

# MICHIGAN'S OIL AND GAS FIELDS, 1966

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## ACKNOWLEDGMENTS

The contents of this publication result from the joint efforts of the Survey's Oil and Gas Section. The publication brings together under one cover many related oil and gas field statistical data not usually found in any other industry or government publication.

Certain kinds of data such as number of exploratory wells drilled, amount of exploratory or development well drilled footage, well classifications, and so forth, may differ from statistical data reported by regional or national trade journals, or by petroleum industry reporting services. The kinds of data mentioned have been treated uniformly as near as possible from year to year. In general, the data agrees closely with statistics printed in recent years by the American Association of Petroleum Geologists,

Oil and gas field data of historical and general interest is included and thus preserved herein for future reference. The summary is, therefore, a source of information most useful in evaluating Michigan's past history and future prospects as a petroleum and natural gas province. Furthermore, the gathering, maintenance, and compilation of the many statistical data contained in this

summary reflects, in part, the varied functions of the Oil and Gas Section of the Survey.

Current oil and gas production figures are provided by the Michigan Department of Revenue. Other statistics are based on data gathered by the Geological Survey.

The statistics in this report have been compiled from records kept by staff members of the Oil and Gas Section supervised by L. W. Price. Oil and Gas Section unit supervisors directed the gathering and maintenance of the basic records. Unit supervisors who assembled and summarized the basic data for manuscript preparation are:

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The cover photo, showing a part of the gas storage facilities in Six Lakes gas storage field, central Michigan, was provided through courtesy of Michigan Consolidated Gas Company, owners and operators.

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G. D. Ells  
Compiler

## PETROLEUM INDUSTRY IN MICHIGAN IN 1966

### Introduction

Over-all oil and gas field activity was slightly below that of 1965. The most active regions of new field exploration and field development drilling were St. Clair and Macomb Counties, the area along the Albion-Pulaski-Scipio oil field trend, and the general northwest quadrant of the Southern Peninsula. Most of the 11 new discoveries were made in the latter region. No large fields were found in 1966 or the preceding year. The small areal extent of the new found fields and greater well spacing contributed to the decline in some facets of oil and gas field activities.

Oil and gas production for 1966 declined a small percentage. The total value of these products amounted to over \$49,739,074 as compared with \$50,340,000 in 1965. Domestic LPG production was valued at about \$3,878,074.

Part I of this publication summarizes significant information on oil and gas field activities and related work of the Oil and Gas Section of the Geological Survey during 1966. Part 25 the green pages, contains specific information on Michigan's oil and gas fields for 1966. Part 3 contains cumulative records of lesser importance to the petroleum industry.

### \* \* \* DRILLING PERMITS \* \* \*

Fewer permits for oil or gas well tests, gas storage reservoir wells, or other types drilled under oil and gas permits were issued by the Regulatory Control Unit. The geographic distribution by district (see map, next page) of permits issued through a 3-year period is shown on the following chart.

DRILLING PERMITS BY DISTRICT

| DISTRICT     | Permits Issued |      |      |
|--------------|----------------|------|------|
|              | 1964           | 1965 | 1966 |
| Basin        | 166            | 117  | 79   |
| Northern     | 9              | 7    | 11   |
| Southeastern | 267            | 247  | 222  |
| Southwestern | 77             | 63   | 43   |
| Western      | 64             | 60   | 75   |
| Totals       | 583            | 494  | 430  |

The consistently higher figures for the southeastern district reflects the exploration and development activity in the St. Clair-Macomb County area, and in the areas adjacent to the Albion-Scipio oil field trend.

Permits for 4 gas storage wells, 2 LPG storage wells, and 1 geological information well are included in the preceding chart. The fluctuation in the number of permits issued for service wells of this kind are as follows:

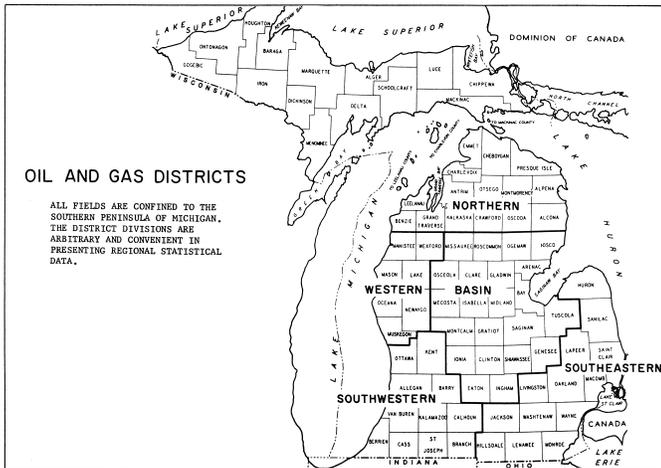
| Service Wells                                   | 1964 | 1965 | 1966 |
|---|------|------|------|
| Gas storage,<br>Observation,<br>Injection, etc. | 122  | 106  | 7    |

No Geological Test permits were issued in 1966.

### \* \* \* WELL COMPLETIONS \* \* \*

The following tabulation shows the number of exploratory and development wells completed over a 3-year period. The figures do not include deepened wells, reworked wells, gas storage reservoir wells, or others not directly related to exploratory or field development drilling.

## [Oil and Gas Districts (Map)]



### EXPLORATORY AND DEVELOPMENT WELL COMPLETIONS

| Year | Exploratory Wells |     |     | Development Wells |     |     | Totals |
|------|-------------------|-----|-----|-------------------|-----|-----|--------|
|      | Oil               | Gas | Dry | Oil               | Gas | Dry |        |
| 1964 | 7                 | 5   | 221 | 75                | 43  | 155 | 506    |
| 1965 | 6                 | 6   | 189 | 47                | 28  | 102 | 378    |
| 1966 | 8                 | 3   | 175 | 49                | 42  | 111 | 388    |

Nearly 38% of the wildcat wells and 26% of the development wells were drilled in St. Clair and Macomb Counties. Exploration in these counties was directed toward finding new Silurian reefs. Elsewhere, wildcat wells were drilled in 34 other counties, and development wells (excluding facility, LPG and miscellaneous wells) in 27. Most of these were drilled to Devonian or younger formations.

Total drilled-well footage decreased in response to fewer wells drilled during the year. The average drilled footage per exploratory well was about 3015 feet, and for development wells, 3012 feet. The fluctuation of drilled footage through a 3-year period is as follows:

| Footage Class | Amount of Drilled Footage |                  |                  |
|---------------|---------------------------|------------------|------------------|
|               | 1964                      | 1965             | 1966             |
| Exploratory   | 654,224                   | 602,682          | 560,941          |
| Development   | 924,584                   | 587,457          | 608,386          |
| Service       | 217,027                   | 254,403          | 33,370           |
| <b>Total</b>  | <b>1,795,835</b>          | <b>1,444,542</b> | <b>1,202,697</b> |

The number and class of well completions by month and district for 1966 are shown on Table 2. The number and class of completions by counties for 1966 are shown on Table 1, and for prior years, on Tables 18 and 23.

### \*\*\* DISCOVERY WELLS \*\*\*

State-wide, the discovery-to-dry hole ratio for exploratory tests drilled was about 1:17 compared with 1:16 in 1965. Nearly 38% of the exploratory or wildcat wells were drilled in St. Clair and Macomb Counties. The discovery well ratio in these counties was about 1:35 compared with 1:18 in 1965. An analysis of discoveries through a 3-year period is shown in chart form. Devonian and

Mississippian formations have produced most of Michigan's oil and gas. The chart helps point out the continued importance of Devonian and younger formations as drilling objectives in Michigan's oil and gas exploration activities.

