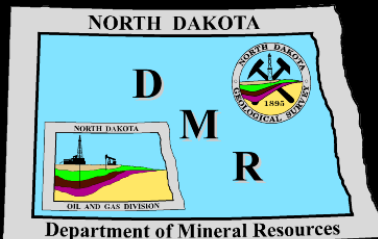


UNITIZATION AND ENHANCED RECOVERY TECHNIQUES

***ND State Legislature
Interim Taxation Committee
Bismarck, ND
April 27, 2016***

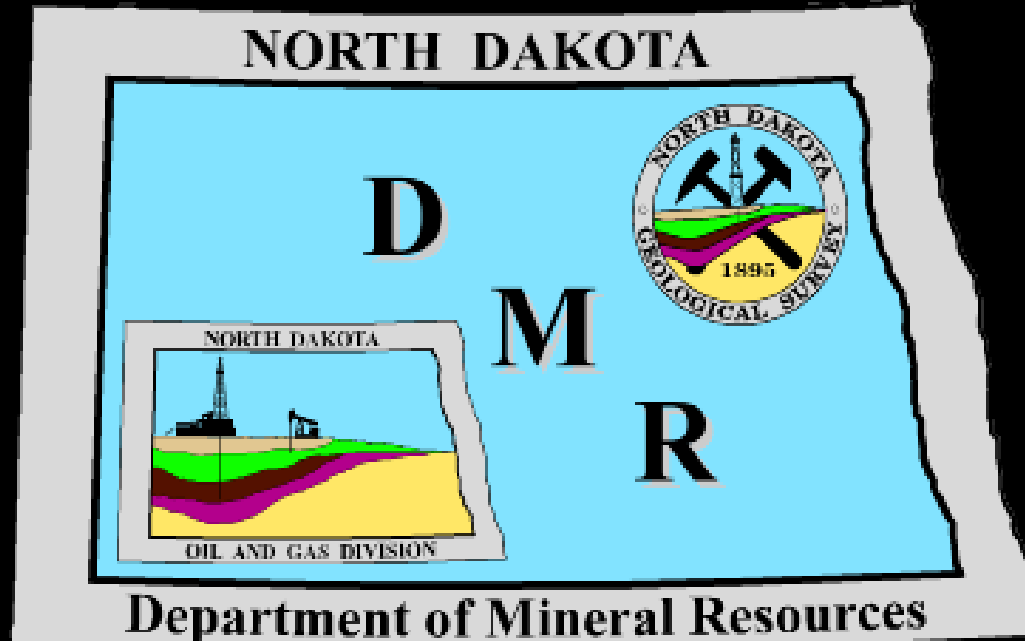


Unitization and Enhanced Oil Recovery

- Unitization Process
- Units Approved
- EOR Results
- Bakken Development
- Bakken EOR Potential

Bruce E. Hicks
Assistant Director
NDIC-DMR-OGD
Bismarck, ND

North Dakota Department of Mineral Resources



<https://www.dmr.nd.gov/oilgas/>

<https://www.dmr.nd.gov/ndgs/>

600 East Boulevard Ave. - Dept 405

Bismarck, ND 58505-0840

(701) 328-8020

(701) 328-8000

←

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NDIC DMR

https://www.dmr.nd.gov/oilgas/

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NORTH DAKOTA

OIL AND GAS DIVISION

Welcome to the North Dakota Industrial Commission, Department of Energy and Gas Division, Home page

Please check out the new [Information Center](#) and [Publications](#)

Proposed Rule Changes and Adoption of New Rules

[Rule Changes Full Notice](#)

[General Guidelines for Temporary Abandonment of Wells](#)

[Bakken and Three Forks Information!](#)

Available on the ND Petroleum Council web site are the [Surface Owner Information Center](#), the [Royalty Owner Information Center](#), and the [Oil and Gas Division](#)

The Oil and Gas Division regulates the drilling and production of oil and gas in North Dakota. Our mission is to encourage and promote the development, production, and utilization of oil and gas in the state in such a manner as will prevent waste, maximize economic recovery, and fully protect the correlative rights of all owners to the end that the landowners, the royalty owners, the producers, and the general public realize the greatest possible good from these vital natural resources.

Phone: (701) 328-8020

Fax: (701) 328-8022

Mail:
NDIC Oil and Gas Division
600 East Boulevard Ave
Bismarck, ND 58505-0840

General Shipping:
NDIC Oil and Gas Division

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35 Reminders

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https://www.dmr.nd.gov/oilgas/informationcenter.asp



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The Director's Cut is an update on current activity in the North Dakota oil patch from the Director of the Department of Mineral Resources.

[Tentative Director's Cut Dates](#)

[Director's Cut - 02/17/2016](#)

[Director's Cut Archive](#)

[Director's Cut Webinars](#)

[Recent Presentations](#)

View [press releases](#) from the Oil and Gas Division

Oil and Gas Division Program Descriptions:

This section of the Information Center is dedicated to program descriptions within the Oil and Gas Division. We will be adding descriptions as they become available, so check back for further information.

[Underground Injection Control Program](#)

[\[DMR Home\]](#) [\[Disclaimer\]](#) [\[Privacy\]](#) [\[Security\]](#) [\[Feedback\]](#)



Activity



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Department ...



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35 Reminders



Activity Upd...

