

NORTH DAKOTA GEOLOGICAL SURVEY
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NORTH DAKOTA CRUDE OIL INVENTORY AS OF JANUARY 1, 1965

by
Clarence B. Folsom, Jr. P. E.

Miscellaneous Series #25

Grand Forks, North Dakota, 1965

NORTH DAKOTA CRUDE OIL INVENTORY AS OF 1 JANUARY 1965

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As of 1 January, 1965, the remaining reserves of crude oil in the State of North Dakota, recoverable by present technical knowledge, available equipment, and current producing practices were 644,726,457 barrels of stock tank oil. This was the highest level reserves have reached since oil was discovered in North Dakota in 1951, in spite of record production of 26,280,379 barrels of oil during 1964.

Of the total, 258,313,000 barrels will be recovered through energy supplementation projects in unitized fields, an increase of 17,478,000 barrels over the comparable figure for 1 January 1964. The increase resulted from the initiation of two new projects during the year in the Cedar Creek-Ordovician Pool in Bowman County, and the Hawkeye-Madison Pool in McKenzie County. At the end of the year 922 of the 1899 producing wells in the state, or 48.5%, were undergoing stimulation by water injection. Another project was nearing final approval at year's end and should be initiated during 1965.

The remainder of the recoverable reserves 386,413,457 barrels are considered to be first order, or primary, reserves. This is in close agreement with the estimate of 389,000,000 barrels published by the Oil and Gas Journal in its issue of 25 January 1965.

During 1964 a total of 90 wildcat wells were completed, representing a considerable increase in activity over 1963 when only 59 wildcats were drilled. As a result of this exploratory activity 9 new pools were discovered establishing a success ratio of 1 in 10 for 1964. These new pools added a total of 10,771,500 barrels to recoverable reserves.

Revisions of former estimates reduced the total by 3,689,000 barrels and, in conjunction with production during the year, resulted in a net reduction from the reserves indicated on 1 January 1964. However, the new discoveries plus the

additional reserves made available by the initiation of energy supplementation projects were enough to offset these factors and provide a net increase of nearly 10 million barrels. From these figures it can be seen that the State of North Dakota must rely heavily on unitized operations if it is to maintain a satisfactory reserve/production ratio. The reserves on 1 January 1965 represented a 8979 days supply at the average rate of production during 1963 (71804 barrels per calendar day), whereas the figure for 1 January 1964 had represented 9257 days supply at the 1962 average rate (68575 barrels per calendar day).

The inventory has been tabulated by Marketing District, County, and geologic interval in the tables at the end of the report.

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:

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

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

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 1965 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.

Developments during 1964

The year ending 1 January 1965 was a year of new records for North Dakota. Record production, record reserves, and a 72% increase in the number of permits issued made 1964 the best year since 1958.

The discovery of the Medora Field, in Billings County, with production from both the Heath and Madison pools, was the highlight of the year. This field accounted

for 40% of the reserves added by new discoveries. As a result interest in the construction of a pipeline in the Dickinson-Glendive area was indicated by several potential carriers. With the extension of the Portal Pipeline west to Grenora, the Billings County area remained the only major producing area not served by a trunk pipeline.

The major part of the drilling activity centered in Renville County and resulted in the discovery of three new fields in the county. The Mouse River Park field, developed rapidly with 17 producing wells being completed before the end of the year. In addition, two producing wells were completed as outposts to the northwest corner of the field.

Three price cuts were posted during the year with District I crude down 10¢ a barrel, and District II crude down an average of 23¢ a barrel from the previous quotations. Crude runs from leases remained reasonably stable with a slight increase being noted in District III. North Dakota continued to account for about 1% of the domestic crude oil marketed, on a daily basis.

North Dakota's share of the nations recoverable reserves continued its steady climb, as indicated below:

1 January 1962	1.375%
1 January 1963	1.670
1 January 1964	1.340
1 January 1965	1.363

however its share of the domestic market fell from 1.375%, in 1961, to 0.937% in 1964.

Discussion of tables

The distribution of reserves by Marketing District is shown in Table I. Comparison with the table in Miscellaneous Contribution #22 indicates that Marketing District IIb increased its percentage of the reserves primarily at the expense of District IIIb. When it is recalled that District IIIb was the site of the largest

discovery (the Medora Field) some idea of the extent of the activity in Renville County can be obtained.

Williams County remained the leader in reserves with 33.64% of the total for the state. McKenzie, Bottineau, Burke, and Mountrail followed in order, holding their same relative positions as in the previous inventory.

Mississippian formations continued to provide the bulk of reserves with 80% of the total. In general, percentage of total reserves decreased with an increase in depth continuing a trend which was noted in previous inventories.