### ANALYSIS OF DISCOVERY WELLS BY GEOLOGIC SYSTEM

| System        | Formation or Pay     | Number of Discoveries |      |      |
|---------------|----------------------|-----------------------|------|------|
|               |                      | 1964                  | 1965 | 1966 |
| Pennsylvanian |                      | none                  | none | none |
| Mississippian | "Michigan Stray Ss." | 3                     | 1    | 1    |
|               | "Berea"              | none                  | none | none |
| Devonian      | Antrim Shale         | none                  | 1    | none |
|               | "Traverse Lime"      | 5                     | 5    | 3    |
|               | Dundee               | 1                     | 1    | 1    |
|               | "Reed City"          | none                  | 1    | 3    |
| Silurian      | Detroit River        |                       |      |      |
|               | "Sour Zone"          | 1                     | none | none |
|               | Richfield            | 1                     | none | none |
| Ordovician    | Salina-Niagaran reef | --                    | --   | 2    |
|               | Niagaran reef        | 1                     | 4    |      |
| Cambrian      | Trenton-Black River  | none                  | none | 1    |
|               | Prairie du Chien     | none                  | none | none |

All discovery wells are listed on page 6. Except for the 2 new Salina-Niagaran reef fields, none of the discoveries appears to have oil or gas potential greater than a class E pool (less than 1 million barrels oil or 6 Bcf. gas, A.A.P.G. classification). All 1966 discoveries are in established and potentially productive regions. None opens for exploration large areas of new, undrilled territory. They do provide further incentive for exploration, especially among the smaller independents.

The single Ordovician outpost discovery to the prolific Albion-Scipio trend is of special interest. This well was drilled about one-half mile west and near the southern end of the trend. It established the first production west of the main part of the field. Oil production from this single well outpost amounted to more than 23,000 barrels at year's end. Several dry holes have been drilled in an attempt to extend the productive area or join it to the main part of the field. On the east side of the trend, at least 5 linear and very narrow spurs of productive area have been discovered and linked by development drilling to the central part of the field. The west side of the trend has not been adequately explored. The outpost discovery shows that more oil and gas are still to be found adjacent to the trend. Exploration for these linear features will be slow and costly in terms of dry holes drilled. Yet, their extension and delineation may provide insight to the nature of Ordovician fracture patterns in southern Michigan. Recognition of these fracture patterns, should they exist, may ultimately lead to new oil fields like the Albion-Pulaski-Scipio trend. This remarkable field, an apparently dolomitized fracture system in Ordovician age rocks, extends over a distance of nearly 35 miles. It has produced close to 67 million barrels of oil and over 60 million Mcf. gas since 1957.

**\*\*\* OIL AND GAS PRODUCTION \*\*\***

Oil production declined slightly in 1966. No large reserves were found or developed during the year that would offset the decline. Oil production amounted to 14,273,099 barrels as compared with 14,728,223 barrels produced in 1965.

Gas production amounted to about 34,120,013 Mcf. as compared with 35,120,368 Mcf. in 1965. Prompt conversion of newly developed reef reservoirs to gas storage fields has had definite impact on recent domestic gas production trends, whereby high volume withdrawal from a reef field one year is followed by shut-in and conversion to gas storage the subsequent year. Thus, the remaining reserves from the converted field are immediately diverted from market to cushion gas.

LPG production stripped from Michigan gas amounted to 1,846,702 barrels. The bulk of this production came from the Albion-Scipio, Belle River Mills, Boyd, and Reed City gas plants. An additional 495,617 barrels were stripped from gas imported into Michigan via pipeline.

Oil and gas production for 1966 is shown on Table 4. Production by individual fields or pools is found in Part 2. Production by month and by geographic district is shown on the following charts.

**OIL AND GAS PRODUCTION BY MONTH**

| Month         | Production        |                   |
|---------------|-------------------|-------------------|
|               | Barrels Oil       | MCF Gas           |
| January       | 1,197,159         | 2,510,768         |
| February      | 1,123,672         | 2,777,864         |
| March         | 1,212,287         | 2,635,167         |
| April         | 1,207,260         | 2,718,874         |
| May           | 1,226,397         | 2,542,473         |
| June          | 1,190,758         | 2,428,438         |
| July          | 1,174,951         | 2,919,725         |
| August        | 1,221,059         | 3,701,084         |
| September     | 1,162,367         | 2,774,833         |
| October       | 1,206,068         | 2,744,311         |
| November      | 1,146,499         | 3,141,324         |
| December      | 1,204,622         | 3,225,152         |
| <b>Totals</b> | <b>14,273,099</b> | <b>34,120,013</b> |

**OIL AND GAS PRODUCTION BY DISTRICT**

| District      | Production        |                   |
|---------------|-------------------|-------------------|
|               | Barrels Oil       | MCF Gas           |
| Basin         | 3,900,431         | 2,622,314         |
| Northern      | 105,769           | 370,819           |
| Southeastern  | 7,081,646         | 26,295,477        |
| Southwestern  | 2,903,260         | 4,375,935         |
| Western       | 281,993           | 455,468           |
| <b>Totals</b> | <b>14,273,099</b> | <b>34,120,013</b> |

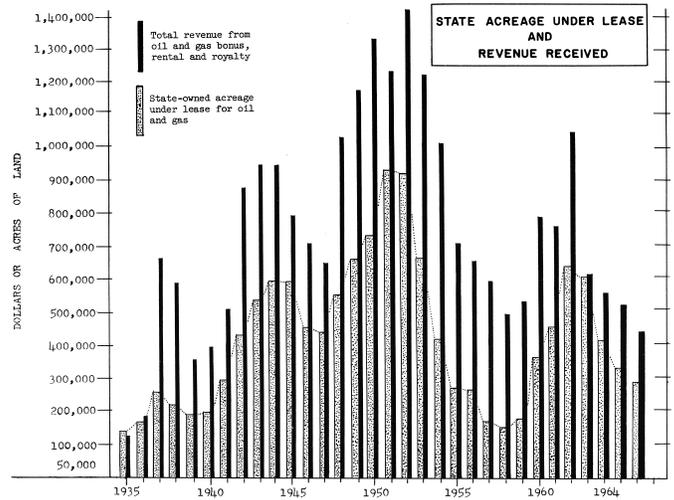
**1966 DISCOVERY WELLS**

| Field                                | County and Location | Operator and Lease                         | Permit Number | Comp. Date | Depth to Pay | Total Depth | Initial Production |                   | Prod. Form. | Basis for Loc. |
|--------------------------------------|---------------------|--|---------------|------------|--------------|-------------|--------------------|-------------------|-------------|----------------|
|                                      |                     |  |               |            |              |             | n(N) IP BOPD       | m(T) IP MCF/CD    |             |                |
| <b>NEW OIL FIELDS</b>                |                     |  |               |            |              |             |                    |                   |             |                |
| Peacock, Sec. 7                      | Lake 7-19N-13W      | Miller Bros. etal #1 USA-Peacock No. 1     | 26366         | 7-12       | 3001         | 3003        | P8 <sup>t</sup>    |                   | R. C.       | Sub.           |
| Peacock, Sec. 9                      | Lake 9-19N-13W      | Cook Bros. etal Hannon etal No. 1          | 26552         | 9-17       | 2289         | 2293        | P40 <sup>t</sup>   |                   | Trav.       | Sub.           |
| Muttonville                          | Macomb 13-40N-14E   | Mich. Cons. Gas Co. Fawcett No. 1          | 26437         | 7-16       | 2576         | 3039        | gas, no gauge      |                   | Niag.       | Grav.          |
| Hardy Dam                            | Mecosta 5-13N-10W   | Mich. Cons. Gas Co. Herring No. 1          | 26447         | 5-29       | 3351         | 3393        | P72 <sup>n</sup>   |                   | R. C.       | Sub.           |
| Mecosta                              | Mecosta 10-14N-8W   | The Taggart Co. Colegrove No. 1            | 26310         | 1-23       | 1345         | 1359        |                    | 1620 <sup>n</sup> | Stray       | Sub.           |
| Vogel Center                         | Missaukee 32-21N-6W | Merrill Drig. Co. Mulder No. 2             | 26335         | 3-17       | 3892         | 3895        | P70 <sup>t</sup>   |                   | dd.         | Sub.           |
| Entrican                             | Montcalm 21-11N-7W  | Enness etal No. 1                          | 26555         | 10-12      | 2870         | 2907        | P10 <sup>t</sup>   |                   | Trav.       | Sub.           |
| Carey Lake                           | 26-18N-11W          | Newaygo J. R. Barwick State-Goodwell No. 1 | 26435         | 8-12       | 3411         | 3413        | P100 <sup>t</sup>  |                   | R. C.       | Sub.           |
| Four Corners                         | 1-3N-15E            | Economy Oil & Gas Co. Guldenstein No. 1    | 26600         | 11-27      | 2205         | 2465        | gas, no gauge      |                   | Niag.       | Sub.           |
| <b>OUTPOST/EXTENSION DISCOVERIES</b> |                     |  |               |            |              |             |                    |                   |             |                |
| Scipio                               | Hillsdale 35-5S-2W  | Bell & Gault Drig. Co. Pearson No. 1       | 26114         | 2-16       | 4163         | 3850        | P90 <sup>t</sup>   |                   | Trent.      | Sub.           |
| Oxbow                                | Mason 26-17N-17W    | R. J. Gorman Helenius No. 1                | 26618         | 10-21      | 1672         | 1672        | P20 <sup>t</sup>   |                   | Trav.       | Sub.           |

NOTE: (T) IP refers to Initial Potential after acid, sand-fracture, or a combination of well stimulation methods.