Unitization and Enhanced Oil Recovery

- **Unitization Process**
- Units Approved
- EOR Techniques & Results
- Bakken Development
- Bakken EOR Potential

Unitization Process

NDCC Sec 38-08-09.3

- **Project substantially increases oil recovery**
- **EOR unnecessary for approval**
- **Voluntary and Statutory Units**
 - **both require Commission approval**

Unitization—Statutory Approval

NDCC Sec 38-08-09.5

- 60% mineral interest owner approval**
- 60% working interest owner approval**
- NDIC approval**

Unitization and Enhanced Oil Recovery

- Unitization Process
- **Units Approved**
- EOR Techniques & Results
- Bakken Development
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Units Approved

- **127 Units approved**
 - **124 EOR w/fluid injection**
 - **Most water injection**
 - **high pressure air (8)—fire flood**
 - **also propane, CO₂, polymers, N₂, + other fluids**
 - **3 created to increase reserves w/o injection**
 - **Little Missouri-Pierre Unit—shallow gas reservoir**
 - **Cedar Creek-Pierrre Unit—shallow gas reservoir**
 - **Corral Creek-Bakken Unit**

Bakken Units

- **Corral Creek-Bakken Unit**

- **Effective 1-1-2012**
- **30,884 acres**
- **increased reserves over 5 million barrels of oil**
- **81 wells originally planned**
- **122 wells drilled currently**
- **194 wells currently planned**
- **EOR not planned initially**
 - **EOR only after due notice and hearing**

- **Grail-Bakken Unit**

- **24,947 acres**
- **failed to achieve 60% MIO approval**

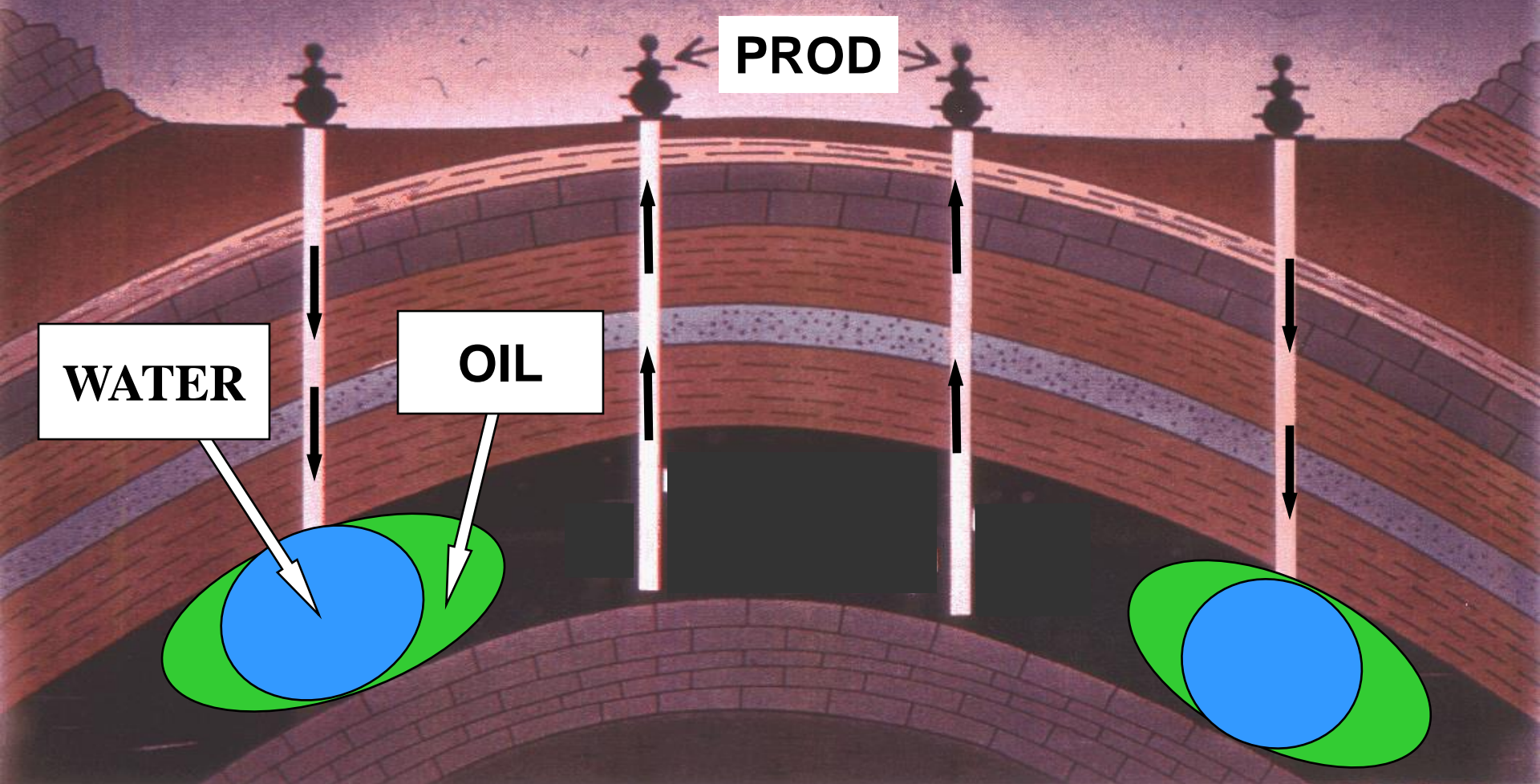
Unitization and Enhanced Oil Recovery

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- **EOR Techniques & Results**
- Bakken Development
- Bakken EOR Potential

