

NORTH DAKOTA GEOLOGICAL SURVEY
Wilson M. Laird, State Geologist

NORTH DAKOTA CRUDE OIL INVENTORY AS OF JANUARY 1, 1969

by

Clarence B. Folsom, Jr. P. E.

Miscellaneous Series #38

Grand Forks, North Dakota, 1969

NORTH DAKOTA CRUDE OIL INVENTORY AS OF 1 JANUARY 1969

by
Clarence B. Folsom Jr. P. E. 1/

ABSTRACT

North Dakota's reserves of crude oil, recoverable with present technical knowledge, available equipment, and current operating practices, were 663,623,900 barrels on 1 January 1969. This figure is a decrease from the 713,717,844 barrels reported for 1 January 1968.

The decrease in inventory reflected decreased drilling activity in the state during 1968 as well as fewer new energy supplementation projects.

307,922,231 barrels, or 46.4% of the total reserves, will be recovered by energy supplementation.

Reports of 233 well completions were received by the Geological Survey in 1968. Of these, 40 were completed as producing wells. About 76.2% of the production in the month of December, 1968 came from unit operation and 27.5% of the producing wells are considered to be marginal, or stripper wells.

Four new pools were opened during the year but only three were credited to wildcat exploration. With permits issued for 138 wildcat prospects the success ratio was 1 in 34.

The methods used, the data sources, and the assumptions made in previous reports in this series have been followed so that the results may be compared and valid conclusions drawn therefrom.

1/ Chief Petroleum Engineer, North Dakota Geological Survey

Results of the Study

Technically recoverable reserves of crude oil in North Dakota were 663,623,900 stock tank barrels on 1 January 1969. Of this amount 307,922,231 barrels, or 46.4%, were credited to energy supplementation projects. Twenty-four of the 121 producing pools in the state were undergoing unitized operation compared with 22 on 1 January 1968. Two new projects were initiated in the state during 1968 and two others were under study at year's end.

Oil production for the year of 1968 was 24,572,624 stock tank barrels, a decline of 5.0% from the total for 1967. This was the second successive year in which production declined. Cumulative oil recovery to 1 January 1969 was 306,527,109 stock tank barrels of which 1,112,769 barrels were produced from second order reserves.^{2/}

The initiation of injection in the two energy supplementation projects approved by the Industrial Commission during 1968 added only 2,897,000 barrels to the inventory and 2,052,966 barrels were deleted from prior estimates so that the net addition did not offset withdrawals in these pools. During the year three new fields were discovered and a new pool was opened in an old field. These new pools added 2,474,500 barrels but 18,651,849 barrels were deleted by revision of the estimated net pay thickness in several pools due to additional development.

There were 2,075 wells, in North Dakota, capable of producing on the first of January 1969. Of these 572 were classified as stripper wells, unable to produce more than ten barrels of oil per day, compared with 360 on 1 January 1968. Twenty of the stripper wells were abandoned during 1968 and

^{2/} The terms "primary" and "secondary" have been dropped in favor of the terms "first order" and "second order" because it is felt that these programs should constitute a continuing phase of production and should not be defined by rigid time boundaries.

and 232 wells reached stripper stage during the year. Some of these marginal wells were converted to service wells and, in unitized pools, some of them were shut-in. The sudden increase in the number of stripper wells emphasized the decline in production.

During 1968 the Geological Survey issued 249 drilling permits and received 233 reports of completion. There were 92 wells abandoned as dry holes. One hundred and thirty-eight wells, classified as wildcats when the permit was issued, were completed and resulted in four new pool discoveries. Total footage drilled during 1968 was 1,297,409 feet for an average of 5979 feet per well. Comparing this with the average for 1967 (6710 feet) reflects the increase in drilling activity generated by new interest in the "Muddy" formation which occurs at shallow depths in most areas in the state.

The results of the study have been tabulated in several categories and the tables appear at the end of the report.

