

## Disclaimer

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of an information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process or service by trade name, trademark, manufacturer or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

## Abstract

Horizontal drilling in the Dundee began with the 1995 completion of the Cronus – Tow #1-3 HD-1 well in Crystal Field of Montcalm County. This well was the demonstration test well of this Class 2 reservoir project. Its success has resulted in the drilling of 11 additional wells and the planning and permitting of 13 more. About 74 horizontal wells had been drilled before this project began in 1994. By the end of 1996, at least 146 wells had been completed. Currently there are 102 wells being planned, drilling, or testing. Tables containing lists the number of wells by geologic horizon are included in this report.

As part of this Class 2 reservoir an MS-Excel data set of oil production history study on Crystal Field and 29 other Dundee fields in Michigan has been compiled. Figures and tables demonstrate the properties of these data sets and some of the visualization products that can be produced to help interpret the historical performance and management of these Dundee reservoirs. Some tentative criteria have also been established in this project to evaluate the potential additional oil recovery from these Dundee fields.

A 1-day workshop will be offered September 18 in Grand Rapids, Michigan in conjunction with the MOGA meeting. We will present the results of the DOE Dundee project and will make the data collected available to the gas and oil industry on a CD ROM. Topics to be covered include in-depth analyses of 30 Dundee fields in the Central Michigan Basin, including construction and interpretation of the structure maps, production history charts and discussion of potential for future production. The 4th issue of the MOFRC Newsletter was send to MOFRC members in July.

---

# RECOVERY OF BYPASSED OIL IN THE DUNDEE FORMATION USING HORIZONTAL DRAINS

## SUMMARY OF TECHNICAL PROGRESS BY TASK

### RESERVOIR CHARACTERIZATION

#### Production History Analysis

Production history data is an accessible and easily used resource for evaluating the past performance and management history of an oil field. Using digital data sets and off-the shelf software, almost anyone can produce powerful analyses and visualizations of oil field performance and development history.

Several public domain sources of data are available in Michigan. Individual field production history (annual and cumulative) has been published by the Michigan Geological Survey in their Annual Statistical Summaries of Michigan's Oil and Gas Fields. Unfortunately this series was discontinued in 1987, however there are annual reports from 1934 to 1986. For many fields in Michigan (including Dundee fields) this data set covers the complete life of the field.

Michigan Geological Survey also maintains a data set called the "brine reports" or AWSUM reports. This data is annual reports by lease from all fields producing water. Early records from the 1930's and 1940's are very spotty, but information is nearly complete from 1946 to 1994. The earliest reports contain only water production data, however oil production data was incorporated from 1950 to 1994. The information is reported by lease (not individual well, although there are many one well leases in

Michigan) within each field. Data is reported as barrels of water (or oil) produced daily. We have found that the daily reported water values are, when summed, very consistent with the daily field totals published in the Annual Statistical Summaries. Because of averaging or rounding, the daily reported oil production values do not correlate well with other sources of oil production data (Annual Statistical Summaries or MOGA ). Oil production data from these “brine reports’ should only be used if no other source of information is available.

A third source of oil production data is the Michigan Oil and Gas Association’s (MOGA) Annual Production reports. This series was published annually from 1945 to 1972. Data was reported by lease within each field (similar to the State “brine reports”). Oil production is given as barrels annually per lease. Although there are many leases with one well per lease, as many as eight wells may be combined into a single lease number. Combining information from these three data sets will provide

- annual field oil and water production histories
- daily (or annual) lease oil and water production histories
- annual status of wells within fields (active, newly drilled, abandoned, shut-in).

At present most of this data is only available in paper or microfilm format. For analysis and interpretation of Michigan’s oil production history data it is recommended that the available data be put into digital form in a spreadsheet format. We have found that Microsoft Excel works very well for this purpose, however other software, such as Lotus or Quattro Pro could be equally effective.

