

# Large Potential Reserves Remain for Secondary Oil Recovery in Ohio\*

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## Abstract

As part of the U.S. Department of Energy's Tertiary Oil Recovery Information System (TORIS) Project in 1995, the Ohio Department of Natural Resources, Division of Geological Survey and Division of Oil and Gas Resources Management conducted an evaluation of the oil remaining in about 80% of the reservoirs in Ohio. The study indicated that these reservoirs contained approximately 5.7 billion barrels of original oil in place (OOIP) and that only about 369 million barrels of oil or 6.5% have been recovered by primary production methods.

Since 1903, when the first known attempt at increasing oil production by secondary recovery methods was initiated in Ohio, at least 340 secondary and enhanced oil recovery projects have been documented. All of the early projects involved either air injection or natural gas repressurization.

Ohio legalized water flooding in 1939, and secondary recovery operations increased dramatically. By 1942, secondary recovery operations reached their peak and accounted for 15.9% of Ohio's daily oil production. However, since 1942, secondary recovery of oil in Ohio has continued to decline and today accounts for less than 1% of Ohio's daily conventional oil production. This is appallingly low when compared to the surrounding Appalachian states, where secondary recovery accounts for 25-50% of their conventional oil production. Today, there are only three legitimate water flood operations currently active in Ohio and all three of these projects are near the end-life of the project and are in decline.

This presentation will address the problems and provide solutions to addressing the lack of legitimate secondary recovery operations in Ohio and demonstrate there has been success in Ohio through the evaluation of case studies of historical secondary oil recovery operations. With the decline in conventional oil and gas activity in Ohio due to the development of the Utica Point Pleasant and Marcellus unconventional shale plays, secondary oil recovery from conventional reservoirs such as the Berea Sandstone, Clinton Sandstone, and Rose Run Sandstone in Ohio can offer new opportunities for the conventional oil and gas operator.

# LARGE POTENTIAL RESERVES REMAIN FOR SECONDARY OIL RECOVERY IN OHIO

**Prepared by Thomas E. Tomastik, CPG, ALL Consulting**



Presented at the 2019 American Association of Petroleum Geologists  
Eastern Section Meeting, October 12-16, 2019, Worthington, Ohio

# INTRODUCTION

- As part of the U.S. Department of Energy's Tertiary Oil Recovery Information System (TORIS) Project in 1995, the Ohio Department of Natural Resources conducted an evaluation of the oil remaining in about 80% of Ohio's reservoirs.
- This study indicated that these reservoirs contained approximately 5.7 billion barrels of original oil-in-place and that only about 369 million barrels or 6.5% of this oil has been recovered by primary production methods.



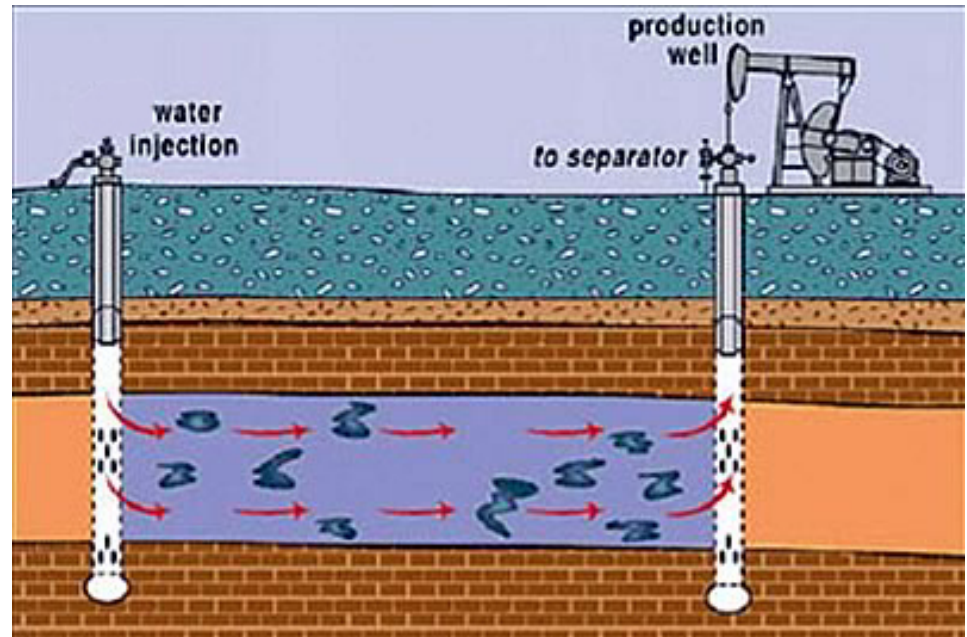
Source: ALL Consulting, 2017





# HISTORY OF SECONDARY RECOVERY IN OHIO

- Since 1903, when the first known attempt at increasing oil production by secondary recovery occurred in Ohio, at least 340 secondary oil recovery projects have been documented.
- All the early projects involved either air injection or natural gas repressurization.