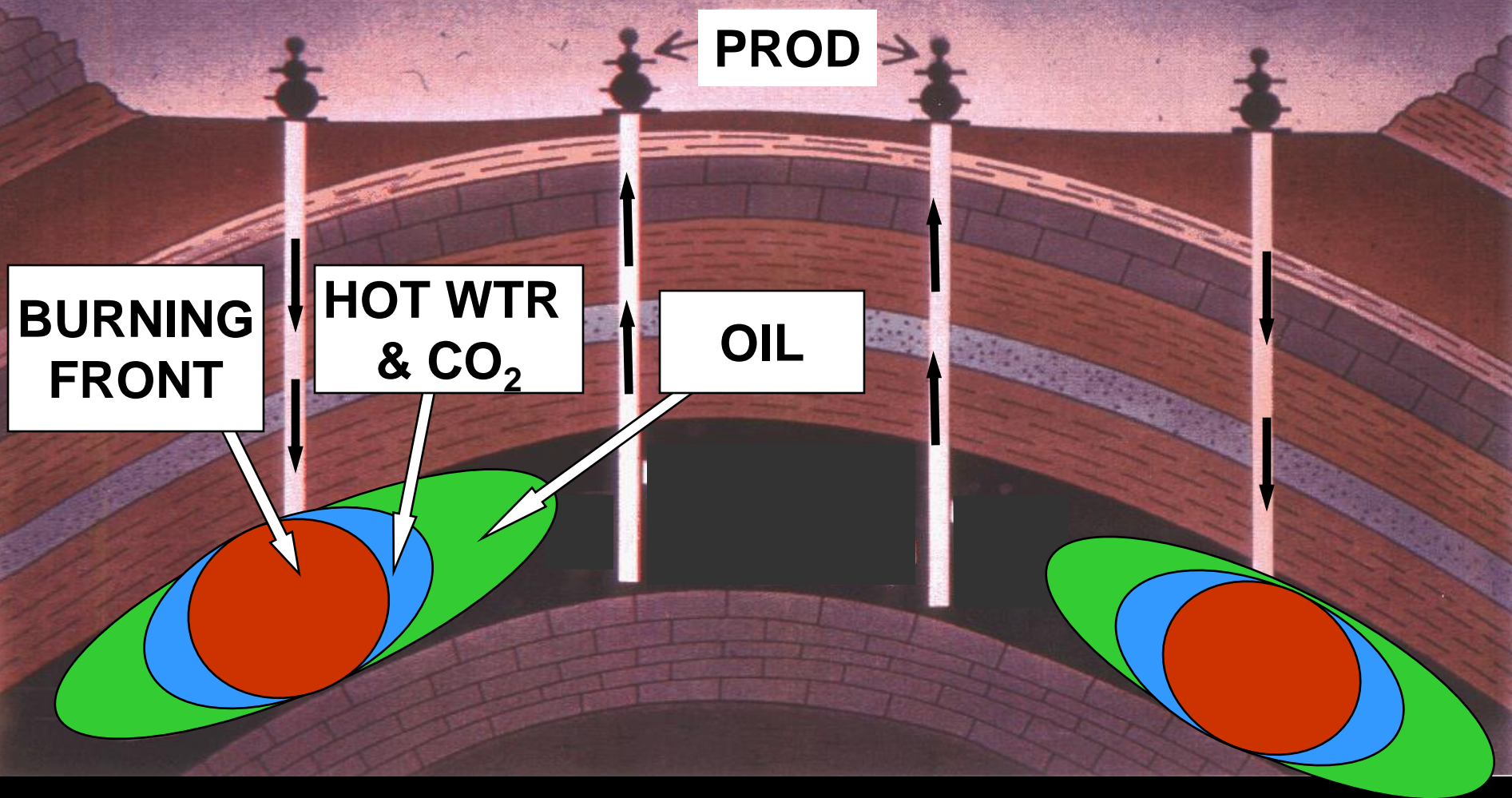
Unitization and Enhanced Oil Recovery

- **Conventional Oil Reservoir**
 - Primary 15% recovery
 - Secondary add 15% recovery
 - Tertiary add 10% recovery
 - 40% recovery of Original Oil in Place (OOIP)
- **Unconventional Oil Reservoir**
 - Bakken-Three Forks Formations
 - 3% Primary recovery / well
 - Secondary & Tertiary recovery ?

