NORTH DAKOTA GEOLOGICAL SURVEY

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NORTH DAKOTA CRUDE OIL INVENTORY AS OF JANUARY 1, 1963

by

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Reserves of crude oil in North Dakota on 1 January 1963, recoverable by presently known equipment and techniques, stood at 578,703,732 barrels, down 16,531,261 barrels, or 2 3/4% from the previous year.

Contrary to first impressions, the outlook should be considered optomistic, however, since the North Dakota Industrial Commission has already approved three fluid injection projects which will add 65,000,000 barrels to the recoverable reserves. Due to the fact that actual injection operations had not been started before January 1st, and adhering to the policy followed in earlier inventories of not including credit for oil recoverable by fluid injection until such operations are under way, these additional reserves are not included in the total.

During 1962 the initiation of fluid injection operations in the North Tioga-Madison Pool in Burke, Divide, and Williams Counties added 28 million barrels to our recoverable reserves; an amount which more than offset the 25,117,007 barrels produced during the year. Because of 'windows' in the royalty segment of the Unit, full credit was not given to the North Tioga project since fully effective operation, as a unit, will not be possible. Should the situation alter, and the remaining royalty interests be committed to the unit, an additional ten million barrels could be added.

New discoveries during 1962 added 6,000,000 barrels to the inventory. However, revisions of previous estimates resulted in an over-all reduction. The major revisions were made in earlier estimates for the Beaver Lodge-

Devonian and Beaver Lodge-Silurian pools. Development drilling in these pools have proven them to be of lesser areal extent than previously estimated. The Silurian reservoir is considered to be a condensate reservoir.

Reserves of crude oil and natural gas are frequently reported in terms of the number of years of production, at the current rate, which they represent. On the basis of the average daily production for 1962, of 68,978 barrels per day, the reserves indicated here would represent a 23 year supply. However, such a statement is not realistic since it does not allow for new additions and discoveries and since fields decline slowly and do not produce at a constant rate.

Reservoirs studies conducted by engineers of the North Dakota Geological Survey show that the currently producing reservoirs will not be completely depleted until the year 2038. New discoveries and secondary recovery and pressure maintenance operations will ensure another century of oil production for the state of North Dakota.

The reserves indicated in this inventory represent 1.67% of the U. S. reserves as reported by the Oil and Gas Journal of 28 January 1963. This would represent an increase from the 1.375% of a year ago. It is not apparent what source was used for the Journal's report but their figure for North Dakota is considerably below the estimates contained in this inventory. This difference is undoubtedly due to the difference in the bases of the estimates since this inventory does not take into account the economics of production, whereas it is assumed that the Oil Journal's estimates do include this factor. (See page 3).

During the past year there has been considerable discussion of the possibility of allocating domestic crude oil demand among the producing

states on some basis such as reserves. It is assumed that each state would be allocated a share of current production proportionate to its percentage of domestic reserves.

Assuming that some such procedure were adopted, and using the reserve estimates from this inventory, North Dakota would be entitled to market approximately 125,000 barrels per day or about 50% more than is currently being sold.

As of 1 January 1963, North Dakota has the necessary productive capacity to supply such a market but actual sales of crude oil were restricted by the increasing influx of cheaper Canadian-produced oil into markets which should be logically served by North Dakota producers.

Projects designed to supplement reservoir energy now account for 30% of the estimated recoverable reserves in North Dakota. To date none of this additional reserve has been drawn on for current production. A number of additional projects will get under way during 1963 which will increase this figure to about 40%. In addition studies are now in progress on the feasibility of supplementing the natural reservoir energy in a number of additional pools.

Explanation of methods used in this study.

Throughout this inventory the standard volumetric method of estimating reserves has been used, according to the following formula;

$$R = 7758\ A\ h\ p\ (1-s)\ r\ /\ B$$ where

- R Recoverable reserves by presently known techniques
- A Proven acreage
- h Net average productive thickness in feet
- p Percent porosity
- s Percent water saturation
- r Recovery factor-percent
- B Reservoir volume factor - Barrels per barrel

As noted on page 3, the recovery factor used here does not take into account the economics of production. Since the study is intended to serve the same purpose as the annual inventories conducted by private business concerns the economic situation was considered to be beyond the scope of the work.

