves along with annual production schedules and resultant economic analyses. The remaining methods are used to review the Fair Market Value of a property with certain economic scenarios. It is hoped that this paper will allow the Natural Resources Law Institute participants to have a greater understanding of how to arrive at a Fair Market Value of oil and gas properties and to discern a reasonable value from one that is unrealistic.

References

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3. "U.S. oil, gas asset sales hit record in 1998," Oil and Gas Journal, volume 97, issue 11, March 15, 1999
4. Engineering Economic Analysis, Revised Edition, Newnan, D.G., pub. Engineering Press, San Jose, California, 1976

APPENDIX

EXHIBIT A

RESERVE CLASSIFICATION

Reserves estimates have been classified in accordance with the approved definitions by the Board of Directors of the Society of Petroleum Engineers (SPE), Inc. on March 7, 1997. These definitions have been developed in cooperation with other technical organizations and are widely accepted in the oil and gas industry. While they are not identical, these definitions basically conform to the definitions used by the United States Securities and Exchange Commission.

The definitions, which are provided in their entirety on the following pages, basically require that reserve estimates be classified as proved or unproved. These are defined as follows:

Proved Reserves which can be estimated with reasonable certainty to be recoverable under current economic conditions. Current economic conditions include prices and costs prevailing at the time of the estimate.

Unproved Reserves which are based on geologic and/or engineering data similar to that used in estimates of proved reserves; but technical, contractual, economic, or regulatory uncertainties preclude such reserves being classified as proved. They may be estimated assuming future economic conditions different from those prevailing at the time of the estimate.

There are two subcategories of unproved reserves:

a. **Probable-** Probable reserves are less certain than proved reserves and can be estimated with a degree of certainty sufficient to indicate they are more likely to be recovered than not.

b. **Possible -** Possible reserves are less certain than probable reserves and can be estimated with a low degree of certainty, insufficient to indicate whether they are more likely to be recovered than not.

Reserves are further classified by producing status. The status categories that have been used in this report, if applicable, are as follows:

Developed **- Producing**
Developed **- Nonproducing - Shut-in**
Developed **- Nonproducing - Behind Pipe**
Developed **- Improved Recovery**
Undeveloped **- Undrilled**

Society of Petroleum Engineers

Definitions For Oil and Gas Reserves

Approved by the Board of Directors, Society of Petroleum Engineers (SPE), Inc.

PETROLEUM RESERVES DEFINITIONS

SOCIETY OF PETROLEUM ENGINEERS (SPE)
AND
WORLD PETROLEUM CONGRESSES (WPC)

PREAMBLE

Petroleum[1] is the world's major source of energy and is a key factor in the continued development of world economics. It is essential for future planning that governments and industry have a clear assessment of the quantities of petroleum available for production and quantities which are anticipated to become available within a practical time frame through additional field development technological advances, or exploration. To achieve such an assessment, it is imperative that the industry adopt a consistent nomenclature for assessing the current and future quantities of petroleum expected to be recovered from naturally occurring underground accumulations. Such quantities are defined as reserves, and their assessment is of considerable importance to governments, international agencies, economists, bankers, and the international energy industry.

The terminology used in classifying petroleum substances and the various categories of reserves have been the subject of much study and discussion for many years. Attempts to standardize reserves terminology began in the mid 1930's when the American Petroleum Institute considered classification for petroleum and definitions of various reserves categories. Since then, the evolution of technology has yielded more precise engineering methods to determine reserves and has intensified the need for an improved nomenclature to achieve consistency among professionals working with reserves terminology. Working entirely separately, the Society of Petroleum Engineers (SPE) and the World Petroleum Congresses (WPC) produced strikingly similar sets of petroleum reserve definitions for known accumulations which were introduced in early 1987. 'These have become the preferred standards for reserves classification across the industry. Soon after, it became apparent to both organizations that these could be combined into a single set of definitions which could be used by the industry worldwide. Contacts between representatives of the two organizations started in 1987, shortly after the publication of the initial sets of definitions. During the World Petroleum Congress in June 1994, it was recognized that while any revisions to the current definitions would require the approval of the respective Boards of Directors, the effort to establish a worldwide nomenclature should be increased. A common nomenclature would present an enhanced opportunity for acceptance and would signify a con=on and unique stance on an essential technical and professional issue facing the international petroleum industry.