As part of a U.S. Department of Energy - Class 2 reservoir study on Crystal and 29 other Dundee fields in Michigan we have compiled an MS-Excel data set of oil production history. Figures and tables, herein, demonstrate the properties of these data sets and some of the visualization products that can be produced to help interpret the

historical performance and management of these Dundee reservoirs. Some tentative criteria have also been established in this project to evaluate the potential additional oil recovery from these Dundee fields. Steepness or rate of decline during the early years of production. Declines of more than 20-25 % per year are suspicious.

#### High rate of abandonment of wells.

Abandonment of more than 5 or 10 percent of a field's wells during the early life of the field should be an indicator of inefficient reservoir management. In water-drive reservoirs, rapidly increasing water cut may suggest that production flow rates are too high resulting in up-coning of water from the aquifer. Eventually the large amount of water to be handled results in the abandonment of the well. Premature abandonment of wells results in mobile oil being left in the reservoir in the interwell locations. Sites for recovery of bypassed oil is likely to be in the interwell areas at maximum distances from the old boreholes.

#### History of Horizontal Drilling in Michigan

As part of this study we have been tracking horizontal wells in Michigan. There had been about 74 wells drilled before this project began in 1994. By the end of 1996, at least 146 wells had been completed. Currently there are 102 wells being planned, drilling, or testing. The table below lists the number of wells by geologic horizon.

#### Previous Horizontal Wells

DRILLED AND COMPLETED FROM 1987 – 1996 - 146 total wells

MICHIGAN "STRAY" FM. - 8

ANTRIM SHALE - 19

TRAVERSE LIME - 0

DUNDEE FM. AND REED CITY MBR. - 7

RICHFIELD MBR. OF LUCAS FM. - 0

DETROIT RIVER "SOUR ZONE" MBR. OF LUCAS FM. - 1

SALINA A-1 CARBONATE - 2

NIAGARA FM. "PINNACLE REEF" - 87

TRENTON/BLACK RIVER FM. - 12

GLENWOOD/ST. PETER SS./ PRAIRIE DU CHIEN - 10

Current Horizontal Well Activity

PERMITTED OR DRILLING AS OF JULY 25, 1997 - 102 wells

MICHIGAN "STRAY" FM. - 1

BEREA SS. - 2

ANTRIM SHALE - 13

TRAVERSE LIME - 1

DUNDEE FM. AND REED CITY MBR. - 18

RICHFIELD MBR. OF LUCAS FM. - 4

DETROIT RIVER "SOUR ZONE" MBR. OF LUCAS FM. - 1

SALINA A-1 CARBONATE - 2

NIAGARA FM. "PINNACLE REEF" - 55

TRENTON/BLACK RIVER FM. – 1

GLENWOOD/ST. PETER SS./ PRAIRIE DU CHIEN - 4

Dundee Horizontal wells

Horizontal drilling in the Dundee began with the 1995 completion of the Cronus – Tow #1-3 HD-1 well in Crystal Field of Montcalm County. This well was the demonstration test well of this Class 2 reservoir project. Its success has resulted in the drilling of 11 additional wells and the planning and permitting of 13 more. The table below documents this history of Dundee development in the last two years.

Dundee Horizontal Wells Already Drilled, Drilling, or Waiting on Completion

Bay Co., Muskegon Dev.-McNally 2-28 HD1, Kawkawlin Field, **Producing oil 10 bopd**

Bay Co., Muskegon Dev.-Macey 2-34 HD1, Kawkawlin Field, **Producing oil 20 bopd**

Clare Co., Newstar Energy-St. Redding & Sparrow 1-29 HD1, Freeman-Redding Field

Drilled to TD, 1800' lateral, testing

Clare Co. - Winterfield Field - Dart Oil and Gas - Frankhauser 10-29 HD1, SE,SW,NE(SL); SW,SE,NW(340S/947E)(BHL) SEC29-20N-6W, **P#52098, TD vertical, run 7", evaluating.**