WATER INJECTION PROCESS

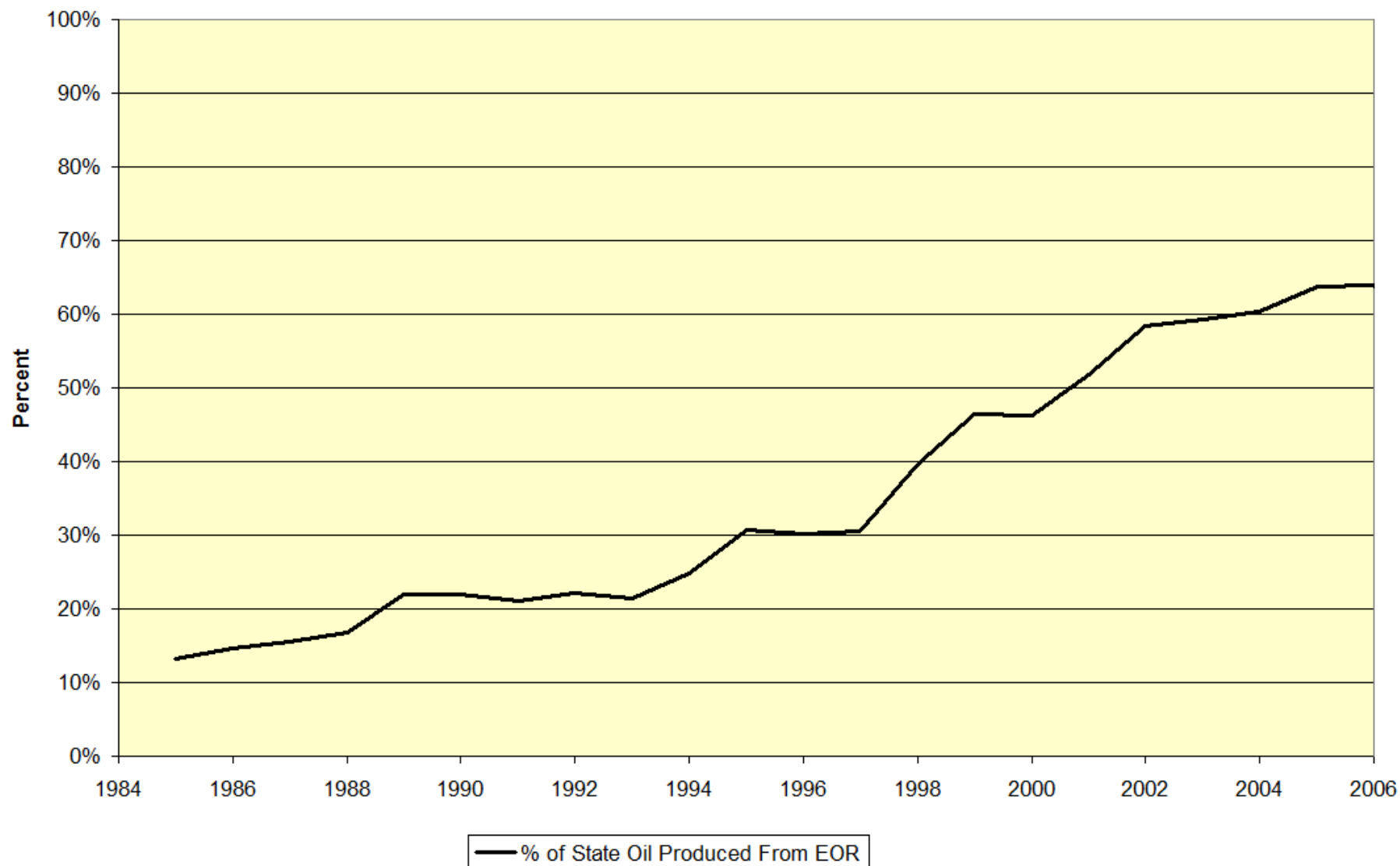


AIR INJECTION PROCESS



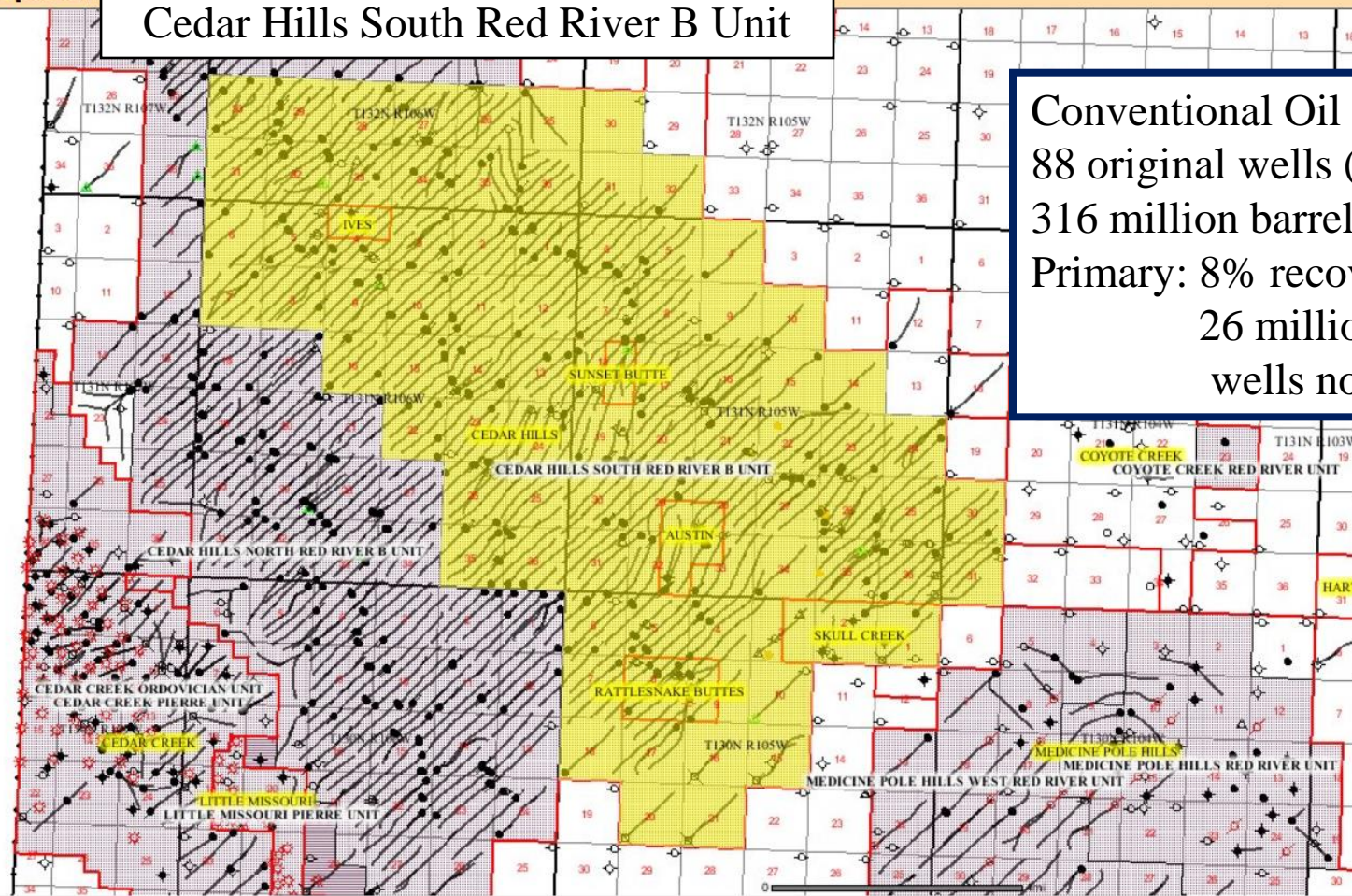


Unit Production



Cedar Hills South Red River B Unit

Conventional Oil Reservoir
88 original wells (1H/640)
316 million barrels OOIP
Primary: 8% recovery of OOIP
26 million bo
wells not fraced



ND OIL & GAS LAYERS
Oil and Gas
Wells

Topo/DRG 100k
NAIP 2014

Refresh Map

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Help:

- A closed group, click to open.
- An open group, click to close.
- A map layer.
- A hidden group/layer, click to make visible.
- A visible group/layer, click to hide.
- A visible layer, but not at this scale.
- A partially visible group, click to make visible.
- An inactive layer, click to make active.
- The active layer.