(N) IP refers to Natural Initial Potential or Production

**[State Acreage Under Lease (Graph)]**



**\*\*\* DEEP TESTS \*\*\***

The deepest hole drilled in Michigan in 1966 reached a total depth of 6661 feet in Ordovician Black River age rocks. The well was drilled near the north end of the Howell anticline and on the west side of the structure. The top of the Trenton group was about 875 feet structurally lower than a previously drilled dry hole located about 3/4 mile to the east and higher on structure. No shows of hydrocarbons were reported. The test further delineates the Howell structure which has been scantily explored. The Howell gas field (now a gas storage reservoir), the Fowlerville gas field and, at the southern end, the Northville oil field are located on and along parts of this anticlinal complex.

All 5 Cambrian tests drilled in 1966 were located around the southern edge of the basin where these rocks are at a shallower depth. None encountered shows of oil or gas in Cambrian rocks. Locations of these tests and others are shown on the chart below.

# IMPORTANT 1966 DEEP TESTS

# TABLE 1. DRILLING PERMITS, WELL COMPLETIONS, OIL AND GAS PRODUCTION BY COUNTY, 1966.

| County       | Location   | Operator and Lease                         | Permit Number | System and Formation | Total Depth | Expl. Class | Results |
|--------------|------------|--|---------------|----------------------|-------------|-------------|---------|
| Hillsdale    | 20-65-14W  | Houseknecht Oil Prod., Inc. #1 Price et al | 26500         | Camb., T'remp.       | 4088        | NFW         | D & A   |
| Hillsdale    | 3-9E-1W    | Liberty Petroleum Corp., #1 Fellows        | 26655         | Camb., T'remp.       | 3403        | NFW         | D & A   |
| Jackson      | 15-2S-2W   | Texaco, Inc. #1 Konkol                     | 26541         | Ord., P.D.C.         | 5197        | NFW         | D & A   |
| Jackson      | 16-2S-2W   | Texaco, Inc. #1 Benn                       | 26548         | Ord., P.D.C.         | 5085        | NFW         | D & A   |
| Lake         | 23-19N-14W | C. J. Moskowitz #1 USA                     | 26459         | Sil., Niag.          | 5930        | NFW         | D & A   |
| Lenawee      | 13-7S-2E   | Ashland Oil & Refining Co. #1 Muck         | 26411         | Camb., T'remp.       | 3800        | NFW         | D & A   |
| Livingston   | 21-4N-3E   | Cobra Oil & Gas Corp. et al #1 Sherwood    | 26623         | Ord., B.R.           | 6661        | NFW         | D & A   |
| Vason        | 30-20N-17W | Iskraadsen Oil & Gas Co. #2 Caravel Oil    | 26465         | Sil., Niag.          | 4357        | NFW         | D & A   |
| Presque Isle | 16-34N-5E  | Alinda Hunt Hill Trust #1 Reisener         | 26544         | Sil., Niag.          | 3144        | NFW         | D & A   |
| Sanilac      | 27-9N-15E  | Hallwell Gas & Oil #1 Spencer              | 26480         | Camb., E.C.          | 6292        | NFW         | D & A   |
| Van Buren    | 8-2S-14W   | Alkay Oil Co. #1 McKnight                  | 26265         | Ord., Trenton        | 3004        | NFW         | D & A   |
| Van Buren    | 24-2S-14W  | Hallwell Oil & Gas #1 Ignacek              | 26313         | Sil., Niag.          | 2041        | NFW         | D & A   |
| Van Buren    | 35-3S-14W  | L. A. Shimmell #1 Reed                     | 26706         | Camb., Fran.         | 3628        | NFW         | D & A   |
| Washtenaw    | 6-1S-3E    | W. R. Albers #1 Knaiser                    | 25698         | Ord., B.R.           | 4784        | DFT         | D & A   |

## \*\*\* OIL AND GAS VALUATION \*\*\*

The average price paid at the wellhead for Michigan Crude was \$2.87 per barrel. The 1966 total valuation of this mineral resource amounted to about \$40,912,946 as compared with a valuation of \$41,036,743 in 1965.

Gas produced from Michigan fields was valued at \$8,773,844 as compared with \$9,303,334 in 1965. The average price of Michigan gas sold at the wellhead was \$.26 per MCF. LPG's stripped from Michigan produced gas was valued at about \$3,878,074. In addition, LPG's stripped from imported gas was valued at about \$1,040,795.

## \*\*\* OIL AND GAS FIELDS \*\*\*

New oil field discoveries in 1966 increased the number of active oil fields to 193. There were three fields or pools abandoned and two re-activated during the year. New well completions, including reworks and wells deepened to lower pools, increased the year-end total of producible wells in the state to 4,315. This figure includes 314 wells which were shut down or shut in, but does not include gas wells or injection wells which produced some oil during the year. The number of oil wells on production at year's end was about 4000.

New gas field discoveries in 1966 increased the number of producible dry gas fields and pools to 81. Only 59 of these fields produced gas for commercial sale, others were shut in or used for domestic or lease fuel. The total number of gas wells in the fields amounted to 429. Five small gas fields or pools were abandoned during the year.

There were 125 wells abandoned in 1966. These included pay zone abandonments and wells converted to injection wells. Data on individual oil fields are found in Part 2.

TABLE 1. DRILLING PERMITS, WELL COMPLETIONS, OIL AND GAS PRODUCTION BY COUNTY, 1966 (Sheet 1 of 2)

| County         | Permits Issued | Classification of 1966 Well Completions |           |     |    |            |     |           | County Production |             |
|----------------|----------------|---|-----------|-----|----|------------|-----|-----------|-------------------|-------------|
|                |                | Oil Wells                               | Gas Wells | SWD | MS | W.R. Deol. | LPG | Dry Holes | Total Completions | Barrels Oil |
| Allegan        | 13             | 2                                       |           |     |    |            |     | 11        | 280,190           | 284,598     |
| Antrim         |                |   |           |     |    |            |     | 2         | 298,405           |             |
| Arenac         | 2              |   |           |     |    |            |     |           | 13,078            |             |
| Barry          | 0              |   |           |     |    |            |     |           | 337,956           |             |
| Bay            | 0              |   |           |     |    |            |     |           | 69                |             |
| Berrien        | 3              |   |           |     |    |            |     | 3         |                   |             |
| Branch         |                |   |           |     |    |            |     |           |                   |             |
| Calhoun        | 17             | 4                                       |           |     |    |            |     | 11        | 15                | 2,359,457   |
| Cass           | 1              |   |           |     |    |            |     | 1         | 1                 | 4,759       |
| Clare          | 2              |   |           | 1   |    |            |     | 1         | 2                 | 602,875     |
| Clinton        | 1              |   |           |     |    |            |     | 1         | 1                 |             |
| Crawford       | 1              |   |           |     |    |            |     |           |                   | 86,982      |
| Genesee        |                |   |           |     |    |            |     |           |                   | 2,960       |
| Gladwin        | 3              |   |           |     |    |            |     | 2         | 2                 | 385,712     |
| Grand Traverse | 1              |   | 2         |     |    |            |     | 2         | 2                 |             |
| Gratiot        | 1              |   |           |     |    |            |     | 1         | 1                 | 35,199      |
| Hillsdale      | 37             | 6                                       |           |     |    |            |     | 29        | 35                | 4,596,984   |
| Huron          |                |   |           |     |    |            |     | 1         | 1                 | 3,390       |
| Ionia          |                |   |           |     |    |            |     | 1         | 1                 |             |
| Iosco          | 2              |   |           |     |    |            |     | 2         | 2                 |             |
| Isabella       | 2              |   | 1         |     |    |            |     | 2         | 3                 | 280,301     |
| Jackson        | 17             | 4                                       |           |     |    |            |     | 13        | 17                | 1,680,446   |
| Kalamazoo      |                |   |           |     |    |            |     |           |                   |             |
| Kalkaska       |                |   |           |     |    |            |     |           |                   | 17,219      |
| Kent           | 1              |   |           |     |    |            |     | 1         | 1                 | 101,265     |
| Lake           | 9              |   |           |     |    |            |     | 10        | 12                | 14,534      |
| Lapeer         | 2              |   |           |     |    |            |     | 7         | 10                | 33,340      |
| Lenawee        | 24             |   |           |     |    |            |     | 18        | 23                | 283         |
| Livingston     | 1              |   |           |     |    |            |     | 1         | 1                 | 16,698      |