Gladwin Co. - Beaverton Field - Newstar Energy - Calhoun 1 HD1, NE,SE,SW(SL);

SW,SE,SW(490S/832E)(BHL) SEC 2-17N-2W, **P#51889, TD vertical, 5 1/2” for testing.**

Gladwin Co. - Buckeye, North Field - Ranch Prod. - Salla, John 9-11 HD1,

NW,SW,SW(SL); N,NW,SW(330N/660W)(BHL) SEC 11-18N-1W, **P#52002, TD, 1000’,horizontal, 5 1/2”, testing.**

Isabella Co. - Sherman Field - Lees Petroleum - Stegman&Anderson 3-33 HD1,

SE,NE,SE(SL); SW,NE,SE(700N/650E)(BHL) SEC 33-15N-6W, **P#51656, TD vertical hole, evaluating.**

Mecosta Co., Don Yohe Enterprises-Rousseau 1-12 HD, Fork Field, **Producing oil/water 60 oil 30 water.**

\*Montcalm Co., Cronus Expl.-Tow 1-3 HD1, Crystal Field, **100 BOPD**

Montcalm Co., Cronus Expl.-Frost 5-3 HD, Crystal Field, **Producing oil/water 10 bbls oil 100 bbls water**

Montcalm Co., Cronus Expl.-Happy Holiday Tree Farm 6-3 HD, Crystal Field,

**Producing oil/water 5 bbls oil 100 bbls water**

Osceola Co., Apollo Expl.-Sylvan 1-9 HD1, Sylvan Field, **Producing oil/water 35 bbls oil 5 bbls water**

\*Demonstration well for Class 2, Dundee Fm. reservoir study.

Dundee Horizontal Wells Permitted to be Drilled

Bay Co., Muskegon Dev.-Dennis McNally 4 HD, Sec. 28-15N-4E, S,NW,SE, **P# 15173, re-enter old hole, Kawkawlin Oil Field**

Bay Co., Muskegon Dev.-Paige 2 HD, Sec. 34-15N-4E, N,NW,NW, **P# 9990**, ,  
re-enter old hole, Kawkawlin Oil Field

Bay Co. - Pinconning Field - Lithos Expl. - Pintoski et al 1-35 HD1,  
NW,SE,NE(SL) SEC 35-17N-4E, NW,NW,NW(330N/98W)(BHL) SEC 36-17N-4E,  
AP#970416.

Clare Co. - Winterfield Field - Dart Oil and Gas - Benchley 9-31 HD1,  
SE,SE,NE(SL); SW,SW,NE(340S/340W)(BHL) SEC 31-20N-6W, **P#52099**

Clare Co. - Winterfield Field - Cronus Expl. - Wayne State 1-33 HD,  
NW,NE,SE(SL); NE,NW,SW(350N/990W)(BHL) SEC 33-20N-6W, AP#970261.

Mecosta Co. – Hardy Dam Field – Jennings/Enveron – Zink 1-17 HD1,  
SW,SW,NW(SL);NE,NW,NW(330N/990W)(BHL) SEC 17-13N-10W, AP#970451.

Missaukee Co. - Riverside Field - Dart Oil and Gas - Hamming 4-22 HD1,  
NE,SW,NE(SL);NE,SE,NE(981S/330E)(BHL) SEC 22-21N-7W, **P#52097**. Directional  
Redrill of P#31835.

Montcalm Co. - Cronus Expl. - Crystal Field - Cronus Danforth 2-3 HD,  
NE,NE,SE(SL); NE,NE,NE,(330N/660E)(BHL) SEC 3-10N-5W, AP#970102.

Montcalm Co. - Cronus Expl. - Crystal Field - Robbins 3-3 HD, NW,NW,NE(SL);  
SE,SW,NE(330S/660W)(BHL) SEC 3-10N-5W, AP#970101.