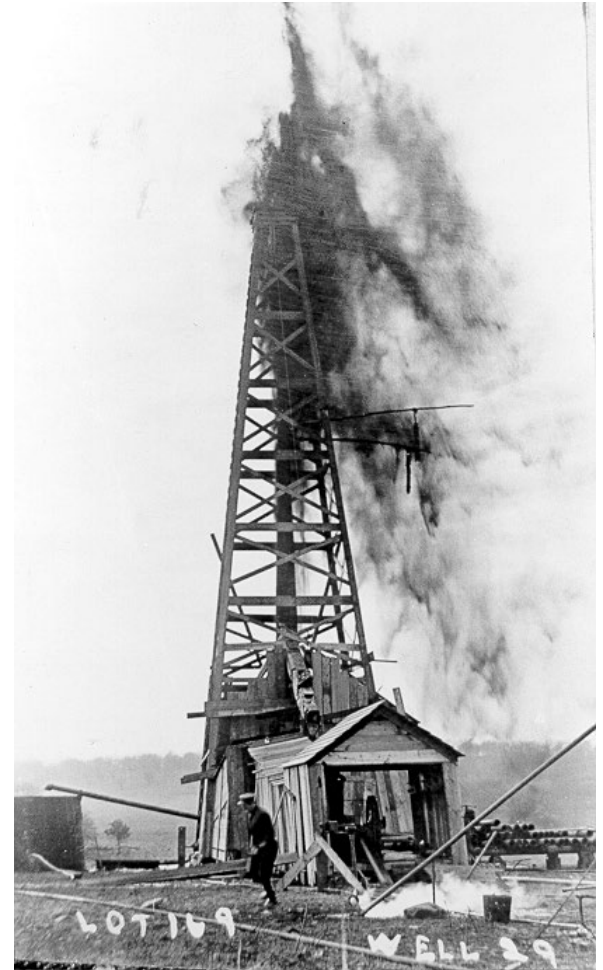


Source: [www.aoghs.org](http://www.aoghs.org), 2019



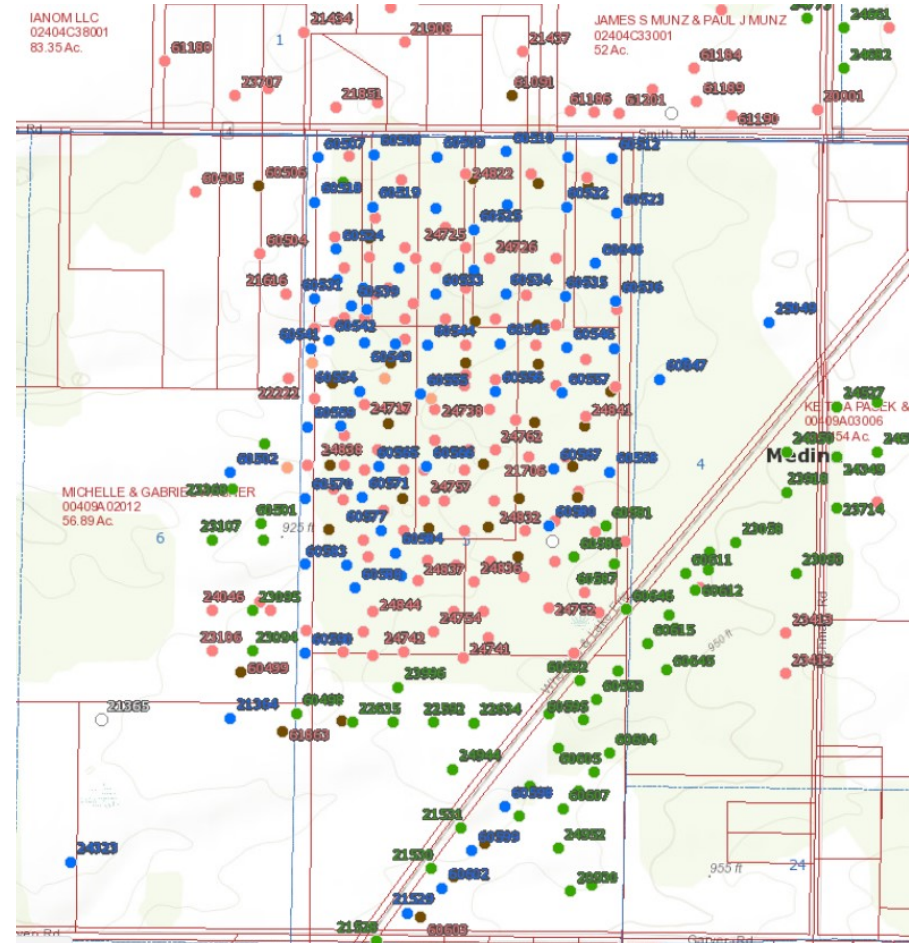
# INITIAL WATER FLOODING IN OHIO

- Ohio legalized water flooding in 1939 and secondary recovery operations increased dramatically.
- By 1942, secondary oil recovery reached its peak and accounted for approximately 15.9% of Ohio's daily oil production.
- However, since 1942, secondary recovery of oil continued to decline and today accounts for less than 1% of Ohio's daily conventional oil production.
- This is appallingly low when compared to the surrounding states were 25-50% of annual conventional oil production comes from secondary recovery operations.



# FIRST WATER FLOODING PROJECTS IN OHIO

- After legalization of water flooding in Ohio in March of 1939, many of the first projects occurred in the Berea Sandstone in the Chatham oilfield in Chatham, Harrisville, and Litchfield Townships of Medina County, Ohio.
- The success of the initial pilot water flood on the Ripley lease in June of 1939 led to widespread water flooding of the Chatham field from the 1940s through the early 1960s.
- Most of the water flood projects utilized either five-spot or line drive water flooding techniques.
- There has been at least 3,326 wells drilled and 58 water flood projects operated since the field was discovered in 1899.



Source: ODNR, DOGRM, 2019



# CHATHAM OILFIELD RESERVOIR CHARACTERISTICS

- Depths to the Berea Sandstone ranged from 178 to 670 feet.
- Sandstone thickness varied from 0 to 260 feet and averaged 51 feet.
- Porosities from cores and logs ranged from 3 to 28% but averaged 16%.
- Core permeability averaged 40.3 millidarcies but ranged as high as 363 millidarcies.
- Oil saturation averaged 39.6%.