Developments in 1968

The year was featured by the 'Muddy Play' which was generated by large discoveries in southeastern Montana. Since the Newcastle Formation (synonymous with 'Muddy') occurs over a large part of the state and at relatively shallow depths these discoveries touched off a leasing spree in the eastern one-third of North Dakota. In the southwestern part of the state, land that was already under lease was reevaluated by the operators. Sixty-nine wells were drilled in Slope and Bowman counties.

In eastern North Dakota 16 permitted wells, and 57 stratigraphic test holes were drilled.^{3/}

^{3/} A 'Stratigraphic test well' means a hole, except a seismograph shot hole, drilled for the purpose of gathering information in connection with the oil and gas industry, which hole does not exceed five inches in diameter under surface casing.(NDIC Rules)

Since permits are not required for 'strat tests' they are not included in the previous data for permits, footage, and completions.

In the south-central part of the state 12 wells were permitted, all of which gave the 'Muddy' as the objective. Most of the activity involved small independent operators, but major companies did take part, as etals, in some of the programs. The information obtained will it is hoped, lead to additional drilling and the possibility of finding additional reserves. Much of the information is confidential but what has been released reported only slight shows.

Market demand for North Dakota crude oil continued to exceed the supply during 1968 and refineries were forced to move into new areas in order to augment declining reserves. Oil which had previously moved to the Twin Cities and Head-of-the-Lakes markets was diverted to the refinery at Mandan and the Williston refinery increased its runs of oil from eastern Montana.

A serious decline in production was reflected in the increased number of wells included in the Stripper Well Survey.^{4/} Although 20 development wells and 16 extension wells were completed as producers they were not of sufficient capacity to offset the decline. During the year three pools began to draw from second order reserves.

In prior years the initiation of energy supplementation projects added sufficient reserves to provide a net increase but most of the pools which would be susceptible to fluid injection are now unitized and we cannot look to such projects for relief in the future.

If North Dakota is to maintain its position in the oil producing industry a substantial increase in exploratory drilling must be forthcoming. North Dakota must compete with other areas, foreign and domestic, for the capital

^{4/} See page 13

investments required by such a program and can only compete by offering a better climate for the industry than can be found elsewhere.

TABLE I

New Field and Pool Discoveries.

| | | |
|------------------|-----------------|----------|
| Tioga - Silurian | Williams County | 2-18-68* |
| East Goose Lake | Williams County | 4- 1-68 |
| Zenith | Stark County | 10-12-68 |
| Round Prairie | Williams County | 12- 1-68 |

*New pool in old field

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:

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

- 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.

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 mechan-

cal 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 1969 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.

Discussion of the Tables

Marketing District I continued to show a steady increase in percent of the state total. This was due to continued development of deeper producing formations. The increase was mostly at the expense of District IIIa which saw little drilling activity during the year. Changes in the other districts were minor.

Among the counties, Williams continued to hold the largest percentage of reserves, followed by McKenzie County.

There were only minor changes in the distribution of reserves between the several geological intervals. The Mississippian pools still provide the majority of North Dakota's reserves, both first and second order.

The reserves found in the Heath Formation are credited to the Permo-Pennsylvanian, reflecting the present thinking of the subsurface section of the Survey.

A word of caution should be given concerning the figures in the column headed 'Producing Acres'. The figures shown are the total of all producing spacing units in the pool. Thus, where there are several pools in a field, the same acreage may be included in one or all of the pools. The area classified as productive will be less than that shown but no effort was made to account for this in the tabulation. Perhaps this can be included in future reports.

Totals for 'Fields' and 'Pools' are given in Table II only since marketing districts are defined in such a way that no 'field' or 'pool' crosses a marketing district boundary, although they can, and do, cross county lines.

Stripper Well Survey

Table Va is included for comparison.^{5/} Production from marginal wells amounted to 4.2% of total production in 1968, up about 1/3 from 1967.

The decline in production caused many wells to fall below the 10 barrels per day average for the month of December which is the basis for classification as a stripper well. An increase of 232, or 68%, was the largest increase in a single year since oil production started in 1952.