Montcalm Co. - Cronus Expl. - Crystal Field - Walker 1-35 HD, NW,SW,SE(SL);  
SW,SW,SW(660S/330W)(BHL) SEC 35-11N-5W, AP#970100.

Montcalm Co. – Tolas Oil & Gas - Crystal Field – Brown 1-11 HD1,  
SE,SW,SW(SL); NE,NW,SW(SL); NE,NW,SW(330N/989W)(BHL), SEC 11-10N-5W,  
AP#970497.

Newaygo Co. - Belco Operating - Goodwell Field - Anderson 1-20(re-entry)  
SE,NW,NW(SL) SEC 20-14N-10W.

Osceola Co. - Belco Operating - Evart Field - Gostlin 1-27 HD, SW,NW,NE(SL);  
SE,NE,NE(885N/330E)(BHL), SEC 27-18N-8W, AP#970325.

## TECHNOLOGY TRANSFER

Heidi Wines Master's Thesis at W. M. U.

Heidi Wines has recently finished her Master's Thesis on reservoir characterization of the Crystal Field. She compiled and analyzed all historic, geologic, and engineering data for the field. She also analyzed and interpreted data collected from the drilling and coring of the Cronus – Tow #1-3 HD-1 well. A title page and an abstract of her thesis is included in the appendix.

Database Management

Several new databases related to the Michigan subsurface are under construction. A database containing data on the deepest wells in Michigan has been constructed and well logs from these wells are being digitized. In addition, the wealth of information recently acquired from CMS-NOMECO is being indexed. Details on the data are reported below.

Professional Papers and Presentations

A paper describing the DOE Michigan Dundee project and the results of the Crystal Field demonstration well is in the final stages of preparation. It is entitled "Recovery of Bypassed Oil Through Horizontal Drilling, Dundee Reservoir, Crystal Field, Michigan" and will be submitted to the Oil and Gas Journal.

## Internet Homepages

The Dundee Project now has its own Homepage on the Internet, which is networked to the Geology Department at WMU, can be reached at

HYPERLINK <http://www.geo.mtu.edu/svl/>

<http://www.geo.mtu.edu/svl/>

Western Michigan University, Geology Department has added a data base search system to their web site. All field data from the reservoir characterization task has been placed there. The data can be viewed using a web browser. Searches are made by "query" to a web page database manager called WEBFILER. The internet address of the site is <http://www.geology.wmich.edu>.

## Michigan Oil Field Research Consortium (MOFRC)

The 4th issue of the MOFRC Newsletter was send to MOFRC members in July. This newsletter was established to disseminate information on our project to interested parties in the Michigan oil and gas community and has proven very successful. It is useful not only to update the gas and oil community in Michigan on project activities but also to let companies know where they can send their old files and other materials that have archival value.

## Workshops

A 1-day workshop will be offered September 18 in Grand Rapids, Michigan in conjunction with the MOGA meeting. We will present the results of the DOE Dundee project and will make the data collected available to the gas and oil industry on a CD ROM. Topics to be covered include in-depth analyses of 30 Dundee fields in the Central Michigan Basin, including construction and interpretation of the structure maps, production history charts and discussion of potential for future production.

Digital data for well locations, formation tops and production data for all 30 fields collected during the course of the project will be available on a CD ROM as well as the working files used to generate structure and isopach maps in software programs GeoGraphix and ER Mapper. In addition to the project data, the USGS data for county boundaries, topography, culture and hypsography will be included in the data set. Over 200 Mbytes of data will be included on the CD ROM. The workshop will feature tutorials on converting the project data to the GeoGraphix format and producing maps. There will also be discussion on products such as ER Mapper, the Microsoft Office Suite and several other programs.