Unit Boundaries

Rec	Name	Unitized Formations	Operator
1	CEDAR HILLS SOUTH RED RIVER B UNIT	Red River B	DENBURY ONSHORE, LLC

Map Data Last Updated : 4/19/2016

125%

Cedar Hills South Red River B Unit

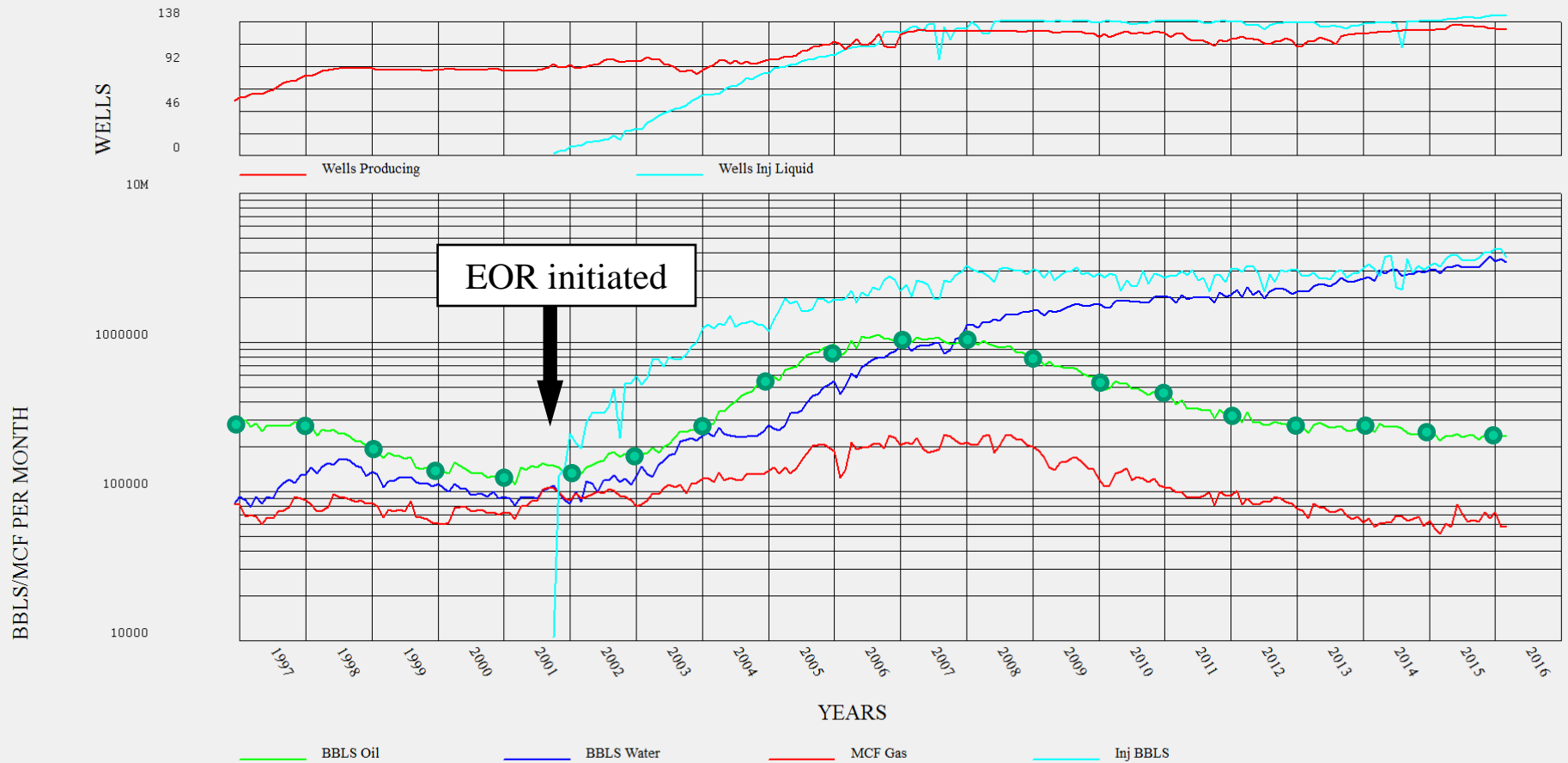
Cum Oil = 101195475

Cum Wtr = 260513822

Cum Gas = 27106733

Cum Inj BBLS = 403488910

Cum Inj MCF = 0



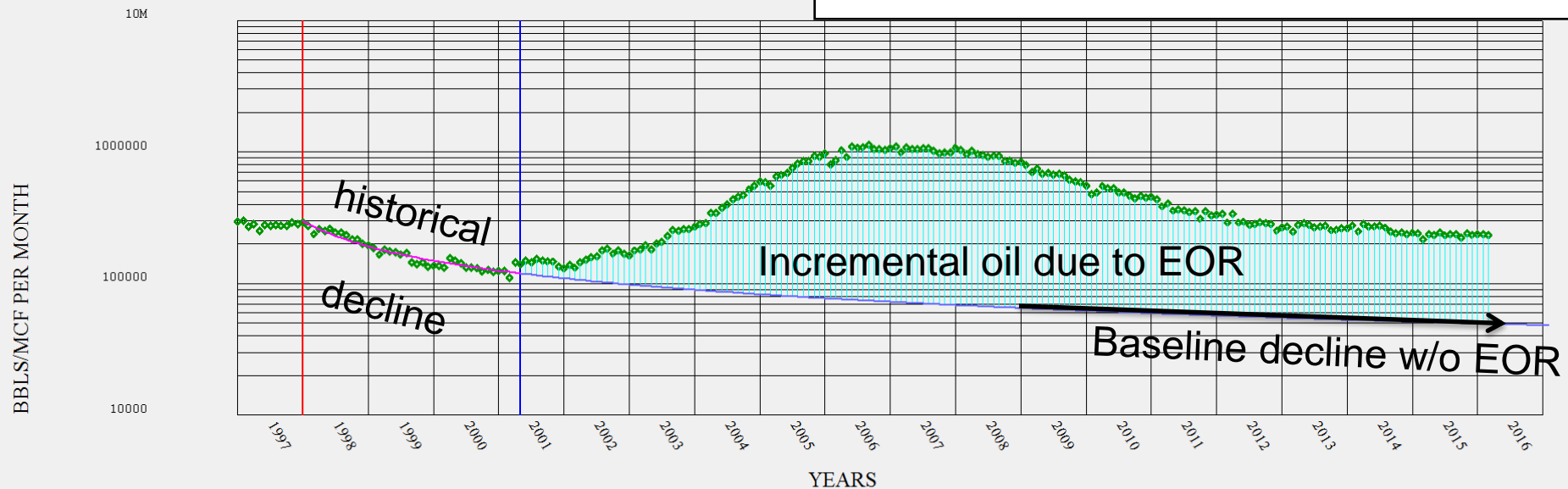
Cedar Hills South Red River B Unit

Incremental Oil Determination

- establish historical decline
- project baseline decline w/o EOR
- calculate oil above the base