TABLE 1. DRILLING PERMITS, WELL COMPLETIONS, OIL AND GAS PRODUCTION BY COUNTY, 1966 (Sheet 2 of 2)

|              |     |    |    |    |  |   |   |     |     |            |            |
|--------------|-----|----|----|----|--|---|---|-----|-----|------------|------------|
| Macomb       | 37  |    | 3  | 5  |  |   |   | 33  | 41  | 3,070      | 9,088,057  |
| Manistee     | 1   |    |    |    |  |   |   | 1   | 1   |            |            |
| Manistee     | 25  | 6  | 1  |    |  |   |   | 15  | 22  | 126,775    |            |
| Mecosta      | 27  | 12 | 2  |    |  |   |   | 10  | 24  | 89,872     | 92,061     |
| Midland      | 2   |    |    |    |  |   |   | 1   | 1   | 228,294    | 934        |
| Missaukee    | 6   | 1  |    |    |  |   |   | 5   | 6   | 444,199    | 672,791    |
| Monroe       |     |    |    |    |  |   |   |     |     | 7,200      |            |
| Montcalm     | 7   | 1  |    |    |  |   |   | 3   | 4   | 202,407    | 5,944      |
| Montmorency  |     |    |    |    |  |   |   |     |     |            |            |
| Muskegon     | 16  | 3  |    |    |  |   |   | 10  | 13  | 34,558     |            |
| Newaygo      | 12  | 1  |    |    |  |   |   | 7   | 8   | 24,312     |            |
| Okland       | 3   |    |    |    |  |   |   | 3   | 3   | 1,038      |            |
| Ogemaw       | 10  |    |    |    |  |   |   | 10  | 10  | 81,214     |            |
| Ogemaw       | 8   | 3  | 1  |    |  |   |   | 2   | 6   | 277,631    | 606,763    |
| Osceola      | 12  |    |    | 4  |  |   |   | 11  | 15  | 435,420    | 290,875    |
| Oscoda       | 8   |    |    |    |  |   |   |     |     | 1,688      |            |
| Otsego       |     |    |    | 6  |  |   |   |     | 6   |            | 985        |
| Otsego       | 6   | 1  |    |    |  |   |   | 5   | 6   | 133,039    | 151,416    |
| Ottawa       |     |    |    |    |  |   |   |     |     |            |            |
| Presque Isle | 1   |    |    |    |  |   |   |     | 1   | 1          |            |
| Roscommon    | 1   |    |    |    |  |   |   |     |     | 177,487    | 714,058    |
| Saginaw      |     |    |    |    |  |   |   |     |     | 25,583     |            |
| Sanilac      | 2   |    |    |    |  |   |   | 1   | 1   | 709,608    | 9,274,217  |
| St. Clair    | 92  | 5  | 17 |    |  | 1 |   | 65  | 88  |            |            |
| Tuscola      | 3   | 2  |    |    |  |   |   | 1   | 3   | 79,989     |            |
| Van Buren    | 2   | 1  |    |    |  |   |   | 4   | 5   | 11,387     |            |
| Washtenaw    | 1   | 1  |    |    |  |   | 1 | 2   | 2   | 28,345     | 177,220    |
| Wayne        | 3   |    |    |    |  |   | 1 | 2   | 3   | 18,005     | 1,153,875  |
| Washtenaw    | 2   |    |    |    |  |   |   | 2   | 2   | 455,468    |            |
| Totals       | 430 | 57 | 44 | 10 |  | 1 | 2 | 290 | 404 | 14,273,099 | 34,120,013 |
| 36 Counties  |     |    |    |    |  |   |   |     |     |            |            |

Includes gas storage field observation wells.  
Does not include reworks resulting in gas wells.  
Does not include reworks resulting in oil wells.

# TABLE 2. DRILLING PERMITS AND NEW WELL COMPLETIONS BY DISTRICTS AND BY MONTHS, 1966.

TABLE 2. DRILLING PERMITS AND NEW WELL COMPLETIONS BY DISTRICTS AND BY MONTHS, 1966

| PERMITS ISSUED                         | DISTRICTS |          |         |              |              | Totals |
|--|-----------|----------|---------|--------------|--------------|--------|
|  | Basin     | Northern | Western | Southwestern | Southeastern |        |
| PERMITS ISSUED                         | 79        | 11       | 75      | 43           | 222          | 430    |
| CLASSIFICATION OF NEW WELL COMPLETIONS |           |          |         |              |              |        |
| Oil Wells (1)                          | 19        | 0        | 12      | 9            | 17           | 57     |
| Gas Wells (2)                          | 4         | 0        | 0       | 0            | 33           | 45     |
| Gas Storage Wells                      | 5         | 0        | 0       | 0            | 5            | 10     |
| Geological Information Test            | 0         | 0        | 0       | 0            | 1            | 1      |
| LPG Storage                            | 0         | 0        | 0       | 0            | 2            | 2      |
| Brine Disposal Well                    | 0         | 0        | 0       | 0            | 1            | 1      |
| Dry Holes                              | 44        | 1        | 55      | 33           | 153          | 286    |
| Total Well Completions                 | 72        | 9        | 67      | 42           | 212          | 402    |
| EXPLORATORY WELLS COMPLETED            |           |          |         |              |              |        |
| Exploratory Tests D & A                | 29        | 1        | 43      | 16           | 97           | 186    |
| Successful Exploratory Tests           | 4         | 0        | 4       | 0            | 3            | 11     |
| Total Exploratory Tests                | 33        | 1        | 47      | 16           | 100          | 197    |

| PERMITS ISSUED                         | MONTHS |      |       |       |     |      |      |      |       |      |      |      | Totals |
|--|--------|------|-------|-------|-----|------|------|------|-------|------|------|------|--------|
|  | Jan.   | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |        |
| PERMITS ISSUED                         | 34     | 27   | 20    | 41    | 31  | 34   | 37   | 36   | 43    | 42   | 40   | 37   | 430    |
| CLASSIFICATION OF NEW WELL COMPLETIONS |        |      |       |       |     |      |      |      |       |      |      |      |        |
| Oil Wells (1)                          | 1      | 3    | 4     | 2     | 5   | 6    | 3    | 7    | 8     | 9    | 6    | 3    | 57     |
| Gas Wells (2)                          | 3      | 3    | 1     | 4     | 4   | 6    | 5    | 5    | 2     | 7    | 3    | 1    | 44     |
| Gas Storage Wells                      | 1      |      |       |       | 1   | 3    | 2    | 3    |       |      |      |      | 10     |
| Geological Information Test            |        |      |       |       |     |      |      |      |       |      |      |      | 1      |
| LPG Storage                            |        |      |       |       |     |      |      |      | 1     |      |      |      | 2      |
| Brine Disposal Well                    |        |      |       |       |     |      |      |      |       |      |      |      | 1      |
| Dry Holes                              | 22     | 30   | 16    | 35    | 23  | 24   | 24   | 24   | 24    | 20   | 21   | 30   | 290    |
| Total Well Completions                 | 34     | 36   | 24    | 21    | 33  | 39   | 39   | 35   | 44    | 32   | 36   | 36   | 402    |
| EXPLORATORY WELLS COMPLETED            |        |      |       |       |     |      |      |      |       |      |      |      |        |
| Exploratory Tests D & A                | 22     | 18   | 9     | 9     | 15  | 15   | 16   | 15   | 15    | 16   | 12   | 22   | 185    |
| Successful Exploratory Tests           | 1      | 1    | 1     | 1     | 1   | 1    | 2    | 1    | 1     | 2    | 1    | 1    | 13     |
| Total Exploratory Tests                | 23     | 19   | 10    | 9     | 16  | 15   | 20   | 16   | 16    | 18   | 13   | 22   | 197    |

(1) Does not include oil wells resulting from rework operations.  
(2) Does not include gas wells resulting from rework operations.