Outlook

It is expected that exploratory activity will continue at a high rate with most interest centered in the Renville-Bottineau area. Additional interest is indicated in the southwestern quarter of the state and this area might become the 'hot-spot' for 1965. Prospects of pipeline connection are expected to kindle interest in the search for additional Madison oil to be blended with available Heath crude. Such blending is necessitated by the high pour-point of the Heath Crude.

Production in 1965 should total about 26 million barrels, possibly exceeding the 1964 record. Competition with crude from Canada as well as crude from other sectors of the Rocky Mountain Area will depend upon increased efficiency of production.

The procedures recommended by the Special Study Committee of the Interstate Oil Compact Commission to increase production efficiency have been in effect in North Dakota for some years with the exception of Statutory Unitized Management. Additional measures such as commingling in the well-bore and installation of LACT equipment have been adopted in recent years, and other new techniques and equipment will be utilized as they become available.

Stripper Well Survey

Table IVb from Miscellaneous Series No. 22 is included here, as Table IVa for the purpose of comparison. The new Table IVb reflects the same information for 1 January 1965.

On that date there were 1899 wells in North Dakota capable of producing oil. Of these, 226 were classified as sub-marginal on the basis of their performance during December 1964. This represented 12% of the producing wells and accounted for 2.3% of the total oil production in the state during 1964.

The average production for the sub-marginal wells during 1964 was 7.26 barrels of oil per well per producing day, compared to 4.18 barrels per day for the previous year.

Well stimulation techniques were applied with outstanding success during 1964 and many wells which had been classified as sub-marginal in earlier years were restored to rates of production in excess of 10 barrels per day (the limit used in this study). Thus, in spite of a higher rate of abandonment the total number of sub-marginal wells declined even more. Eighteen wells were abandoned during the year but two of these were converted to injection wells in reservoir energy supplementation projects.

Although the number of sub-marginal wells was reduced the recoverable reserves underlying the wells on 1 January 1965 was 44.2 million barrels STO as compared to 40.9 million barrels on 1 January 1964. The difference is accounted for by the initiation of reservoir energy supplementation projects, and revisions of earlier estimates.

In reservoirs being operated as units the sub-marginal wells were generally shut-in with their allowables being transferred to other wells. These non-producing wells remain available for emergency use or for conversion to injection and brine disposal wells.

The increased number of abandonments is considered to reflect the three reductions in crude price postings which occurred during 1964. These reductions amounted to an average of 23¢ per barrel, in District II, and 10¢ per barrel, in District I. It is reasonable to assume that these cuts were, at least partly, due to the increased flow of foreign imports into the Marketing Area usually supplied by North Dakota producers and the resulting increase in abandonments stands as mute testimony to the necessity for more effective import restrictions.

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 Juanita Williams, Ass't. Petroleum Engineers for the Survey, and Mr. F. E. Wilborn, Jr., the Survey's Statistician.

TABLE I

CRUDE OIL INVENTORY IN NORTH DAKOTA

	Primary Reserves STO	Secondary Reserves STO	Total Recoverable Oil-STO	Production To 1-1-65	Remaining Recoverable Oil 1-1-65	% of Total	Fields	Pools	Acres	Fields Abandoned 1-1-65	Fields Producing 1-1-65	Pools Producing 1-1-65
District I	372662500	249301000	622163500	150922726	471170774	73.06	35	50	161909	2	33	48
District IIa	62396000	2000000	64396000	17147495	47248505	7.33	20	20	53380	3	17	17
District IIb	54350500		54350500	14464987	39885513	6.18	24	25	36240	5	19	20
District IIc	56621500	834000	57455500	11654416	45801084	7.10	16	17	30060	0	16	17
District IIIa	3192000		3192000	1331535	1860465	6.29	1	1	3040	0	1	1
District IIIb	41117000	6178000	47295000	8351195	32765805	6.94	8	12	22029	2	6	10
	590539500	258313000	848852500	203872354	644980146	100.00	104	125	306658	12	92	113
Less Gasoline Plant Recovery					253689							

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TABLE II

CRUDE OIL INVENTORY IN NORTH DAKOTA

	Primary Reserves STO	Secondary Reserves STO	Total Recoverable Oil-STO	Production To 1-1-65	Remaining Recoverable Oil 1-1-65	% of Total	Fields	Pools	Acres	Fields Abandoned 1-1-65	Fields Producing 1-1-65	Pools Producing 1-1-65
Billings	27561500		27561500	4657018	22904482	3.55	5	8	13740	2	3	6
Bottineau	91480000	834000	92314000	17987728	74326272	11.53	27	28	48420	0	27	28
Bowman	10105500	6178000	16283500	3168106	13115394	2.03	2	3	7289	0	2	3
Burke	74200000	19809750	94009750	23387912	70621838	10.95	22	22	57125	2	20	20
Divide	13512000	9052500	22564500	2358691	20205809	3.13	6	6	7635	1	5	5
Dunn	648000		648000	206819	441181	0.07	1	1	360	0	1	1
McHenry	3230000		3230000	133225	3096775	0.48	1	1	1000	0	1	1
McKenzie	169082000	42177000	211259000	48186699	163072301	25.29	15	25	64200	2	13	23
Mountrail	28329000	43994000	72323000	19471737	52851263	8.20	3	3	15060	0	3	3
Renville	14835500		14835500	7735957	7099543	0.95	9	9	14900	3	6	6
Stark	1327500		1327500	223173	1104327	0.17	2	3	1320	2	1	1
Ward	99000		99000	39320	59680	0.01	1	1	660	0	1	1
Williams	156129500	136267750	292397250	76315969	216081281	33.64	10	15	74949	0	10	15
	590539500	258313000	848852500	203872354	644980146	100.00			306658			
Less Gasline Plant Recovery					253689							