Berea Sandstone - Waterflood Oil Sample

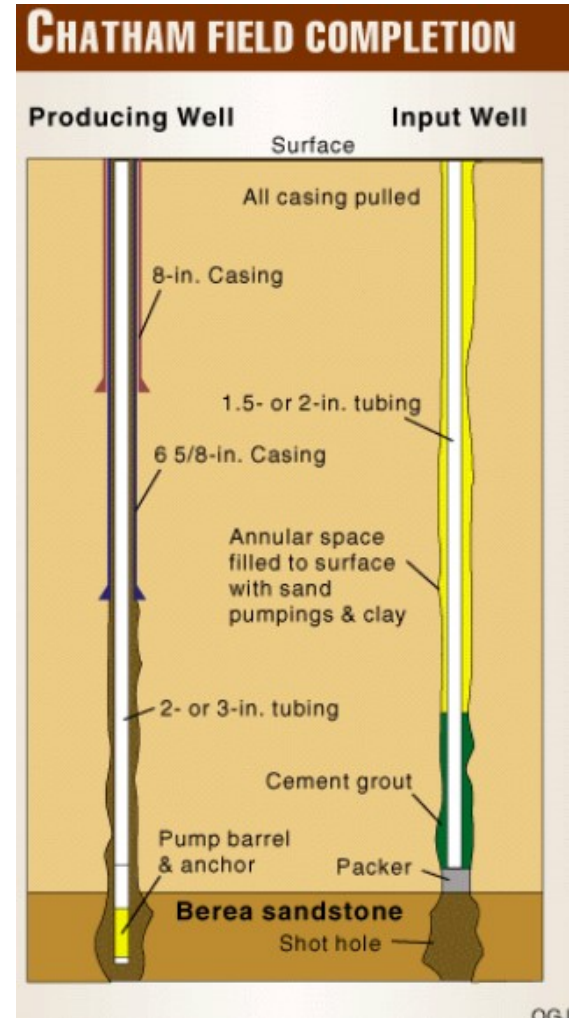
Source: Tomastik, 2019





# CHATHAM COMPLETION METHODS

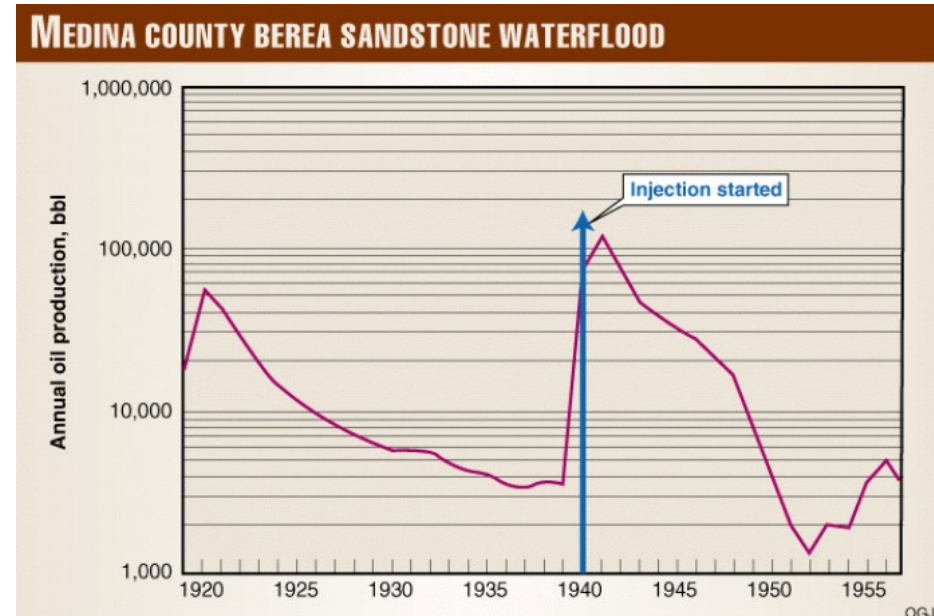
- Wells in the Chatham oil field were completed 8" drive pipe to 50 to 70 feet; 6-5/8" production casing to 120 to 150 feet; and then 2-inch or 3-inch tubing into the top of the Berea Sandstone.
- Injection wells were completed in a similar manner but once tubing and packer was set in the top of the Berea cement was placed on top of the packer and all casing was pulled.
- Completion was open hole.
- Most wells were shot with nitroglycerin, with one quart for each foot of sandstone.





# BEREA SANDSTONE - CHATHAM CASE STUDY — DANIEL ROSS LEASE

- Depth to the Berea ranged from 242 to 494 feet.
- The Daniel Ross lease comprised a total of 63 acres.
- Pay thickness varied from 2 to 182 feet and averaged 69 feet.
- Average core analysis indicated 40.1% oil saturation, 18.3% porosity, and 113.08 millidarcies permeability.
- Primary oil production from 1919 to 1940 was 258,671 barrels.
- Water flooding commenced in February of 1940 using a five-spot pattern.
- Cumulative secondary oil production from 1940 to 1961 was 483,009 barrels.