## **\*\*\* OIL AND GAS IMPORTS AND EXPORTS \*\*\***

Crude oil imports to Michigan refineries increased from 36,468,716 barrels in 1965 to 39,082,719 barrels in 1966. Of this amount, 32,572,587 barrels came from western and mid-western states and 6,510,132 barrels came via pipeline from western Canada oil fields.

Oil exported to northern Indiana (Ft Wayne) and Ohio refineries amounted to 378,963 barrels in 1966 as compared with 23,245 barrels in 1965.

Compilations by the Gas Section, Michigan Public Service Commission, indicate that 599,174,318 MCF of gas was imported by pipeline to Michigan storage fields and markets. Gas imports were from Texas, Louisiana, Oklahoma, and Kansas fields.

Large volumes of imported gas are stored in Michigan's gas storage field network during warm months and withdrawn during the winter season to augment gas delivered by pipeline, Michigan had 23 gas storage fields in operation at the end of 1966. The storage fields differ in area! extent and capacity, varying from several hundred to several thousand acres. The Six Lakes field (cover photo), central Michigan, spreads over more than 11,000 acres. Before conversion to gas storage, the field produced more than 51% billion cubic feet of gas from the Michigan Stray Sandstone formation. The Belle River Mills field, eastern Michigan, is a Niagaran reef reservoir covering about 800 acres. Production from this field amounted to over 21 billion cubic feet of gas before conversion to gas storage.

The "Loreed" project in the Reed City field, central Michigan, is a combination storage-repressuring operation involving the Dundee-Reed City oil pool. According to the American National Gas Company Annual Report 1966, the Reed City "Loreed" and Belle River Mills reservoirs were capable of delivering an aggregate of over one-half billion cubic feet of gas on a peak day. Their capacity will be expanded and when development is completed the two fields are expected to have about three times their present deliverability.

### **\*\*\* LPG EXTRACTION \*\*\***

LPG recovery from gas plant operations increased from 86,891,724 gallons in 1965 to 98,377,386 gallons in 1966. The top 6 fields or plants producing LPG's were: Albion-Scipio, 30,356,822 gallons; Willow Run, 20,815,896 gallons; Boyd, 17,569,415 gallons; Belle River Mills, 16,848,982 gallons; Reed City, 12,030,799 gallons, and Hamilton, 342,518 gallons. The Belle River Mills plant functions as a gas recycling and storage field facility. The Boyd plant serves 10 fields and receives both dry and oil well gas. The Reed City plant serves a combination storage and repressuring operation now in progress in the. Reed City field. The combination storage-repressuring operation involves Reed City reservoir rocks. The project has been designated "Loreed" by the operating company.

## **\*\*\* DESCRIPTIVE WELL LOG AND SAMPLE LIBRARY \*\*\***

The Regulatory Unit of the Oil and Gas Section received 480 new well records and well rework records from Michigan operators during the year. Many of these new records were made available for public distribution by the Petroleum Geology Unit which processed, published, and incorporated 507 new logs into the log library. More than 26,000 published well logs and other well records are available for purchase or use and inspection at Survey offices.

During the year, over 8,000 descriptive well logs were printed and distributed upon request to individuals and companies interested in Michigan's oil and gas exploration industry. Individual log orders ranged from a single log request to as many as 960. In addition to individual log orders, 48 subscription log orders were mailed out each month to individuals, companies, government agencies, and universities.

The Survey loaned 129 sets of well samples to company or consulting geologists and 171 sets to university students or personnel for postgraduate studies and other projects. An additional 84 sets were also examined at Survey offices. The Survey acquired 384 new sets from recently drilled wells and 460 sets from discontinued, company sample libraries.

### **\*\*\* OIL FIELD BRINE PRODUCTION \*\*\***

Oil field brine production in 1966 was at about the same level as in past years. There were 16 fields producing brine in excess of 2000 barrels per day. These fields and their daily average brine production are shown on the adjacent chart.

The fields shown on the chart account for about 70 percent of the state's total oil field brine production. The bulk of the brine is returned to the producing formation, mainly the Traverse and Dundee. Most of the balance is returned to other formations. A small percentage is used on roads for dust control, or returned to oil waste burning pits.

Brine production by individual fields is found on the oil and field tables in Part 29. Other data is found on Table 8, page 34, and Table 26, page 59.

### **\*\*\* REVISIONS AND CORRECTIONS \*\*\***

Revisions have been made for certain oil production figures shown on Tables 18 and 19 (pages 58 and 59 respectively) appearing in Michigan's Oil and Gas Fields, 1965 issued in 1966. These tables appear as Tables 20 and 219 on pages 52 and 53, of this 1967 issue. Revisions are marked with an asterisk (\*).

Oil and gas well figures on last years Table 23 were inadvertently deleted from Arenac, Barry, Bay, Berrien, Cass, Crawford, and Gratiot Counties. These have been restored and brought up-to-date.

The table titled: Fluid Injection into Producing Formations in Oil Fields now lists only the more important projects. Others, listed in previous years, have been arbitrarily deleted from this issue.

Charts showing the amount of oil field brine returned to specific subsurface formations have been deleted from this issue. Refer to previous issues for specifics on subsurface oil field brine disposal.

### MAJOR BRINE PRODUCING FIELDS

| Field                    | Rank | 1966    | 1965    | 1964    |
|--------------------------|------|---------|---------|---------|
| Coldwater                | 1    | 27,270  | 29,557  | 31,945  |
| Albion-Scipio Trend      | 2    | 18,845  | 10,273  | 8,798   |
| Porter                   | 3    | 8,239   | 8,685   | 8,547   |
| Deep River               | 4    | 7,865   | 7,870   | 7,570   |
| Freeman-Redding          | 5    | 6,640   | 5,560   | 6,695   |
| McBain                   | 6    | 6,180   | 6,467   | 5,524   |
| Stony Lake               | 7    | 4,154   | 4,397   | 6,362   |
| Adams, North             | 8    | 3,583   | 3,262   | 2,857   |
| Vernon                   | 9    | 3,400   | 3,240   | 3,850   |
| Reed City                | 10   | 2,919   | 3,416   | 4,951   |
| Prosper                  | 11   | 2,700   | 2,750   | 2,925   |
| Gilmore                  | 12   | 2,350   | 2,000   | 1,850   |
| Reynolds                 | 13   | 2,297   | 3,656   | 4,210   |
| Pentwater                | 14   | 2,194   | 1,926   | 1,183   |
| Clayton                  | 15   | 2,098   | 2,079   | 1,863   |
| Fork                     | 16   | 2,025   | 2,650   | 2,475   |
| Total                    |      | 102,759 | 97,788  | 101,605 |
| State Total (all fields) |      | 144,382 | 145,102 | 148,972 |