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TABLE III

CRUDE OIL INVENTORY IN NORTH DAKOTA

	Primary Reserves STO	Secondary Reserves STO	Total Recoverable Oil-STO	Production To 1-1-65	Remaining Recoverable Oil 1-1-65	% of Total	Fields	Pools	Acres	Fields Abandoned 1-1-65	Fields Producing 1-1-65	Pools Producing 1-1-65
Devonian	63389000	33550000	96939000	15989632	80949368	12.56	15	29558		2		13
Mississippian	482892500	217985000	700877500	179618585	521258915	80.85	97	244880		7		10
Ordovician	12314000	6178000	18492000	3343390	15148610	2.35	4	14029		1		3
Pennsylvanian	16903000		16903000	2653320	14249680	2.21	5	9060		1		4
Silurian	13907000	600000	14507000	2234414	12272586	1.90	3	8771		1		2
Triassic	1134000		1134000	33013	1100987	0.13	1	360				1
	590539500	258313000	848852500	203872354	644980146	100.00		306658				
Less Gasline Plant Recovery					253689							

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TABLE IVa
NORTH DAKOTA STRIPPER WELLS

	No. of wells	1963 Production	Acres	Abandoned 1963	Primary Reserves 1-1-64	Secondary Reserves 1-1-64	Average daily Production Dec. 1963	Average daily Production per well 1963
Billings	7	19686	1120	1	113924		37	5.23
Bottineau	66	146900	4876	1	8471238	37655	358	5.43
Bowman	1	4079	80		425195		10	9.68
Burke	56	130725	6610		6123671	4014525	199	3.56
McKenzie	31	57236	820	1	6866500	898082	164	5.29
Mountrail	30	57089	2382		1421092	4046832	125	4.16
Renville	9	35736	820		771084		57	6.35
Williams	71	117607	6067		7743822		183	2.58
	271	569058	25175	3	31936526	8997094	1133	4.18 B/D/well

TABLE IVb
NORTH DAKOTA STRIPPER WELLS

	No. of wells	1964 Production	Acres	Abandoned 1964	Primary Reserves 1-1-65	Secondary Reserves 1-1-65	Average daily Production Dec. 1964	Average daily Production per well 1964
Billings	4	8897	1164	1	1001871		15	3.0
Bettineau	54	131640	3840.87	1	6184527		9312	6.92
Bowman	7	24147	560	3	683040	494000	482	8.46
Burke	63	188778	7526.69	6	7236702	4102000	8463	7.44
Divide	1	2281	160	0	303025	543000		
McKenzie	25	52921	2391.87	3	3223594	1176000	3575	8.26
Mcuntrail	20	50649	1591.58	0	654241	2024000	3576	6.75
Renville	10	21991	820	4	1254304		523	6.79
Williams	42	123105	3886.10	0	9558882	5830000	6523	7.15
	266	604409	21941.11	18	30100186	14169000	32469	7.26 B/D/well

APPENDIX "A"

MARKETING DISTRICT I

Geographical description: Township 148 North to 161 North, Ranges 94 West 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, and Hawkeye.

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, and Perella.

Subdistrict B

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

Fields: Dickinson, Haas, North Haas, Kuroki, Wayne, Wiley, Elmore, Sherwood, Eden Valley, Pratt, Glenburn, Lansford, Mohall, North Maxbass, South Antler Creek, Southwest Haas, Tolley, Chola, Southwest Aurelia, and Mouse River Park.

Subdistrict C

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

Fields: North Souris, Scandia, Northeast Landa, Roth, Starbuck, South Starbuck, North Westhope, Westhope, South Westhope, Newburg, East Newburg, West Roth, Boundary Creek, and Russell.

MARKETING DISTRICT III

Subdistrict A

Geographical description: Townships 158 North to 160 North, Ranges 98 West to 107 West, inclusive.

Fields: Grenora

Subdistrict B

Geographical description: Townships 129 North to 158 North, Ranges 98 West to 107 West, inclusive.

Fields: Little Missouri, Cedar Creek, Rocky Ridge, Fryburg, Medora, and Rough Rider.