Cedar Hills South-RR "B" Unit

- EUR w/o EOR = 26 mil bo
- current Incremental = 74 mil bo
- current oil cum = 101 mil bo



Unitization and Enhanced Oil Recovery

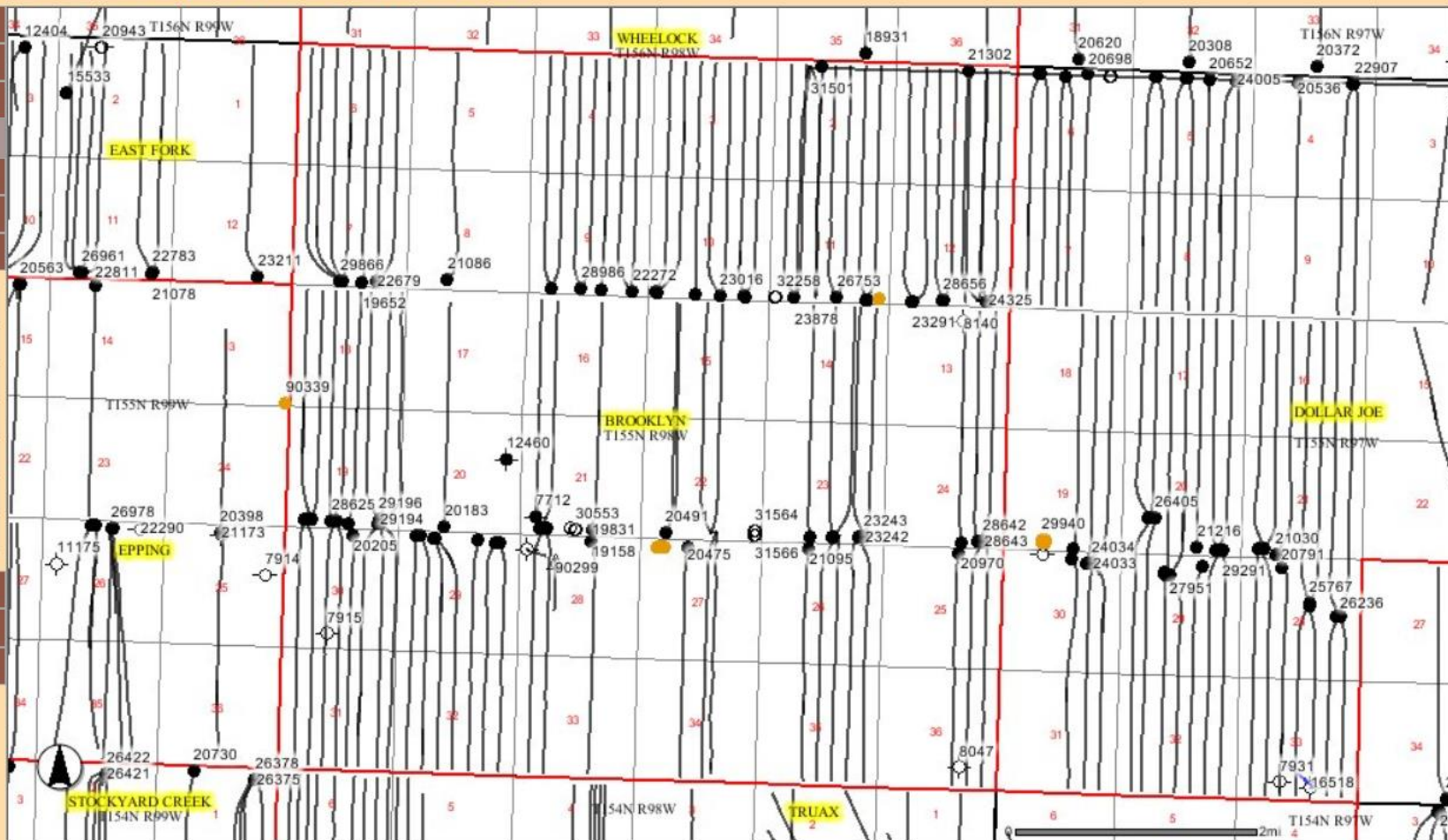
- Unitization Process
- Units Approved
- EOR Techniques & Results
- **Bakken Development—encourages EOR**
 - **Uniform Spacing—orderly development**
 - **Energy Corridors**
- Bakken EOR Potential



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Distance

Find Section



Zoom In



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Oil and Gas Subscription: ArcIMS Viewer