This should not constitute a valid criticism of the method since it is anticipated that future research and experience will increase, rather than decrease, the total ultimate recovery from our oil reservoirs.

For the purpose of this inventory a 40 acre tract was considered proven acreage if it contained a producing well or if it offset a producing well. Credit given to offsetting 40 acre tracts was reduced if they contained dry holes or were offset in turn by dry holes.

The net average productive thickness was determined by Sidney B. Anderson, Chief Subsurface Geologist for the North Dakota Geological Survey, from mechanical logs on file in his office. Drill stem tests, core analyses and other information were considered. Additional development, particularly in relatively new pools, tended to reduce the average thicknesses used in earlier estimates.

Porosities and saturations were taken from core analyses, where available, or from log calculations. When such data was not available values were assigned by analogy to other nearby pools producing from the same geologic intervals under similar conditions.

The formation volume factors were obtained from reservoir fluid analyses, when available, or by analogy.

The final result of the calculation was rounded off to the nearest thousand barrels, if the total was over 1 million, or to the nearest 500

barrels. The cumulative production to 1 January 1963 was then deducted to arrive at the final figure. Since the production is known to the exact barrel this results in the final figure being shown to the single barrel.

Reserves due to supplementation of reservoir energy were added only in those cases where fluid injection was actually in progress.

Discussion of tables.

The results of the inventory have been tabulated according to Marketing Districts (Table I), Counties (Table II), and Geologic Ages (Table III).

No attempt has been made to tabulate the results by pools or fields since in a number of cases, this would provide competitive information where all production in the field, or pool, is owned by a single operator.

It would appear, from Table I, that the proportional withdrawals of crude from the reserves in the separate marketing districts is in line with their reserves.

Williams County continues to lead in recoverable reserves with McKenzie, Bottineau, Burke and Mountrail counties following in that order. Reference to the last inventory shows that Burke County, as predicted, has displaced Mountrail County in the tabulation. However, it should be noted that the percentage of total recoverable reserves attributed to Williams County has dropped from the 47.5% in last year's inventory. Bottineau and Burke counties showed increased percentages but the largest change was in Bowman County which increased its share of the reserves from 1.1% to 7.18% during the year. In general this reflects the years

drilling activity which was concentrated in these areas.

As in previous inventories, production from the pools designated 'Spearfish-Charles' has been included in the Mississippian since the oil is considered to have migrated from the Charles into the Spearfish. Only one pool is considered to have Spearfish reserves. The Sanish has been included in the Devonian tabulation as has the Bakken-Three Forks.

From the tabulation it will be noted that the Devonian pools have been reduced, materially, from the earlier estimates, reflecting the general disappointment with the results of development. It is hoped that further exploration will justify the early optimism.

The number of fields and pools has been shown in each table. However the totals are shown only in Table I. Since no field, or pool, overlaps a marketing district boundary this total will reflect a true picture.

The acreage shown will total more than the actual developed surface acreage since, in a multi-pool field, the same acreage may be counted more than once.

Appendix 'A' shows the fields included in the various marketing districts.

Stripper Well Survey

In conjunction with the crude oil inventory a tabulation of sub-marginal wells was made. A 'sub-marginal' well is considered to be any well which, on the basis of its last reported production, is unable to produce an average of ten barrels per day. This study was undertaken

in an effort to demonstrate the importance of these wells to the state's petroleum industry.

Of the 1799 wells in the state which were capable of producing on 1 January 1963, 247 or 13.7% were marginal on the basis of the definition above. This is an increase over the 10% reported last year.

These sub-marginal wells average 5.6 barrels per day during 1962. Five of the wells which were sub-marginal on the last survey were plugged and abandoned during the year. Seventy-one wells were in fields undergoing water injection.

Sub-marginal wells in North Dakota account for 42 million barrels of the recoverable oil reserves. Their production during 1962 was the equivalent of about one weeks production from all the wells in the state.

The abandonment of only five sub-marginal wells during the year was in sharp contrast to the 24 wells abandoned the previous year. This can be attributed to the price increases realized in 1962 for oil from District II. This was an outstanding example of the importance of economic factors in the conservation of oil and gas. It is estimated that about ½ million barrels of oil will be left in the tracts on which these five wells were located. Since one of the wells was in a pool undergoing fluid injection its reserves will probably be recovered through adjacent wells, leaving the net loss of ultimate recovery at about 250,000 barrels compared to the 1 million barrel loss estimated for 1961.