Any action which would cause these wells to be plugged and abandoned must be carefully avoided. They represent about 16% of the recoverable reserves and must be continued in production as long as possible if maximum recovery is to be obtained.

^{5/} From Miscellaneous Series #36

While some of these reserves might be recovered through adjacent wells about 50 million barrels of reserves will have to be produced through the stripper wells themselves if violation of the correlative rights of the owners, under whose land the reserves lie, is to be avoided.

Price increases and cost reductions will be most effective in achieving the necessary result.

Those who advocate abandonment of these wells on the grounds of low efficiency do not seem to realize that wells in North Dakota are already producing at capacity and would not be able to assume any substantial part of the burden of the 2800 barrels per day that are being produced by these marginal wells. Abandonment would simply mean a loss of production and the waste of that portion of the reserves that will be recovered before economic considerations make continued operation unfeasible.

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. F. E. Wilborn, Jr., Assistant Petroleum Engineer for the Survey, and Miss Judy Peterson, the Survey's Statistician.

TABLE II

CRUDE OIL INVENTORY IN NORTH DAKOTA

| | Primary Reserves Bbls. STO | Secondary Reserves Bbls. STO | Total Recoverable Bbls. STO | Production to 1-1-69 Bbls. STO | Remaining Recoverable Bbls. STO | % of Total | Fields Disc. to 1-1-69 | Pools Disc. to 1-1-69 | Fields Abandoned to 1-1-69 | Fields Producing 1-1-69 | Pools Producing 1-1-69 | Produci Acres |
|------------------------------|----------------------------------|------------------------------------|-----------------------------------|--------------------------------------|---------------------------------------|------------------|------------------------------|-----------------------------|----------------------------------|-------------------------------|------------------------------|------------------|
| District I | 359792550 | 282697000 | 642489550 | 211463176 | 431026374 | 69 | 31 | 53 | 1 | 30 | 47 | 166215 |
| District IIa | 68408200 | 9222000 | 77630200 | 25687180 | 51493020 | 7.8 | 22 | 23 | 4 | 17 | 19 | 65325 |
| b | 86222000 | - | 86222000 | 31191906 | 55030094 | 8.3 | 30 | 31 | 5 | 25 | 25 | 55000 |
| c | 41865500 | 10938000 | 52803500 | 16979267 | 35824233 | 5.4 | 17 | 18 | 1 | 16 | 17 | 34605 |
| District IIIa | 6364000 | - | 6364000 | 2145855 | 4218145 | 0.6 | 1 | 1 | 0 | 1 | 1 | 3788 |
| b | 99105000 | 6178000 | 105283000 | 19700946 | 85582054 | 12.9 | 10 | 14 | 2 | 8 | 12 | 31909 |
| | 661757250 | 309035000 | 970792250 | 307168330 | 663623920 | 100 | 111 | 140 | 13 | 98 | 121 | 356842 |
| Less Gasoline Plant Recovery | | | | 469965 | 469965 | | | | | | | |
| | | | | 306698365 | 663153955 | | | | | | | |