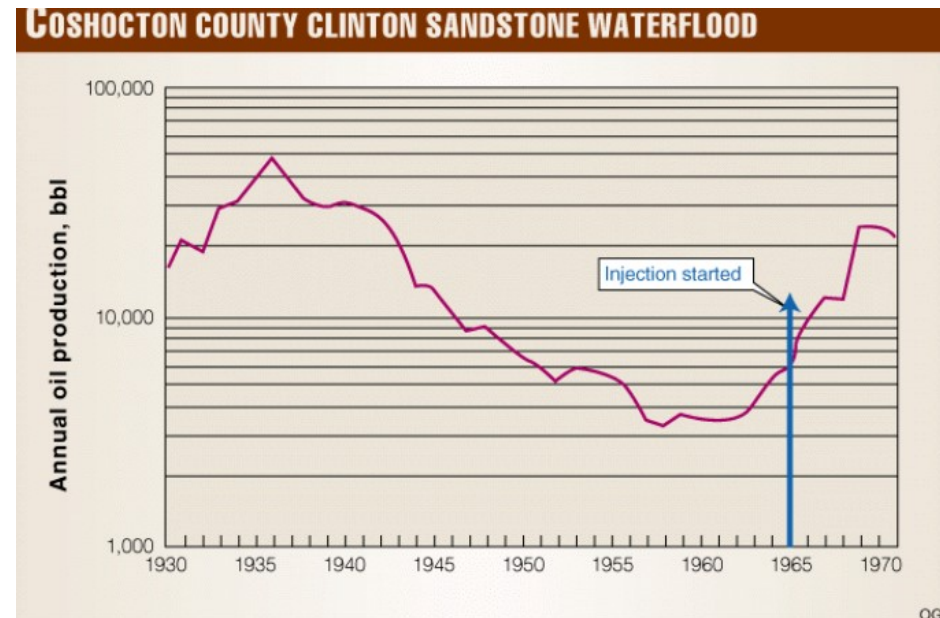


Source: Tomastik and OGJ, 1999



# ADDITIONAL HISTORIC WATER FLOOD PROJECTS IN OHIO

- There were several historic water flood and gas repressurization projects in the Clinton sandstone in Ohio.
- Several of these projects were in Coshocton, Hocking, and Perry counties and had some limited success during the 1940s to 1990s.
- Additionally, in the 1950s and the 1990s, several pilot water floods were attempted in Trenton Limestone in northwestern Ohio and were not very successful.



Source: Tomastik and OGJ, 1999



# CURRENT OHIO SECONDARY RECOVERY OPERATIONS

- Currently, there are only four legitimate secondary oil recovery (enhanced recovery project) water flood injection projects in Ohio that are in operation.
- There are additional “permitted” enhanced recovery projects (ERP) in Ohio, but these are one injection well operations that are not set up like standard water flood operations and have very limited impact on increasing oil production.
- The four active ERP projects include injection into the Berea Sandstone in Ashland County, Knox Dolomite in Erie County, an unnamed Pottsville Group sandstone in Lawrence County, and the Clinton sandstone in Stark County.



# ASHLAND COUNTY WATER FLOOD

- There are six enhanced recovery projects currently in operation in Perry Township.
- Injection is into the Berea Sandstone at depths ranging from 518 to 790 feet and these wells are completed open hole.
- Five of these projects are operated by Deep Resources and one is operated by Fawn Resources LLC.
- The first project was permitted in 1974 by Quaker State Oil Refining and the last one was permitted in 2007 by Mohican River Energy.
- There are 78 injection wells and 158 oil producing wells at these six projects.

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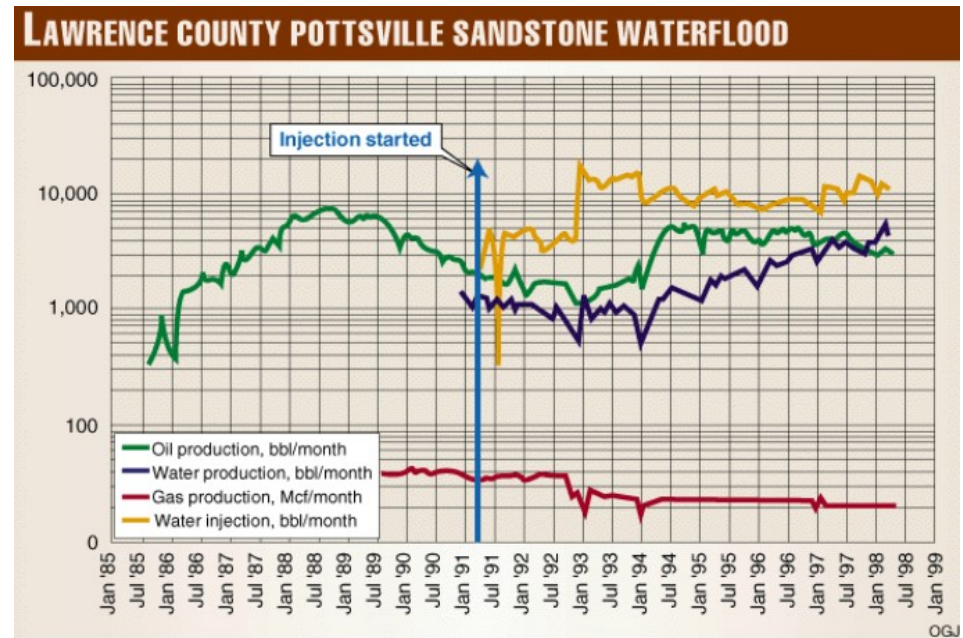
# ERIE COUNTY WATER FLOOD