### \*\*\* PUBLIC HEARINGS \*\*\*

Act No. 61 of the Public Acts of 1939, as amended, provides for hearings on oil and gas matters. Act No. 326 of the Public Acts of 1937, as amended, provides for hearings on matters pertaining to natural dry gas. Hearings on matters of local concern involving the administration of rules and regulations, such as exceptions to spacing orders, or pooling of interests to form drilling units, are conducted by the Supervisor of Wells, Act No. 61, amended, now provides that the State Geologist shall act as Supervisor of Wells. Heretofore, the Director of Conservation had served in that capacity. Hearings on matters involving broad policies and practices having field-wide or state-wide application are conducted by the Supervisor of Wells and before the Advisory Board. Oil and gas hearings held during 1966 are summarized on the following chart.

| Hearing Per Month                    | January | February | March | April | May | June | July | August | September | October | November | December | Total |
|--------------------------------------|---------|----------|-------|-------|-----|------|------|--------|-----------|---------|----------|----------|-------|
| <b>Items of Causes Heard</b>         |         |          |       |       |     |      |      |        |           |         |          |          |       |
| <b>Spacing Orders:</b>               |         |          |       |       |     |      |      |        |           |         |          |          |       |
| Adopted                              | 2       | 1        | 1     | 1     | 2   | 1    | 1    | 2      | 1         | 1       | 1        | 1        | 7     |
| Amended                              | 2       | 1        | 1     | 1     | 1   | 1    | 1    | 1      | 2         | 1       | 1        | 1        | 8     |
| Abrogated                            | 1       | 1        | 1     | 1     | 1   | 1    | 1    | 1      | 1         | 1       | 1        | 1        | 5     |
| <b>Proration Orders:</b>             |         |          |       |       |     |      |      |        |           |         |          |          |       |
| Adopted                              | 1       | 1        | 1     | 1     | 1   | 1    | 1    | 1      | 1         | 1       | 1        | 1        | 1     |
| Amended                              | 1       | 1        | 1     | 1     | 1   | 1    | 1    | 1      | 1         | 1       | 1        | 1        | 0     |
| Abrogated                            | 1       | 1        | 1     | 1     | 1   | 1    | 1    | 1      | 1         | 1       | 1        | 1        | 2     |
| <b>Exceptions to Spacing Orders:</b> |         |          |       |       |     |      |      |        |           |         |          |          |       |
| Approved                             | 3       | 2        | 5     | 2     | 4   | 2    | 1    | 1      | 2         | 3       | 1        | 1        | 25    |
| Denied                               | 2       | 2        | 1     | 1     | 1   | 1    | 1    | 1      | 1         | 1       | 1        | 1        | 3     |
| <b>Pooling, Drilling Unit:</b>       |         |          |       |       |     |      |      |        |           |         |          |          |       |
| Adopted                              | 1       | 1        | 1     | 1     | 3   | 1    | 1    | 1      | 1         | 1       | 1        | 1        | 4     |
| Denied                               | 1       | 1        | 1     | 1     | 1   | 1    | 1    | 1      | 1         | 1       | 1        | 1        | 0     |
| Determine Reservoir Status           | 1       | 1        | 1     | 1     | 1   | 1    | 1    | 1      | 1         | 1       | 1        | 1        | 6     |
| Unitization of Pool                  | 1       | 1        | 1     | 1     | 1   | 1    | 1    | 1      | 1         | 1       | 1        | 1        | 1     |
| Authorize, Directional Drilling      | 1       | 1        | 1     | 1     | 1   | 1    | 1    | 1      | 1         | 1       | 1        | 1        | 1     |
| Authorize, Water Injection           | 1       | 1        | 1     | 1     | 1   | 1    | 1    | 1      | 1         | 1       | 1        | 1        | 1     |
| Authorize, Geol. Info Well           | 1       | 1        | 1     | 1     | 1   | 1    | 1    | 1      | 1         | 1       | 1        | 1        | 1     |
| Item heard, no action taken          | 1       | 1        | 1     | 1     | 1   | 1    | 1    | 1      | 1         | 1       | 1        | 1        | 2     |
| Total Items or Causes                | 8       | 4        | 6     | 3     | 8   | 5    | 13   | 6      | 2         | 3       | 3        | 6        | 67    |

### \* \* ACTIVE MICHIGAN OIL REFINERIES \* \*

| COMPANY                                     | REFINERY LOCATION    | NOMINAL CAPACITY*<br>BBLs. DAY |
|---|----------------------|--------------------------------|
| Bay Refining, Division Dow Chemical Company | Bay City             | 15,000                         |
| Crystal Refining Company                    | Carson City          | 6,200                          |
| Delta Terminal Company                      | Rapid River          | 4,000                          |
| Lakeside Refining Company                   | Kalamazoo            | 3,500                          |
| Leonard Refineries, Inc.                    |                      |                                |
| Leonard Division                            | Alma                 | 29,000                         |
| Roosevelt Division                          | Mt. Pleasant         | 7,500                          |
| Marathon Oil Company                        | Detroit              | 45,000                         |
| Marathon Oil Company (abandoned 1966)       | Muskegon             | -----                          |
| Naph-Sol Refining Company                   | Muskegon             | 10,000                         |
| Oscocla Refining Company                    | West Branch          | 5,000                          |
| Petroleum Specialties, Inc.                 | Flat Rock (Inactive) | 6,500                          |
| Socoxy Mobil Oil Company                    | Trenton              | 40,500                         |
| Total Refinery Capacity                     |                      | 172,200                        |

\*Individual refinery operating rates may be less or slightly more than nominal rates shown.

### PART 2, OIL AND GAS FIELDS EXPLANATION

Part 2 brings together general information on Michigan's oil and gas fields, gas storage reservoirs and related items. The tables summarize information relating to oil and gas accumulations which have been designated and names as oil or gas fields.

**OIL AND GAS FIELDS.** Most fields consist of one pool with oil or gas production coming from a single formation. A few fields have 2 or more separate pools each producing from a different formation or stratigraphic interval and at a different depth. Pools for individual fields are shown under PRODUCING FORMATION OR POOL. The PAY ZONE part of the table generally refers to the discovery well for the specific pool. The PAY THICKNESS shown on the tables does not necessarily indicate net producing pay for the reservoir. The DEEPEST FORMATION TESTED column indicates the deepest total depth and formation penetrated in the field.

**LOCATION OF OIL FIELDS, GAS FIELDS, ETC.** These tables show the specific locations of the fields and the sections which have or have had producing wells. Miscellaneous wells which produced some oil but were eventually abandoned as dry holes are also included. Miscellaneous wells reporting some gas production are also included.

**OIL AND GAS FIELD MAPS.** It is not practical to outline and show the names of all the hydrocarbon accumulations that have been designated as a field or pool. In general, the field names shown on the several maps are in agreement with the field names shown on the oil and gas field tables. Certain miscellaneous or single well fields are not shown on the maps but are listed in the tables.

**ABANDONED OIL AND GAS FIELDS OR POOLS.** Oil and gas fields or pools are considered abandoned when all wells have been plugged to the surface and the equipment has been removed from the area. Fields abandoned during a given year are entered into the

abandoned field tables in the following year. Abandoned oil fields with less than 500 barrels of cumulative oil production are not shown in the tables. Production from fields having less than 500 barrels cumulative production is accounted for in the table summaries. Fields or pools may be re-activated from time to time when new producing wells are drilled.

**GAS FIELDS.** Many gas fields are listed as "shut in" due to lack of marketing facilities, slow field development, or lack of substantial reserves. Production from fields listed as "Domestic" or "Lease Fuel" is not metered or considered commercial.

**GAS STORAGE RESERVOIRS.** Most gas storage reservoirs were originally classified as gas fields or pools and upon depletion or near depletion they were converted to storage reservoirs. Undeveloped gas storage reservoirs are gas pools that have been designated to become storage reservoirs at some future time.

**LPG STORAGE.** Surface and underground storage facilities for liquified petroleum gas.

**OIL WELL GAS.** This is casinghead gas produced incidental to the production of oil from pools or fields generally classified as oil accumulations.

**CASINGHEAD GAS PLANT DATA.** These tables indicate the distribution of gross input gas to plants and the resulting net hydrocarbons available for market.