TABLE III

CRUDE OIL INVENTORY IN NORTH DAKOTA

| | Primary Reserves Bbls. STO | Secondary Reserves Bbls. STO | Total Recoverable Bbls. STO | Production to 1-1-69 Bbls. STO | Remaining Recoverable Bbls. STO | % of Total | Fields Disc. to 1-1-69 | Pools Disc. to 1-1-69 | Fields Abandoned to 1-1-69 | Fields Producing 1-1-69 | Pools Producing 1-1-69 | Product Acres |
|------------------------------|----------------------------------|------------------------------------|-----------------------------------|--------------------------------------|---------------------------------------|------------------|------------------------------|-----------------------------|----------------------------------|-------------------------------|------------------------------|------------------|
| Billings | 49032500 | - | 49032500 | 12743461 | 36289039 | 5.5 | 5 | 8 | 2 | 6 | 6 | 22220 |
| Bottineau | 86418500 | 10938000 | 92356500 | 27982508 | 69373992 | 10.5 | 28 | 29 | 3 | 25 | 26 | 56565 |
| Bowman | 44909500 | 6178000 | 51087500 | 5982464 | 45105036 | 6.8 | 3 | 4 | 0 | 3 | 4 | 7969 |
| Burke | 79523200 | 27031750 | 106554950 | 34858848 | 71696102 | 10.8 | 22 | 23 | 3 | 19 | 20 | 68345 |
| Divide | 14201000 | 9052500 | 23253500 | 3625725 | 19627775 | 2.9 | 8 | 8 | 1 | 7 | 7 | 8360 |
| Dunn | 390000 | - | 390000 | 304239 | 85761 | -0.1 | 1 | 1 | 0 | 1 | 1 | 360 |
| McHenry | 3230000 | - | 3230000 | 303760 | 2926240 | 0.4 | 1 | 1 | 0 | 1 | 1 | 1000 |
| McKenzie | 144356000 | 71273000 | 215629000 | 75366115 | 140262885 | 21.0 | 15 | 28 | 1 | 15 | 22 | 63446 |
| Mountrail | 28329000 | 43994000 | 72323000 | 23652209 | 48670791 | 7.3 | 13 | 3 | 0 | 3 | 3 | 15080 |
| Renville | 29764500 | - | 29764500 | 16724879 | 13039621 | 2.0 | 12 | 12 | 2 | 10 | 10 | 21020 |
| Slope | 1713000 | - | 1713000 | 264643 | 1448357 | 0.2 | 1 | 1 | 0 | 1 | 1 | 720 |
| Stark | 7300500 | - | 7300500 | 2856378 | 4444122 | 0.7 | 5 | 6 | 1 | 4 | 4 | 9080 |
| Ward | 1374000 | - | 1374000 | 303648 | 1070352 | 0.2 | 2 | 2 | 0 | 2 | 2 | 1940 |
| Williams | 171215550 | 140567750 | 311783300 | 102199453 | 209583847 | 31.6 | 11 | 20 | 0 | 12 | 20 | 80757 |
| | 661757250 | 309035000 | 970792250 | 307168330 | 663623920 | | - | - | - | - | - | 356842 |
| Less Gasoline Plant Recovery | | | | 469965 | 469965 | | | | | | | |
| | | | | 306698365 | 663153955 | | | | | | | |

TABLE IV

Crude Oil Inventory in North Dakota

| | Primary Reserves Bbls. STO | Secondary Reserves Bbls. STO | Total Recoverable Bbls. STO | Production to 1-1-69 Bbls. STO | Remaining Recoverable Bbls. STO | % Of Total | Fields Disc. to 1-1-69 | Pools Disc. to 1-1-69 | Fields Producing 1-1-69 | Pools Producing 1-1-69 | Producing Acres |
|------------------------------|----------------------------------|------------------------------------|-----------------------------------|--------------------------------------|---------------------------------------|------------------|------------------------------|-----------------------------|-------------------------------|------------------------------|--------------------|
| Devonian | 66067000 | 36670000 | 102737000 | 29316118 | 73420882 | 11.1 | | 19 | | 14 | |
| Mississippian | 467988750 | 255587000 | 723575750 | 241539515 | 482036235 | 72.6 | | 97 | | 86 | |
| Ordovician | 54752500 | 6178000 | 60930500 | 7402684 | 53527816 | 8.1 | | 9 | | 8 | |
| Permo-Penn | 29859500 | - | 29859500 | 10082412 | 19777088 | 3.0 | | 7 | | 6 | |
| Silurian | 14829000 | 600000 | 15429000 | 5806468 | 9622532 | 1.4 | | 4 | | 3 | |
| Triassic | 28260500 | 10000000 | 38260500 | 13021133 | 25239367 | 3.8 | | 4 | | 4 | |
| | 661757250 | 309035000 | 970792250 | 307168330 | 663623920 | | | 140 | | 121 | |
| Less Gasoline Plant Recovery | | | | 469965 | 469965 | | | | | | |
| | | | | 306698355 | 663153955 | | | | | | |