Thus it could be said that the price increases added about 3/4 million barrels to the ultimate recovery of crude oil in North Dakota, since they prevented the premature abandonment of sub-marginal wells.

Acknowledgements

All of the information and data used in making this inventory was obtained from the files and records of the North Dakota State Industrial Commission, at the office of the North Dakota Geological Survey in Grand Forks.

In addition, to Mr. Anderson, recognition is herewith given to the help and assistance of Mr. Wesley D. Norton and Miss Mary McGill, Ass't. Petroleum Engineers for the Survey, and Mr. F. E. Wilborn, the Survey's Statistician.

TABLE I

CRUDE OIL INVENTORY IN NORTH DAKOTA

	Primary Reserves STO	Secondary Reserves STO	Total Recoverable Oil-STO	Production To 1-1-63	Remaining Recoverable Oil 1-1-63	% of Total	Fields	Pools	Acres	Fields Abandoned 1-1-63	Fields Producing 1-1-63	Pools Producing 1-1-63
District I	341152500	173574000	514726500	118488857	396237643	68.47	29	43	158280.40	0	29	42
District IIa	53308000	2000000	55308000	11950732	43357268	7.48	19	19	42520.00	2	17	17
District IIb	38284500	0	38284500	8269824	30014676	5.18	15	16	23180.00	3	12	12
District IIc	53798000	834000	54632000	8679425	45952575	7.94	12	13	25400.00	1	11	12
District III	68744000	0	68744000	5414867	63329133	10.93	9	11	17960.00	0	9	11
	555287000	176408000	731695000	152803705	578891295	100.00	84	102	267340.40	6	78	94
Less Gasoline Plant Recovery					-187563							
					578703732							

TABLE II

CRUDE OIL INVENTORY IN NORTH DAKOTA

	Primary Reserves STO	Secondary Reserves STO	Total Recoverable Oil-STO	Production To 1-1-63	Remaining Recoverable Oil 1-1-63	% of Total	Fields	Pools	Acres	Fields Abandoned 1-1-63	Fields Producing 1-1-63	Pools Producing 1-1-63
Billings	19450500	0	19450500	3260488	16190012	2.80	5	6	8840.00		5	6
Bottineau	81843000	834000	82677000	12657927	70019073	12.10	18	19	39420.00		17	18
Bowman	42903500	0	42903500	1352534	41550966	7.18	2	3	5320.00		2	3
Burke	65112000	19809750	84921750	16515799	68405951	11.82	21	21	46265.00		20	20
Divide	14860000	9052500	23912500	1685429	22227071	3.84	6	6	7635.00		5	5
Dunn	648000	0	648000	149208	498792	0.09	1	1	360.00		1	1
McHenry	693500	0	693500	29086	664414	0.11	1	1	480.00		1	1
McKenzie	135783500	0	135783500	34456253	101327247	17.51	14	23	60491.40		13	22
Mountrail	28329000	43994000	72323000	16646615	55676385	9.62	3	3	15060.00		3	3
Renville	8051000	0	8051000	4122981	3928019	0.67	5	5	7280.00		4	4
Stark	1441000	0	1441000	136256	1304744	0.22	2	3	1040.00		1	1
Ward	54000	0	54000	2999	51001	0.01	1	1	360.00		0	0
Williams	156118000	102717750	258835750	61788130	197047620	34.03	10	15	74789.00		10	15
	555287000	176408000	731695000	152803705	578891295	100.00			267340.40			

TABLE III

CRUDE OIL INVENTORY IN NORTH DAKOTA

	Primary Reserves STO	Secondary Reserves STO	Total Recoverable Oil-STO	Production To 1-1-63	Remaining Recoverable Oil 1-1-63	% of Total	Fields	Pools	Acres	Fields Abandoned 1-1-63	Fields Producing 1-1-63	Pools Producing 1-1-63
Devonian	58636000	0	58636000	10148334	48487666	8.37	13		27083.70			13
Mississippian	437433000	175808000	613241000	140935034	472305966	81.60	81		219271.00			77
Ordovician	44860000	0	44860000	1356865	43503135	7.51	4		12660.00			4
Silurian	13224000	600000	13824000	347245	13476755	2.33	3		7956.70			2
Triassic	1134000	0	1134000	16227	1117773	0.19	1		360.00			1
	555287000	176408000	731695000	152803705	578891295	100.00	102		267340.40			94