**FLUID INJECTION INTO PRODUCING FORMATIONS.** A number of fields have secondary recovery projects in operation. In most fields listed in these tables, the injection of oil field brines back into the producing formation is a combination brine disposal and pressure maintenance project.

## **PART 3, CUMULATIVE RECORDS**

### **EXPLANATION**

Part 3 contains cumulative statistics principally of oil and gas production, well completions, and oil field brine production and disposal from 1925 through the most recent year-end compilations.

**OIL AND GAS PRODUCTION TABLES.** Oil and gas production figures for individual years prior to 1953 can be found in issues of the "Summary of Operations", Oil and Gas Fields for 1962, and prior years. The tables show the year of the first recorded production from a particular formation, and the yearly and cumulative production totals from 1925 through the most recent year-end compilations.

**WELL COMPLETIONS AND PRODUCTION BY COUNTY.** These tables show the classifications of completed wells on a county basis, and the cumulative amount of oil and gas produced in individual counties. Tables also indicate the total number of dry holes, oil

wells, gas wells, etc., that have been drilled under oil and gas drilling permits in an individual county.

**DRILLING PERMITS, WELL COMPLETIONS, FIELDS DISCOVERED.** These tables show the number of drilling permits issued by year from 1927 through the most recent year-end compilations. Classification of well completions by year, the number of new fields or pools discovered, and the number of producible oil or gas wells on a yearly basis are all shown on the same table.

**BRINE PRODUCTION AND DISPOSAL.** Oil field brine production records prior to 1937 are incomplete. This table shows the reported amount of produced brine and the method of disposal from 1937 to present. Most oil field brine is now returned to subsurface formations. Small quantities are used for dust control or ice and snow removal on county roads in local areas. A small amount of brine is also disposed in burning pits. Brine production and disposal figures should not be considered entirely accurate.

**SERVICE WELLS.** Service wells as listed in this publication are those wells which were drilled to serve some purpose other than the initial production of oil or gas. Oil or gas wells are sometimes converted to salt water disposal, observation, or facility wells in gas storage or pressure maintenance projects. There are several types of service wells:

**LPG Wells.** These are wells drilled for underground storage of liquified petroleum gas. In Michigan, these storage reservoirs are in man-made cavities in salt beds. The cavities have been made by dissolving the salt with water and then pumping out the brine.

**Gas Storage Wells.** These are wells drilled in gas storage reservoirs. They are frequently referred to as facility wells, and are generally used to inject gas into, or extract gas from the reservoir. Certain facility wells may sometime in the history of the field be used as salt water disposal wells, or observation wells.

**Observation Wells.** Most observation wells are related to gas storage projects. They are used to observe underground movement of gas, brines, and other fluids, or to observe pressures.

**Brine Disposal Wells.** These wells, also called disposal wells, are used in the disposal of oil and gas field brines back into some suitable subsurface formation. Brine disposal well permits are issued for these wells.

**Injection and Pressure Maintenance Wells.** These are wells used in secondary recovery, or pressure maintenance projects. They may be new wells drilled specifically for injection or pressure, maintenance, or they may be converted oil or gas wells; their status can change from time to time.

Oil or gas wells are sometimes converted to salt water disposal, observation, or facility wells in gas storage reservoirs, or water injection wells used in secondary recovery or pressure maintenance projects. The types of service wells listed under "Classification of Well

Completions" does not include oil or gas wells converted to service wells.

## ABBREVIATIONS

|           |  |                    |   |
|-----------|--|--------------------|---|
| A.P.I.    | American Petroleum Institute           | M.S.               | Mt. Simon ss.                               |
| (A) I.P.  | (Acid) Initial Production or Potential | NFW                | New Field Wildcat                           |
| A-1 Carb. | A-1 Carbonate                          | (N) I.P.           | (Natural) Initial Production or Potential   |
| A-2 Carb. | A-2 Carbonate                          | Niag.              | Niagaran                                    |
| Bbls.     | Barrels                                | Nt.                | Nontechnical                                |
| B.B.      | Bois Blanc formation                   | OBS                | Observation Well                            |
| B.D.      | Brine Disposal                         | OP                 | Out Post Well                               |
| BDW       | Brine Disposal Well                    | Ord.               | Ordovician                                  |
| BOPD      | Barrels Oil Per Day                    | OWDD               | Old Well Drilled Deeper                     |
| B.R.      | Black River                            | P.D.C.             | Prairie du Chien formation                  |
| Camb.     | Cambrian                               | Penn.              | Pennsylvanian                               |
| "Camb."   | Unidentified Cambrian                  | Pilot Wtr.         | Pilot Water                                 |
| Cat.      | Cataract formation                     | P.M.               | Pressure Maintenance                        |
| c.f.p.b.  | Cubic feet per barrel                  | Prod. Form.        | Producing Formation                         |
| C.H.      | Cabot Head formation                   | R.C.               | Reed City formation                         |
| Cinn.     | Cincinnatian                           | RW                 | Reworked Well                               |
| Cl.       | Clinton formation                      | Rich.              | Richfield formation                         |
| Cold.     | Coldwater formation                    | Sag.               | Saginaw formation                           |
| Compl.    | Completion                             | Sal.-Niag.         | Salina-Niagaran                             |
| Coop.     | Cooperative                            | SD                 | Shut Down                                   |
| D & A     | Dry and Abandoned                      | Seis.              | Seismograph                                 |
| Dev.      | Devonian                               | S.P.               | St. Peter formation                         |
| D.R.      | Detroit River formation                | Stray              | Michigan Stray formation                    |
| D.R. SZ   | Detroit River Sour Zone                | Sub.               | Subsurface geology                          |
| Dres.     | Dresbach formation                     | SW                 | Service Well                                |
| Dd., DD   | Dundee                                 | SWD                | Salt Water Disposal                         |
| Dd.-R.C.  | Dundee-Reed City                       | Sylv.              | Sylvania formation                          |
| DPT       | Deeper Pool Test                       | SZ                 | Sour Zone (in Detroit River)                |
| E.C.      | Eau Claire formation                   | Thick.             | Thickness                                   |
| Explor.   | Exploratory                            | (T) I.P.           | (Treatment) Initial Production or Potential |
| Fran.     | Franconia formation                    | Trav.              | Traverse                                    |
| Geo. Test | Geological Test                        | Tremp.             | Trempealeau formation                       |
| G.O.R.    | Gas-Oil Ratio                          | Trenton-Blk. River | Trenton-Black River                         |
| Grav.     | Gravity, Gravimeter                    | Trent.             | Trenton                                     |
| GS        | Gas Storage                            | Unit.              | Unitized                                    |
| GSW       | Gas Storage Service Well               |                    |   |
| Gw        | Glenwood                               |                    |   |
| Incs.     | Includes                               |                    |   |
| Inj.      | Injection                              |                    |   |
| L.P.G.    | Liquid Petroleum Gas                   |                    |   |
| Marsh.    | Marshall formation                     |                    |   |
| MCF       | Thousand Cubic                         |                    |   |
| MCFGPD    | Thousand Cubic Feet Gas Per Day        |                    |   |
| Mich.     | Michigan formation                     |                    |   |
| Miss.     | Mississippian                          |                    |   |

# STRATIGRAPHIC SUCCESSION IN MICHIGAN

PALEOZOIC THROUGH RECENT



MICHIGAN DEPARTMENT OF CONSERVATION  
Ralph A. MacMullan, Director  
GEOLOGICAL SURVEY  
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ACKNOWLEDGMENT: Compiled with the consent of colleagues in this department, the U. S. Geological Survey, Michigan's universities, other state Geological Surveys, and geologists within Michigan's oil and gas industry. Dr. Arneal T. Cross, Department of Geology, Michigan State University, identified rocks of Mesozoic age and suggested provisional age assignments.