Legend / Layers

Overview Map

View Entire State

Previous View

Clear Selection

Search

Create PDF

Zoom In

Zoom Out

Pan

Rect Identify

Select Object

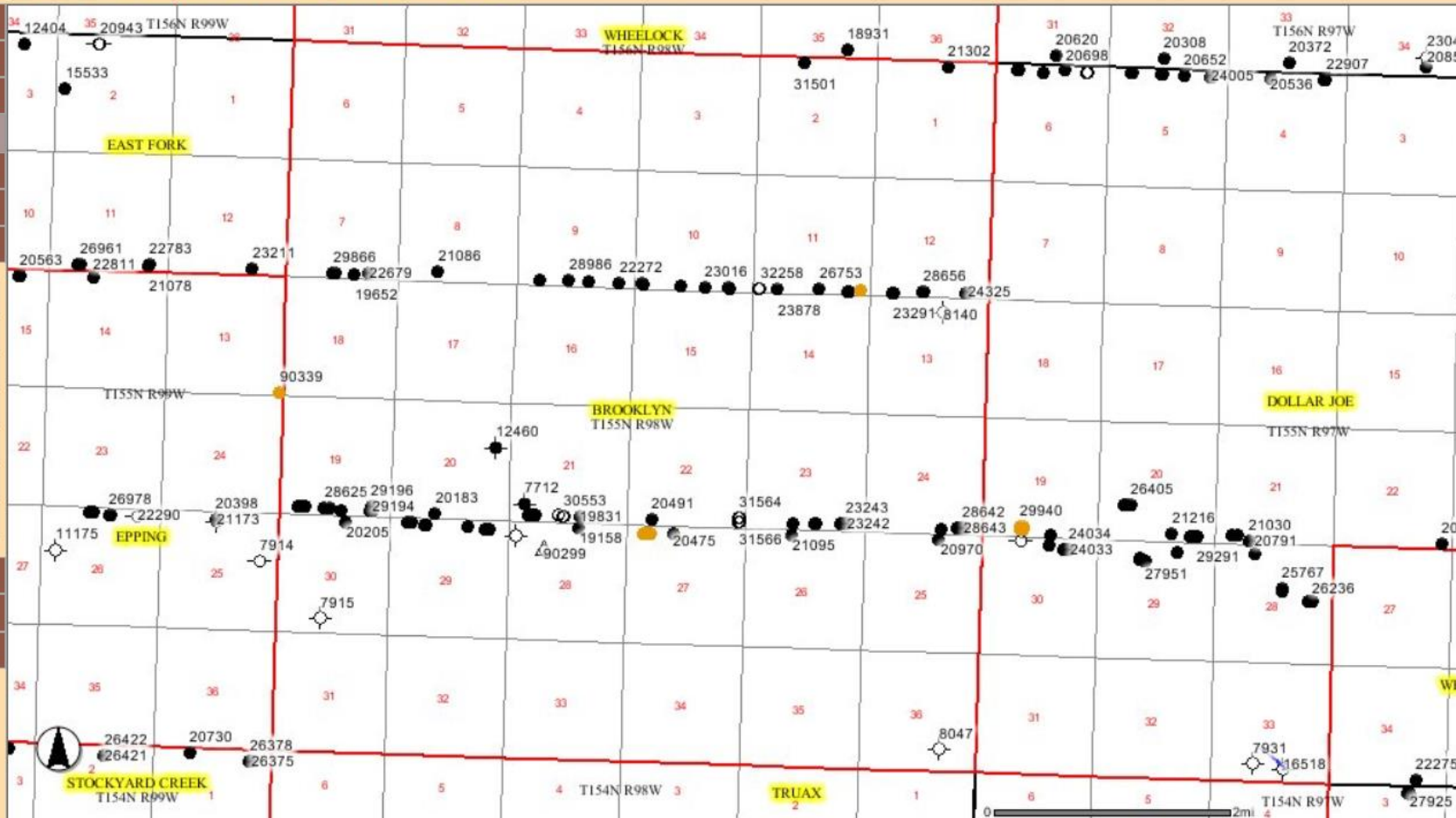
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Distance

Find Well

Find Field / Unit

Find Section



Zoom In



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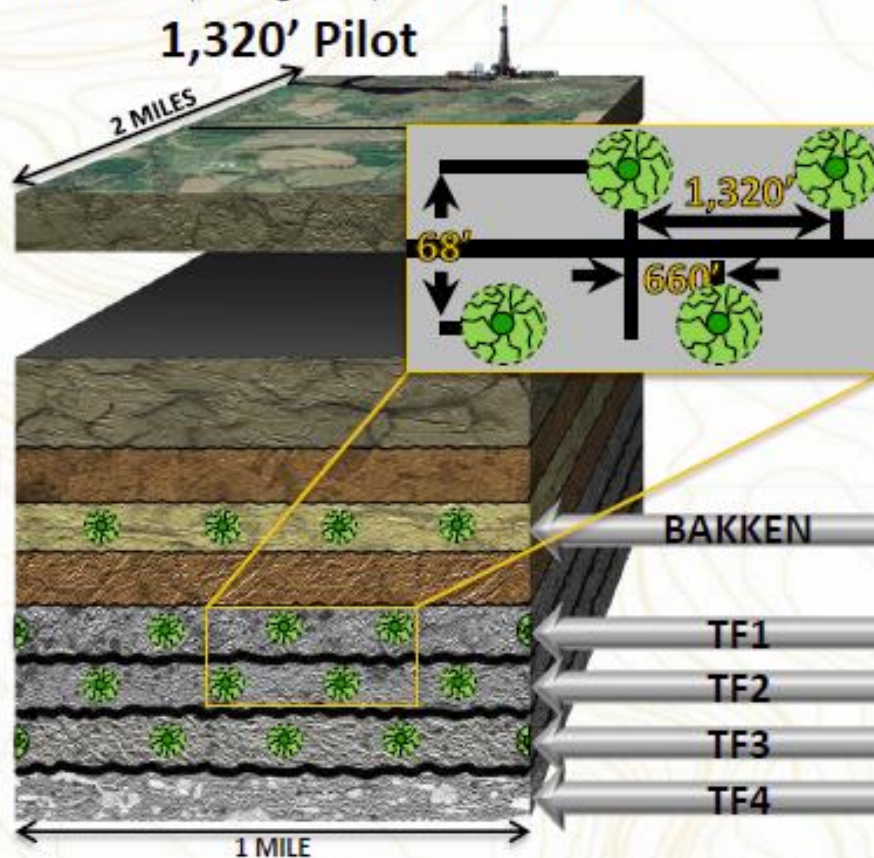