- There is just one enhanced recovery project in operation in Florence Township.
- Injection is into the “Kriysik” or “B” zone sandstone of the Knox Dolomite at depths ranging from 3,865 to 3,886 feet.
- This project was first completed by Sun Oil Company in 1965 and water flooding commenced in 1974.
- This project is currently operated by Franklin Gas & Oil LLC.
- There are four injection wells and five oil producing wells in the project.
- Estimated cumulative oil production through 1995 was 1,500,000 barrels.



# LAWRENCE COUNTY WATER FLOOD

- There is just one enhanced recovery project in operation in Mason Township and commenced in 1991.
- Injection is into an unnamed sandstone within the Pennsylvanian Pottsville Group at depths ranging from 568 to 767 feet.
- This project was originally developed by Mitchell Energy and is now operated by Pillar Energy, LLC.
- There are 22 injection wells and 19 oil producing wells in this project.
- This project has been very successful.

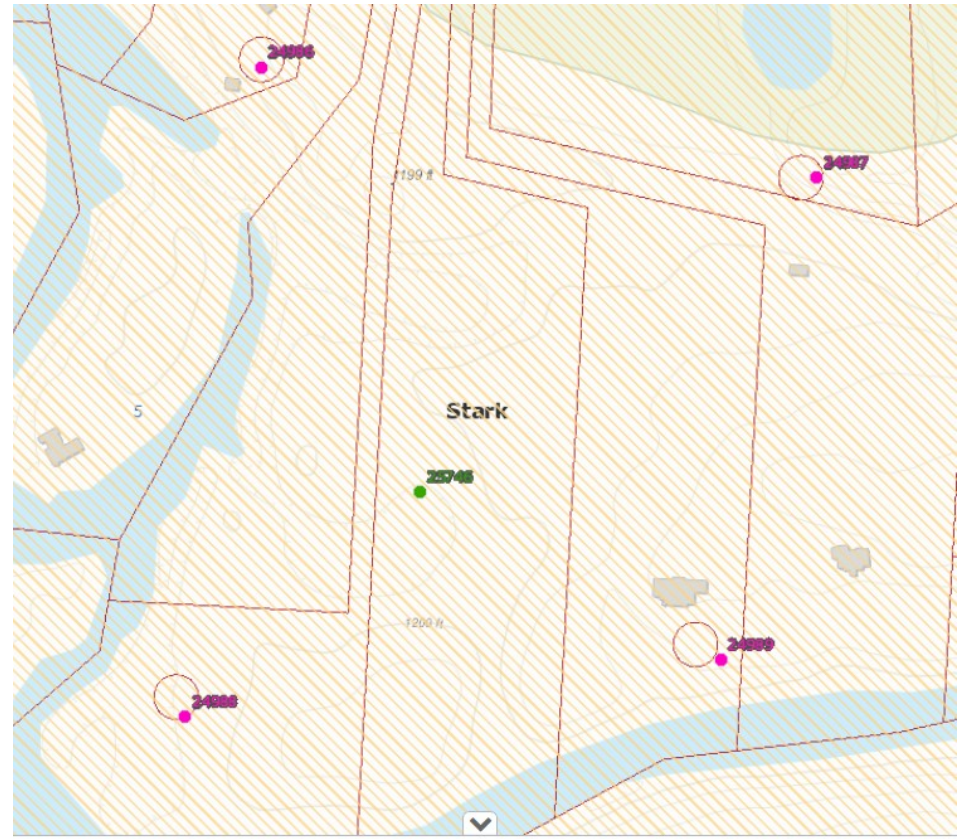


Source: Tomastik and OGI, 1999



# STARK COUNTY WATER FLOOD

- There is just one project and it is in Nimishillen Township, which is part of the East Canton oilfield.
- Injection is into the Clinton sandstone at depths ranging from 4,700 to 4,800 feet.
- This pilot project was developed by EnerVest Operating, LLC and started injecting in 2012.
- There are four injection wells and one oil producing well in the project set in a five-spot pattern.