The workshops will begin at 8:30 a.m. and end at 4:30 p.m. A tentative agenda is:

- 8:30            Coffee & Registration**
- 9:00            Using the CD ROM database**
- 10:00          Tutorial on GeoGraphix project files**
- 11:00          Subsurface mapping with low-cost software**
- 12:00          Lunch Break**
- 1:00            Displaying data with ER Mapper**
- 2:00            Constructing base maps with USGS data files**
- 3:00            Summary**
- 4:00            Adjourn**

Instructors will be J. R. Wood and S. D. Chittick of Michigan Technological University and W. B. Harrison of Western Michigan University. Cost of the workshop is

\$20 payable at the door. The CD ROM data disk is \$80. The CD ROM can be ordered separately for \$100.

## FIGURES & TABLES

Figure 1. Oil production history Evart field Dundee Fm.

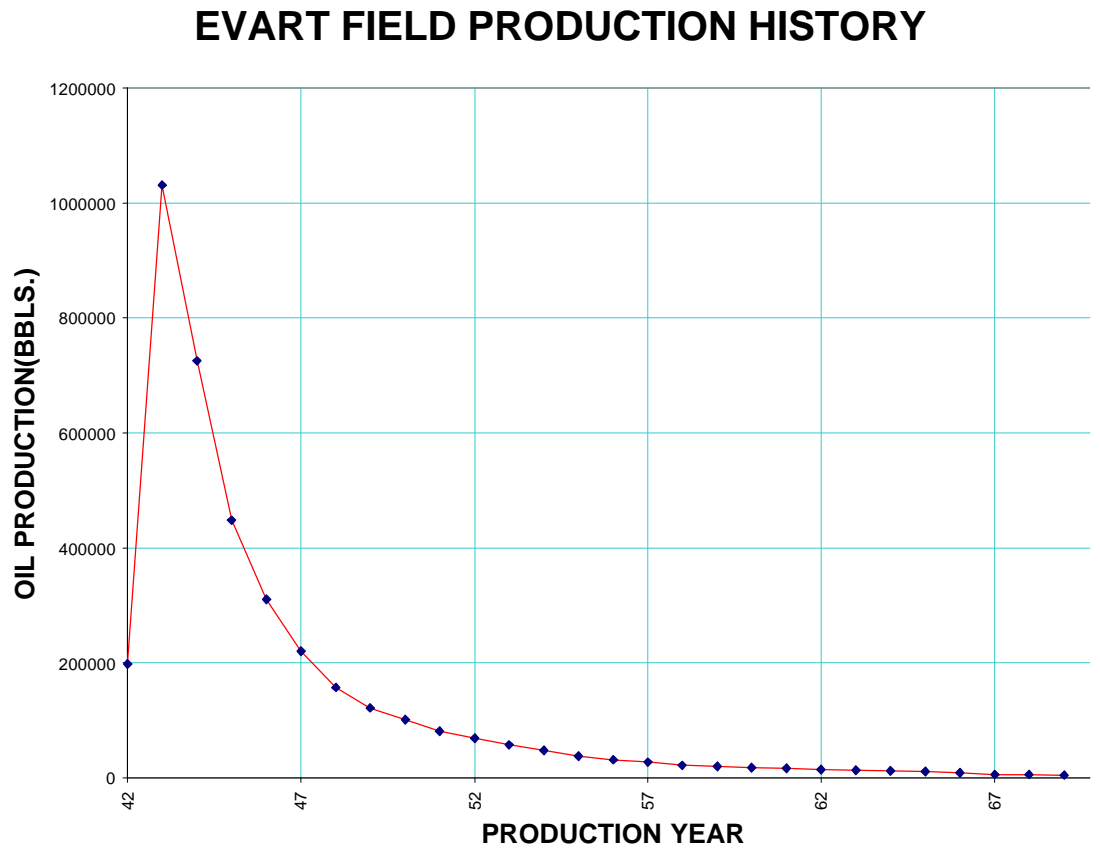


Figure 2. Oil well history Evart field Dundee Fm.