As a first step in the process, the organizations issued a joint statement which presented a broad set of principles on which reserves estimations and definitions should be based. A task force was established by the Boards of SPE and WPC to develop a common set of definitions based on this statement of principles. The following joint statement of principles was published in the January 1996 issue of the SPE *Journal of Petroleum Technology* and in the June 1996 issue of the *WPC Newsletter:*

> *There is a growing awareness worldwide of the need for a consistent set of reserves definitions for use by governments and industry in the classification of petroleum reserves. Since their introduction in 1987, the Society of Petroleum Engineers and the World Petroleum Congresses reserves definitions have been standards for reserves classification and evaluation worldwide.*
>
> *SPE and WPC have begun efforts toward achieving consistency in the classification of reserves. As a first step in this process, SPE and WPC issue the following joint statement of principles.*
>
>> *The SPE and the WPC recognize that both organizations have developed a widely accepted and simple nomenclature of petroleum reserves.*
>>
>> *The SPE and the WPC emphasize that the definitions are intended as standard. general guidelines for petroleum reserves classification which should allow for the proper comparison of quantities on a worldwide basis.*
>>
>> *The SPE and the WPC emphasize that, although the definition of petroleum reserves should not in any manner be construed to be compulsory or obligatory, countries and organizations should be encouraged to use the core definitions as defined in these principles and also to expand oil these definitions according to special local conditions and circumstances.*
>>
>> *The SPE and the WPC recognize that suitable mathematical techniques can be used as required and that it is left to the country to fix the exact criteria for reasonable certainty of existence of petroleum reserves. No methods of calculation are excluded, however, if probabilistic methods are used, the chosen percentages should be unequivocally stated.*

[1] PETROLEUM- For the Purpose of these definitions, the term petroleum refers to naturally occurring liquids and gases which are predominately comprised or hydrocarbon compounds. Petroleum may also contain non-hydrocarbon compounds in which sulfur, oxygen, and/or nitrogen atoms are combined with carbon and hydrogen. Common examples of non-hydrocarbons found in petroleum are nitrogen, carbon dioxide, and hydrogen sulfide.

The SPE and the WPC agree that the petroleum nomenclature as proposed applies only to known discovered hydrocarbon accumulations and their associated potential deposits.

The SPE and the WPC stress that petroleum proved reserves should be based on current economic conditions, including all factors affecting the viability of file projects. The SPE and the WPC recognize that the term is general and not restricted to costs and price only. Probable and possible reserves could be based on anticipated developments and/or the extrapolation occurrent economic conditions.

The SPE and the WPC accept that petroleum reserves definitions are not static and will evolve.

A conscious effort was made to keep the recommended terminology as close to current common usage as possible in order to minimize the impact of previously reported quantities and changes required to bring about wide acceptance. The proposed terminology is not intended as a precise system of definitions and evaluation procedures to satisfy all situations. Due to the many forms of occurrence of petroleum, the wide range of characteristics, the uncertainty associated with the geological environment, and the constant evolution of evaluation technologies, a precise classification system is not practical. Furthermore, the complexity required for a precise system would detract from its understanding by those involved in petroleum matters. As a result, the recommended definitions do not represent a major change from the current SPE and WPC definitions which have become the standards across the industry. It is hoped that the recommended terminology will integrate the two sets of definitions and achieve better consistency in reserves data across the international industry.

Reserves derived under these definitions rely on the integrity, skill, and judgment of the evaluator and are affected by the geological complexity, stage of development, degree of depletion of the reservoirs, and amount of available data. Use of these definitions should sharpen the distinction between the various classifications and provide more consistent reserves reporting.

DEFINITIONS

Reserves are those quantities of petroleum which are anticipated to be commercially recovered from known accumulations from a given date forward. All reserve estimates involve some degree of uncertainty. The uncertainty depends chiefly on the amount of reliable geologic and engineering data available at the time of the estimate and the interpretation of these data. The relative degree of uncertainty may be conveyed by placing reserves into one of two principal classifications, either proved or unproved. Unproved reserves are less certain to be recovered than proved reserves and may be further subclassified as probable and possible reserves to denote progressively increasing uncertainty in their recoverability.

It intent of the SPE and WPC in approving additional classifications beyond proved reserves is to facilitate consistency among professionals using such terms. In presenting these definitions, neither organization is recommending public disclosure of reserves classified as unproved. Public disclosure of the quantities classified as unproved reserves is left to the discretion of the countries or companies involved.

Estimation of reserves is done under conditions of uncertainty. The method of estimation is called deterministic if a single best estimate of reserves is made based on known geological, engineering, and economic data. The method of estimation is called probabilistic when the known geological, engineering, and economic data are used to generate a range or estimates and their associated probabilities. Identifying reserves as proved, probable, and possible has been the most frequent classification method and gives an indication of the probability of recovery. Because of potential differences in uncertainty, caution should be exercised when aggregating reserves of different classifications.

Reserves estimates will generally be revised as additional geologic or engineering data becomes available or as economic conditions change. Reserves do not include quantities of petroleum being held in inventory, and may be reduced, for usage or processing losses if required for financial reporting.