TABLE Va

NORTH DAKOTA STRIPPER WELLS

| <u>County</u> | <u>Number of Wells</u> | <u>1967 Prod. Bbls.</u> | <u>Acres</u> | <u>Abandoned 1967</u> | <u>Primary Reserves 1-1-68</u> | <u>Secondary Reserves 1-1-68</u> | <u>Average BOPD Dec. 1967</u> | <u>Average BOPD/Well 1967</u> |
|---------------|--------------------------------|---------------------------------|--------------|---------------------------|--|--|---------------------------------------|---------------------------------------|
| Billings | 7 | 14046 | 1760 | 0 | 2117158 | | 4.7 | 5.5 |
| Bottineau | 78 | 161072 | 5841 | 2 | 8112729 | 10104421 | 6.0 | 1.6 |
| Bowman | 2 | 2870 | 240 | 3 | 788806 | 80314 | 0.0 | 7.8 |
| Burke | 97 | 213743 | 12393.11 | 3 | 8144727 | 2012725 | 6.6 | 0.4 |
| Divide | 0 | | | 0 | | | | |
| McKenzie | 57 | 157881 | 5686.87 | 1 | 4953673 | 5318900 | 4.7 | 0.7 |
| Mountrail | 18 | 34742 | 1438.64 | 0 | 126033 | 2023724 | 5.6 | 5.3 |
| Renville | 15 | 40612 | 1200 | 3 | 1185600 | | 6.1 | 7.4 |
| Williams | 85 | 192445 | 7409.92 | 9 | 8680721 | 12515379 | 6.9 | 6.2 |
| Ward | 1 | 1262 | 80 | 0 | 12000 | | 0 | 3.5 |
| | 360 | 818673 | 36049.54 | 21 | 34117447 | 32055463 | 4.6 | 3.9 |

TABLE Vb

North Dakota Stripper Wells

| | Number of Wells | 1968 Prod. Bbls. | Acres | Abandoned 1968 | Primary Reserves 1-1-69 Bbls. | Secondary Reserves 1-1-69 Bbls. | Ave. Daily Production Dec. 1968 | Ave. Daily Production Per Well 1968 |
|-----------|-----------------------|------------------------|-------|-------------------|-------------------------------------|---------------------------------------|---------------------------------------|---|
| Billings | 17 | 53988 | 4560 | 0 | 7296222 | 0 | 6.95 | 8.7 |
| Bottineau | 101 | 183183 | 7796 | 1 | 7453790 | 1481136 | 6.36 | 5.0 |
| Bowman | 2 | 10472 | 160 | 0 | 1072002 | 165602 | 8.21 | 14.3 |
| Burke | 150 | 229520 | 18120 | 9 | 13417508 | 6322186 | 6.16 | 4.2 |
| Divide | 0 | - | - | - | - | - | - | - |
| Dunn | 0 | - | - | - | - | - | - | - |
| McHenry | 3 | 11269 | 240 | 0 | 663644 | 0 | 6.66 | 10.1 |
| McKenzie | 89 | 178750 | 8206 | 8 | 7772745 | 7957592 | 6.48 | 5.5 |
| Mountrail | 55 | 85185 | 4372 | 1 | 1653100 | 14657695 | 4.90 | 4.2 |
| Renville | 14 | 43521 | 1120 | 0 | 929633 | 0 | 6.53 | 8.5 |
| Slope | 0 | - | - | - | - | - | - | - |
| Stark | 0 | - | - | - | - | - | - | - |
| Ward | 1 | 55 | 80 | 0 | 0 | 0 | 0 | 0.1 |
| Williams | 140 | 256713 | 11728 | 1 | 8948018 | 28185827 | 5.33 | 5.0 |
| | 572 | 1052656 | 56382 | 20 | 49206662 | 58770038 | 5.6 | 5.0 |

APPENDIX A

MARKETING DISTRICT I

Geographical description: Township 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, 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, East Goose Lake, 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 districts or subdistricts.

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

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, 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, Medicine Pole Hills, Rocky Ridge, Round Prairie, Fryburg, Medora, and Rough Rider.