TABLE IVa

NORTH DAKOTA STRIPPER WELLS

	No. of wells	1961 Production	Acres	Abandoned 1961	Primary Reserves 1-1-62	Secondary Reserves 1-1-62	Average daily Production Dec. 1961	Average daily Production per well 1961
Billings	2	240	160.		191277		0	
Bottineau	49	137445	3640.28	7	6874148	68548	277	5.65
Bowman	1	2997	40.		20694		0	
Burke	27	67741	3509.02	9	4116449	1307734	117	4.33
Divide	1	3435	160.		94265		8	8.00
McKenzie	17	46152	1599.09	1	1966109		99	5.82
Mountrail	22	39765	1750.89		11520854	3057792	86	3.91
Renville	5	11909	320.	3	214148		23	4.60
Williams	50	99076	4313.69	5	7516282	10126032	301	6.02
	173	408760	15877.41	24	32589130	15591432	951	5.5 B/D Average

TABLE IVb

NORTH DAKOTA STRIPPER WELLS

	No. of wells	1962 Production	Acres	Abandoned 1962	Primary Reserves 1-1-63	Secondary Reserves 1-1-63	Average daily Production Dec. 1962	Average daily Production per well. 1962
Billings	5	17016	640.00	0	724013	0	323	8.43
Bottineau	54	113802	3720.28	3	6137346	400000	147	6.60
Bowman	1	4694	80.00	0	823598	0	256	9.80
Burke	30	98730	3761.08	1	4773700	1100000	100	7.26
Divide	1	3176	160.00	0	99287	0	272	8.80
McKenzie	33	84085	3893.04	0	7364797	0	145	7.64
Mountrail	24	45692	1911.19	0	1275241	2000000	100	5.91
Renville	2	4682	160.00	0	154710	0	168	5.79
Williams	67	104742	4643.14	1	7131194	10000000	58	7.40
	217	476619	18868.73	5	28483886	13500000	1569	5.60 B/D/well

APPENDIX 'A'

MARKETING DISTRICT I

Geographical description: Townships 148 North to 161 North, Ranges 94 West to 97 West, inclusive.

Fields : Gros Ventre, Viking, North Tioga, Tioga, McGregor, West Tioga, East Tioga, White Earth, Beaver Lodge, Capa, Hofflund, Delta, Charlson, Blue Buttes, Antelope, Croff, Bear Den, Lost Bridge, Pershing, Camel Butte, Fancy Buttes, Dimmick Lake, Clear Creek, Keene, Sand Creek, Northwest McGregor, Stoneview, Wildrose Field.

MARKETING DISTRICT II

Subdistrict A

Geographical description: Township 164 North, Ranges 88 West to 103 West, inclusive, Township 163 North, Ranges 88 West to 103 West, inclusive, Township 162 North, Ranges 88 West to 103 West, inclusive, Township 161 North, Ranges 88 West to 93 West, and 98 West to 103 West, inclusive, and Township 160 North, Ranges 88 West to 93 West, and 98 West to 103 West, inclusive.

Fields : Baukol-Noonan, Noonan, Short Creek, Columbus, Portal, Rival, Black Slough, Foothills, Northeast Foothills, Rennie Lake, Lignite, Flaxton, Stony Run, Woburn, Bowbells, Coteau, and Dimond.

Subdistrict B

Geographical description: All of the state not included in other districts or subdistricts.

Fields : Dickinson, Haas, North Haas, Kuroki, Wayne, Wiley, Elmore, Sherwood, Eden Valley, Pratt, and Glenburn.

Subdistrict C

Geographical description: Townships 160 North to 164 North, Ranges 77 West to 80 West, inclusive.

Fields : North Souris, Scandia, Northeast Landa, Roth, Starbuck, South Starbuck, North Westhope, Westhope, South Westhope, and Newburg.

MARKETING DISTRICT III

Geographical description: Townships 129 North to 160 North, Ranges 98 West to 107 West, inclusive.

Fields : Little Missouri, Cedar Creek, Rocky Ridge, Fryburg, Scoria, Blacktail, Rough Rider, Elkhorn Ranch, and Grenora.