Reserves may be attributed to either natural energy or improved recovery methods. Improved recovery methods include all methods for supplementing natural energy or altering natural forces in the reservoir to increase ultimate recovery. Examples of such methods are pressure maintenance, cycling, waterflooding, thermal methods, chemical flooding, and the use of miscible and immiscible displacement fluids. Other improved recovery methods may be developed in the future as petroleum technology continues to evolve.

PROVED RESERVES

Proved reserves are those quantities of petroleum which, by analysis of geological and engineering data, can be estimated with reasonable certainty to be commercially recoverable, from a given date forward, from known reservoirs and under current economic conditions, operating methods, and government regulations. Proved reserves can be categorized as developed or undeveloped.

If deterministic methods are used, the term reasonable certainty is intended to express a high degree of confidence that the quantities will be recovered. If probabilistic methods are used, there should be at least a 90% probability that the quantities actually recovered will equal or exceed the estimate.

Establishment of current economic conditions should include relevant historical petroleum prices and associated costs and may involve an averaging period that is consistent with the purpose of the reserve estimate, appropriate contract obligations, corporate procedures, and government regulations involved in reporting these reserves.

In general, reserves are considered proved if the commercial producibility of the reservoir is supported by actual production or formation tests. In this context, the term proved refers to the actual quantities of petroleum reserves and not just the productivity of the well or reservoir. In certain cases, proved reserves may be assigned on the basis of well logs and/or core analysis that indicate the subject reservoir is hydrocarbon hearing and is analogous to reservoirs in the same area that are producing or have demonstrated the ability to produce on formation tests.

The area of the reservoir considered as proved includes (1) the area delineated by drilling and defined by fluid contacts, if any, and (2) the undrilled portions of the reservoir that can reasonably be judged, as commercially productive on the basis of available geological and engineering data. In the absence of data on fluid contacts, the lowest known occurrence of hydrocarbons controls the proved limit unless otherwise indicated by definitive geological, engineering or performance data.

Reserves may be classified as proved if facilities to process and transport those reserves to market are operational at the time of the estimate or there is a reasonable expectation that such facilities will be installed. Reserves in undeveloped locations may be classified as proved undeveloped provided (I) the locations are direct offsets to wells that have indicated commercial production in the objective formation, (2) it is reasonably certain such locations are within the known proved productive limits of the objective formation, (3) the locations conform to existing well spacing regulations where applicable, and (4) it is reasonably certain the locations will be developed. Reserves from other locations are categorized as proved undeveloped only where interpretations of geological and engineering data from wells indicate with reasonable certainty that the objective formation is laterally continuous and contains commercially recoverable petroleum at locations beyond direct offsets.

Reserves which are to be produced through the application of established improved recovery methods are included in the proved classification when (1) successful testing by a pilot project or favorable response of an installed program in the same or an analogous reservoir with similar rock and fluid properties provides support for the analysis on which the project was based, and, (2) it is reasonably certain that the project will proceed. Reserves to be recovered by improved recovery methods that have yet to be established through commercially successful applications are included in the proved classification only (1) after a favorable production response from the subject reservoir from either (a) a representative pilot or (b) an installed program where the response provides support for the analysis on which the project is based and (2) it is reasonably certain the project will proceed.

UNPROVED RESERVES

Unproved reserves are based on geologic and/or engineering data similar to that used in estimates of proved reserves; but technical, contractual, economic, or regulatory uncertainties preclude such reserves being classified as proved. Unproved reserves may be further classified as probable reserves and possible reserves.

Unproved reserves may be estimated assuming future economic conditions different from those prevailing at the time of the estimate. The effect of possible future improvements in economic conditions and technological developments can be expressed by allocating appropriate quantities of reserves to the probable and possible classifications.

PROBABLE RESERVES

Probable reserves are those unproved reserves which analysis of geological and engineering data suggests are more likely than not to be recoverable. In this context, when probabilistic methods are used, there should be at least a 50% probability that the quantities actually recovered will equal or exceed the sum of estimated proved plus probable reserves.

In general, probable reserves may include (1) reserves anticipated to be proved by normal step-out drilling where subsurface control is inadequate to classify these reserves as proved, (2) reserves in formations that appear to be productive based on well log characteristics but lack core data or definitive tests and which are not analogous to producing or proved reservoirs in the area, (3) incremental reserves attributable to infill drilling that could have been classified as proved if closer statutory spacing had been approved at the time or the estimate, (4) reserves attributable to improved recovery methods that have been established by repeated commercially successful applications when (a) a project or pilot is planned but not in operation and (b) rock, fluid, and reservoir characteristics appear Favorable for commercial application, (5) reserves in an area of the formation that appears to be separated from the proved area by faulting and the geologic interpretation indicates the subject area is structurally higher than the proved area, (6) reserves attributable to a Future workover, treatment, re-treatment, change of equipment, or other mechanical procedures, where such procedure has not been proved successful in wells which exhibit similar behavior in analogous reservoirs, and (7) incremental reserves in proved reservoirs where an alternative interpretation of performance or volumetric data indicates more reserves than can be classified as proved.