## EVART FIELD WELL HISTORY

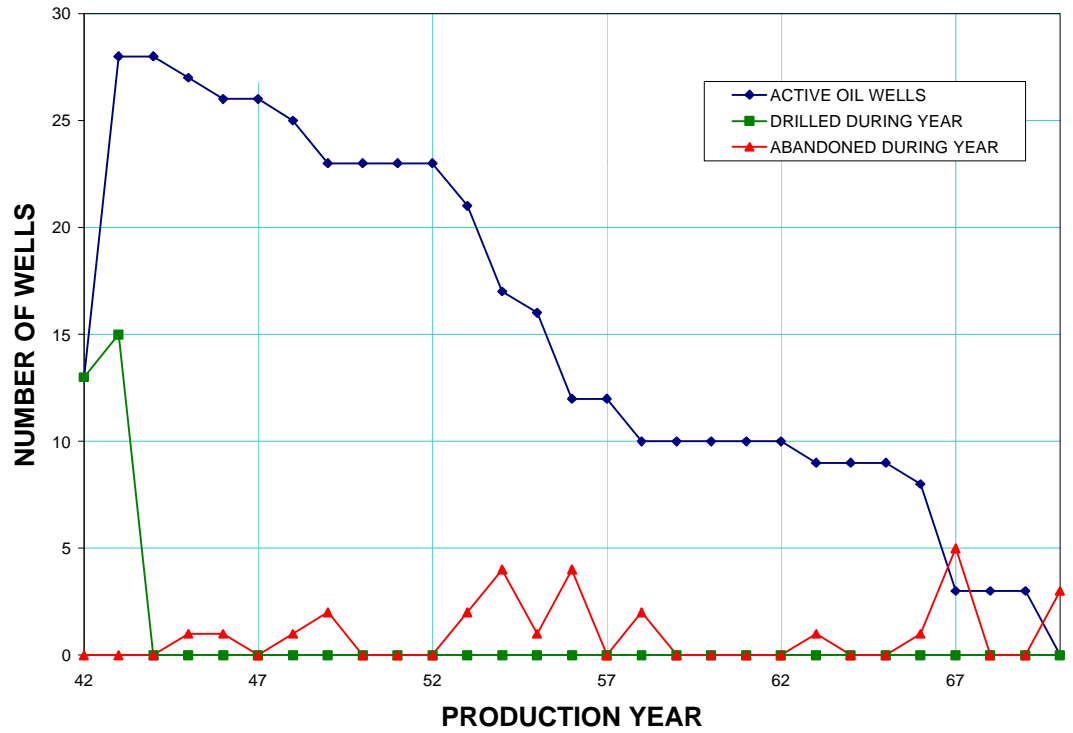


Table 1. Example of Excel spreadsheet for production and well status

EVART FIELD PRODUCTION DATA

DATE	ACTIVE OIL WELLS	DRILLED IN YEAR	ABANDONED IN YEAR	OIL PROD.(BBLs)
1935				
1936				
1937				
1938				
1939				
1940				
1941				
1942	13	13	0	198,192
1943	28	15	0	1,031,310
1944	28	0	0	725,431
1945	27	0	1	447,477
1946	26	0	1	310,627
1947	26	0	0	220,401
1948	25	0	1	156,899
1949	23	0	2	121,751
1950	23	0	0	100,681
1951	23	0	0	80,453
1952	23	0	0	68,482
1953	21	0	2	56,849
1954	17	0	4	47,784
1955	16	0	1	37,960
1956	12	0	4	30,917
1957	12	0	0	27,262
1958	10	0	2	21,821
1959	10	0	0	19,837
1960	10	0	0	17,626
1961	10	0	0	16,324
1962	10	0	0	13,568
1963	9	0	1	12,967
1964	9	0	0	11,981
1965	9	0	0	10847
1966	8	0	1	8,437
1967	3	0	5	5,243
1968	3	0	0	5,535
1969	3	0	0	4,476