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Carlisle D. Ellis, Chairman, Robert W. Kelley, Secretary,  
Henry J. Harberberg, I. David Johnson, Harry O. Sorenson

INFORMAL TERMS

Principal oil and gas plays, and informal terms used in petroleum exploration and applied to parts of formations or groups in the subsurface.

| STRATIGRAPHIC POSITION                           | INFORMAL TERMS   | PAYS                                |
|--|--|-------------------------------------|
| Basal sandstones of Saginaw Fm.                  | Perma sandstone  |                                     |
| In lower part of Michigan                        | triple gas<br>brown line<br>gray clay ss<br>gray det.<br>gray ss                             | Gas<br>Gas & Oil<br>Gas & Oil       |
| Marshall Ss.                                     |  | Gas & Oil                           |
| Coldwater Sh.                                    | Calhoun line<br>Wear sand<br>Calhoun red-rock  | Gas<br>Gas & Oil                    |
| In upper part of Ellsworth Sh.                   | "Berea" (Western Michigan)   | Oil & Gas                           |
| Berea Ss.  | Berea sand (Eastern Michigan)  | Oil & Gas                           |
| Saginaw Bay Ls.                                  | Saginaw Bay  | Oil & Gas                           |
| Upper part of Traverse Group in Western Michigan | Traverse formation<br>Traverse line<br>Stoney Lake zone                                      | Oil & Gas<br>Oil & Gas<br>Oil & Gas |
| Rogers City Ls.                                  |  | Oil & Gas                           |
| Dundee Ls.                                       |  | Oil & Gas                           |
| Dundee Ls. (?), Upper part of Lucas Fm. (?)      | Red City zone  | Oil & Gas                           |
| In Lucas Fm.                                     | massive salt<br>big salt<br>big zone<br>massive anhydrite<br>big anhydrite<br>Rothchild zone | Oil & Gas<br>Oil & Gas<br>Oil & Gas |
| Ankerburg Fm.                                    | black line   | Oil & Gas                           |
| Part of Salina Group E Unit                      | E zone<br>(or Kingh zone)  | Oil                                 |
| Divisions of A-2 Carbonate in Western Michigan   | A-2 dolomite<br>A-2 lime   | Gas<br>Gas                          |

PLEISTOCENE NOMENCLATURE

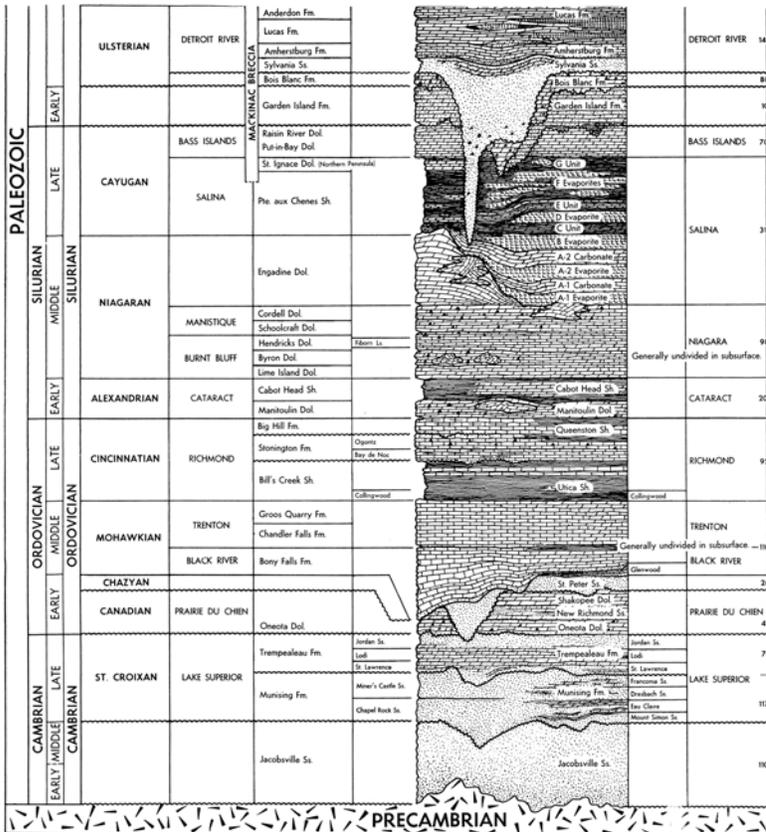
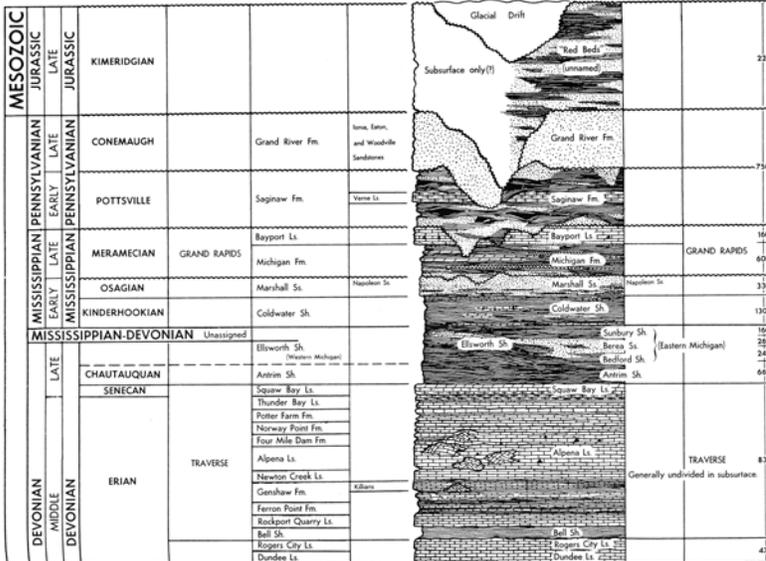
| ERA      | SYSTEM     | SERIES      | STAGE   |
|----------|------------|-------------|---|
| CENOZOIC | QUATERNARY | RECENT      | Valders Stage<br>Two Creeks Interstage<br>Mankato Stage (In Huron?)<br>Cary Stage<br>Tazewell Stage |
|          |            | PLEISTOCENE | Wisconsin Glaciation  |
|          |            |             | Sangamon Inter glaciation   |
|          |            |             |   |

OUTCROP NOMENCLATURE

| GEOLOGIC TIME | ERA | PERIOD | EPOCH | SYSTEM | ROCK-STRATIGRAPHIC |       |           |
|---------------|-----|--------|-------|--------|--------------------|-------|-----------|
|               |     |        |       |        | SERIES             | GROUP | FORMATION |
|               |     |        |       |        |                    |       | MEMBER    |

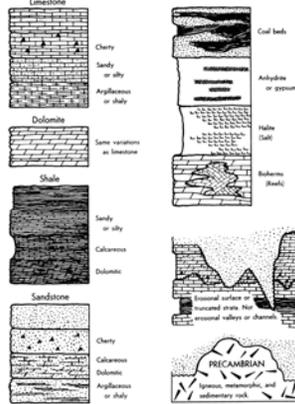
SUBSURFACE NOMENCLATURE

| ROCK-STRATIGRAPHIC  |        |       |
|---|--------|-------|
| FORMATION   | MEMBER | GROUP |
| Approximate maximum thickness, in feet, of rock units in the subsurface. NO SCALE |        |       |



|                               |   |           |
|-------------------------------|---|-----------|
| A-1 Carbonate                 | A-1 dolomite  | Oil & Gas |
| Upper part of Niagaran Series | brown Niagaran<br>gray Niagaran<br>white Niagaran           | Oil & Gas |
| Part of Niagaran Series       | Chert shale<br>(Eastern Michigan)                           | Oil & Gas |
| Trenton Group                 |   | Oil & Gas |
| Black River Group             | Black River formation<br>Black River shale<br>Van Wert zone | Oil & Gas |
| Onondaga Dol.                 |   | Oil       |

EXPLANATION



GEOLOGIC NAMES COMPILATIONS: Harry O. Sorenson, Cambrian and Ordovician; Robert W. Kelley, Early and Middle Silurian; Carlisle D. Ellis, Late Silurian through Detroit River Group of Devonian age; Henry J. Harberberg, Onondaga Limestone through Traverse Group of Devonian age; I. David Johnson, Anson Shale through the Pennsylvanian System; F. Wells Tazewell, glacial geology of the Cenozoic.

CHART 1  
1964

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Geological Survey Division

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