POSSIBLE RESERVES

Possible reserves are those unproved reserves which analysis of geological and engineering data suggests are less likely to be recoverable than probable reserves. In this context, when probabilistic methods are used, there should be at least a 10% probability that the quantities actually recovered will equal or exceed the sum or estimated proved plus probable plus possible reserves.

In general, possible reserves may include (1) reserves which, based on geological interpretations, could possibly exist beyond areas classified as probable, (2) reserves in formations that appear to be petroleum hearing based on log and core analysis but may not be productive at commercial rates, (3) incremental reserves attributed to infill drilling that are subject to technical uncertainty, (4) reserves attributed to improved recovery methods when (a) a project or pilot is planned but not in operation and (b) rock, fluid, and reservoir characteristics are such that a reasonable doubt exists that the project will be commercial, and (5) reserves in an area of the formation that appears to be separated from the proved area by faulting and geological interpretation indicates the subject area is structurally lower than the proved area.

RESERVE STATUS CATEGORIES

Reserve status categories define the development and producing status of wells and reservoirs.

Developed: Developed reserves are expected to be recovered from existing wells including reserves behind pipe. Improved recovery reserves are considered developed only after the necessary equipment has been installed, or when the costs to do so are relatively minor, Developed reserves may be sub-categorized as producing or nonproducing.

Producing: Reserves subcategorized as producing are expected to be recovered from completion intervals which are open and producing at the time of the estimate. Improved recovery reserves are considered producing only after the improved recovery project is in operation.

Non-producing: Reserves subcategorized as non-producing include shut-in and behind-pipe reserves. Shut-in reserves are expected to be recovered from (1) completion intervals which are open at the time of the estimate but which have not started producing, (2) wells which were shut-in for market conditions or pipeline connections, or (3) wells not capable of production for mechanical reasons. Behind-pipe reserves are expected to be recovered from zones in existing wells, which will require additional completion work or future recompletion prior to the start of production.

Undeveloped Reserves: Undeveloped reserves are expected to be recovered: (1) from new wells on undrilled acreage, (2) from deepening existing wells to a different reservoir, or (3) where a relatively large expenditure is required to (a) recomplete an existing well or (b) install production or transportation facilities for primary or improved recovery projects.

Approved by the Board of Directors, Society of Petroleum Engineers (SPE), Inc. March 7, 1997

EXHIBIT B

UNCERTAINTY RELATED TO RESERVE CATEGORIES (RISK)

Respondents were asked how they adjusted their evaluations to account for different reserve categories. The respondents were asked to state whether their adjustments factors were used in acquisitions or loans. There was no statistical difference by size or dollar amount of evaluation.

Adjustment Factors Used for ACQUISITIONS

	Median	Average	Std Dev
Proved Producing	100.0%	97.2%	5.3%
Proved Shut In	90.0%	84.7%	14.0%
Proved Behind Pipe	75.0%	74.9%	16.1%
Proved Undeveloped	58.8%	56.2%	22.7%
Probable Producing	25.0%	31.7%	24.1%
Probable Behind Pipe	25.0%	27.9%	22.8%
Probable Undeveloped	20.0%	21.9%	19.6%
Possible Producing	0.0%	9.3%	13.3%
Possible Behind Pipe	0.0%	7.5%	10.6%
Possible Undeveloped	0.0%	6.3%	10.2%

Adjustment Factors Used for LOANS

	Median	Average	Std Dev
Proved Producing	100.0%	96.6%	6.1%
Proved Shut In	77.5%	78.4%	13.9%
Proved Behind Pipe	75.0%	74.7%	13.1%
Proved Undeveloped	50.0%	53.3%	20.6%
Probable Producing	0.0%	2.3%	5.8%
Probable Behind Pipe	0.0%	2.3%	5.8%
Probable Undeveloped	0.0%	2.3%	5.8%
Possible Producing	0.0%	0.0%	0.0%
Possible Behind Pipe	0.0%	0.0%	0.0%
Possible Undeveloped	0.0%	0.0%	0.0%

For Acquisitions the above risk adjustments are applied mainly to cash flow after discounting (48%) and reserves (41%). For Loans they are applied mainly to cash flow after discounting (53%) and reserves (40%). If reserves are adjusted approximately half of respondents adjust reserves only and leave all other factors unchanged while the other half use professional judgement to adjust other factors.