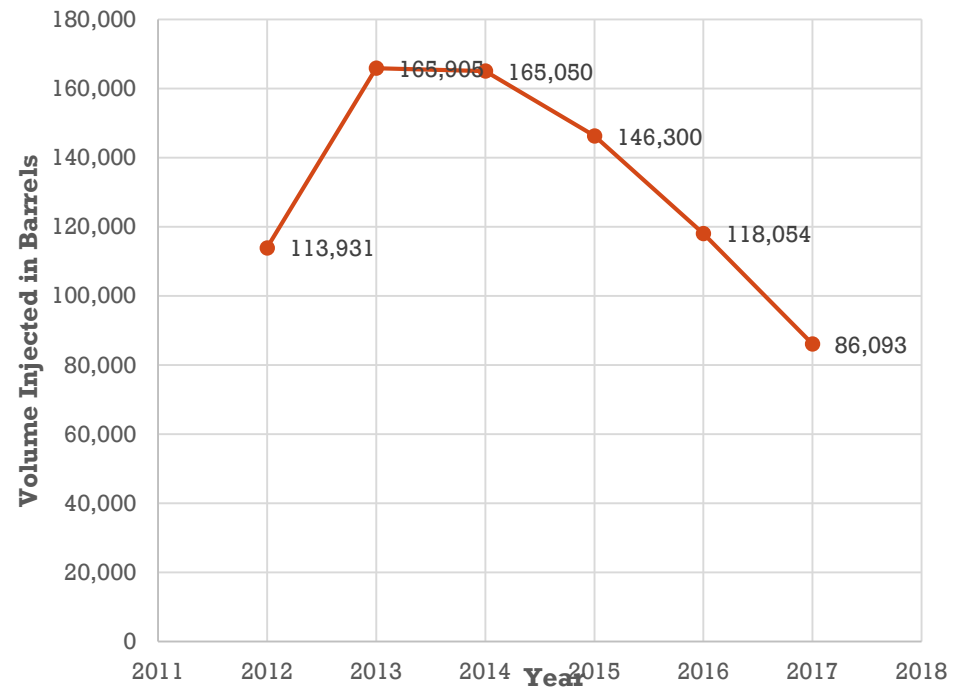
Source: DOGRM and ODNR, 2019



# STARK COUNTY FLINTKOTE ERP PROJECT

- Injection volumes and oil production data was obtained from the Division of Oil and Gas Resources Management.
- Total injection volumes from 2012-2017 was 795,333 barrels.
- Injection volumes not available yet for 2018.
- Oil production peaked in 2012 with 2,378 barrels produced and has steadily declined. Total oil production through 2018 was 8,184 barrels.

Flintkote ERP #1





# WHY THE LIMITED SUCCESS IN OHIO?

- There are several reasons why secondary enhanced oil recovery projects have not been as successful in Ohio as in the surrounding states.
- These reasons can include:
  - Early water breakthrough due to channeling of high permeability zones or excessive injection pressures, which can induce fractures and channel the water.
  - Water injection was limited due to low permeability of the reservoir or the poor quality and improper treatment of the source water for injection operations, which can lead to formation damage of the reservoir.
  - Premature abandonment of a pilot flood before a response was fully seen and evaluated.
  - Poor or antiquated completion methods such as slim hole completions, open hole completions, and stimulation with explosives that limited the success of a project.
  - Costs associated with doing a modern secondary recovery project properly.



# ADDRESSING THE PROBLEMS AND PROVIDING SOLUTIONS

- Previous studies have shown that a large volume of unrecovered oil reserves remains for potential secondary oil recovery in many of Ohio's oil reservoirs.
- The critical component to a successful secondary recovery operation in Ohio is doing it right, which means utilizing modern secondary recovery methodologies and spending the capital.
- Several oil reservoirs (Berea, Clinton, and Rose Run sandstones) in Ohio are suitable for secondary recovery operations and are the most likely candidates.
- Areas within Ohio where the reservoir characteristics (adequate thickness, good porosities, and low gas-oil ratios) are optimal provide the best opportunities for a successful secondary oil recovery project.



# QUESTIONS?

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Source: ALL Consulting, 2017

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