Vern Whitten Photography

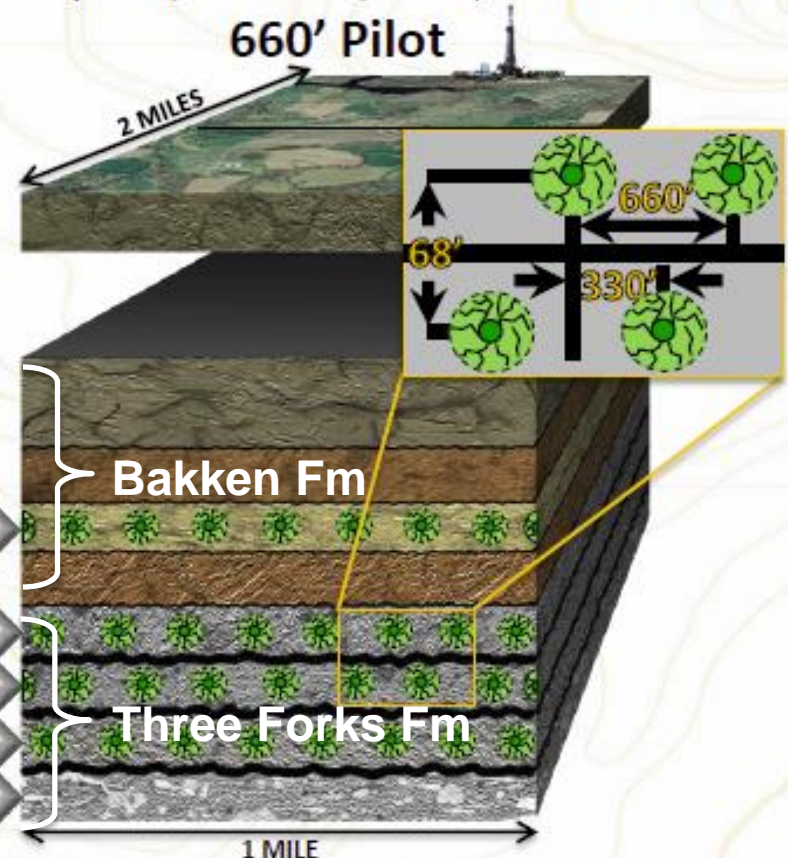
1,320' & 660' Pilot Density Projects: 2013-14

Hawkinson, Tangsrud, and Rollefstad

Wahpeton, Lawrence, Mack, and Hartman



- 3 project areas
- 1,320 ft. same-zone spacing
- 34 new wells (gross)

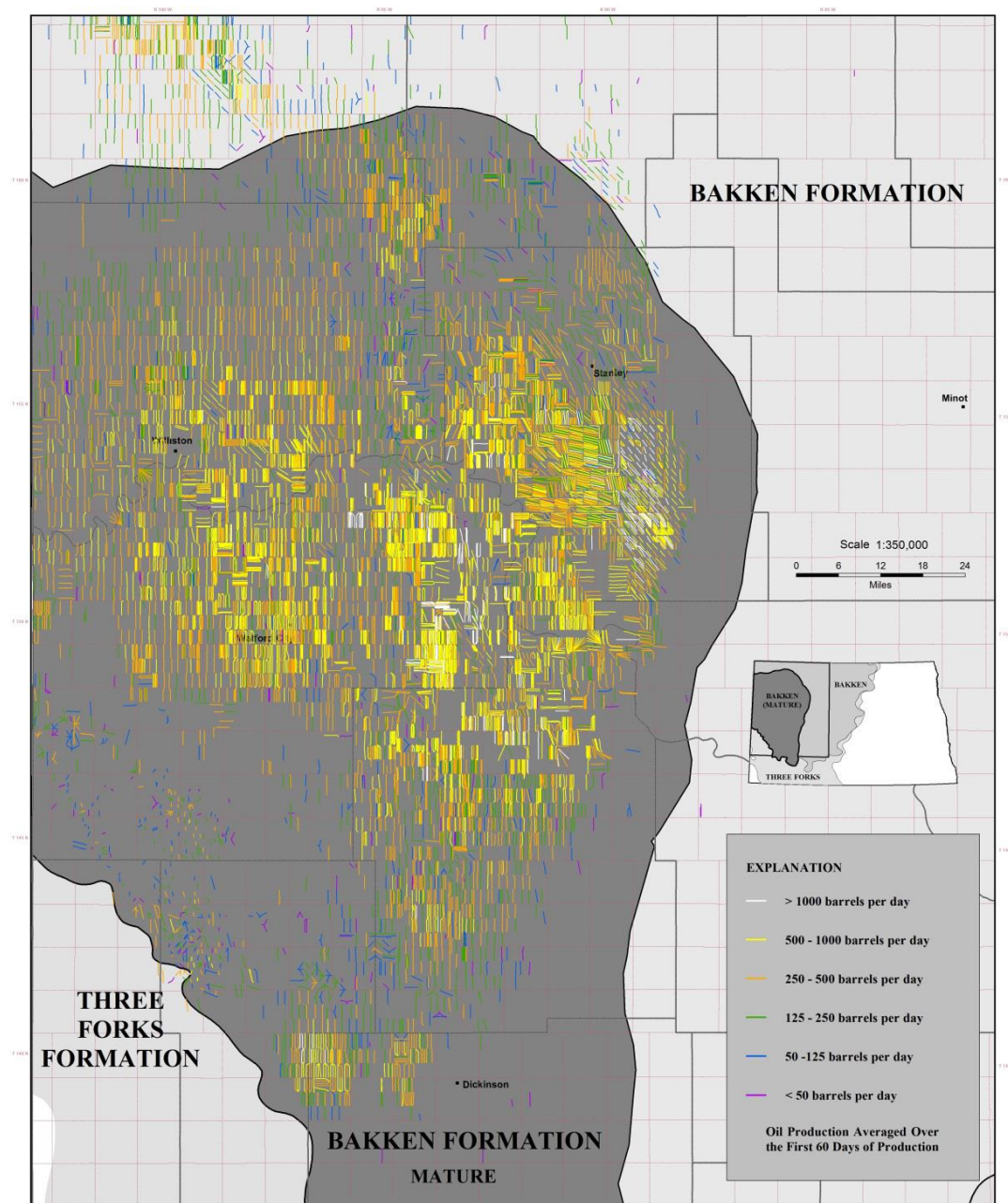


- 4 project areas
- 660 ft. same-zone spacing
- 31 new wells (gross)

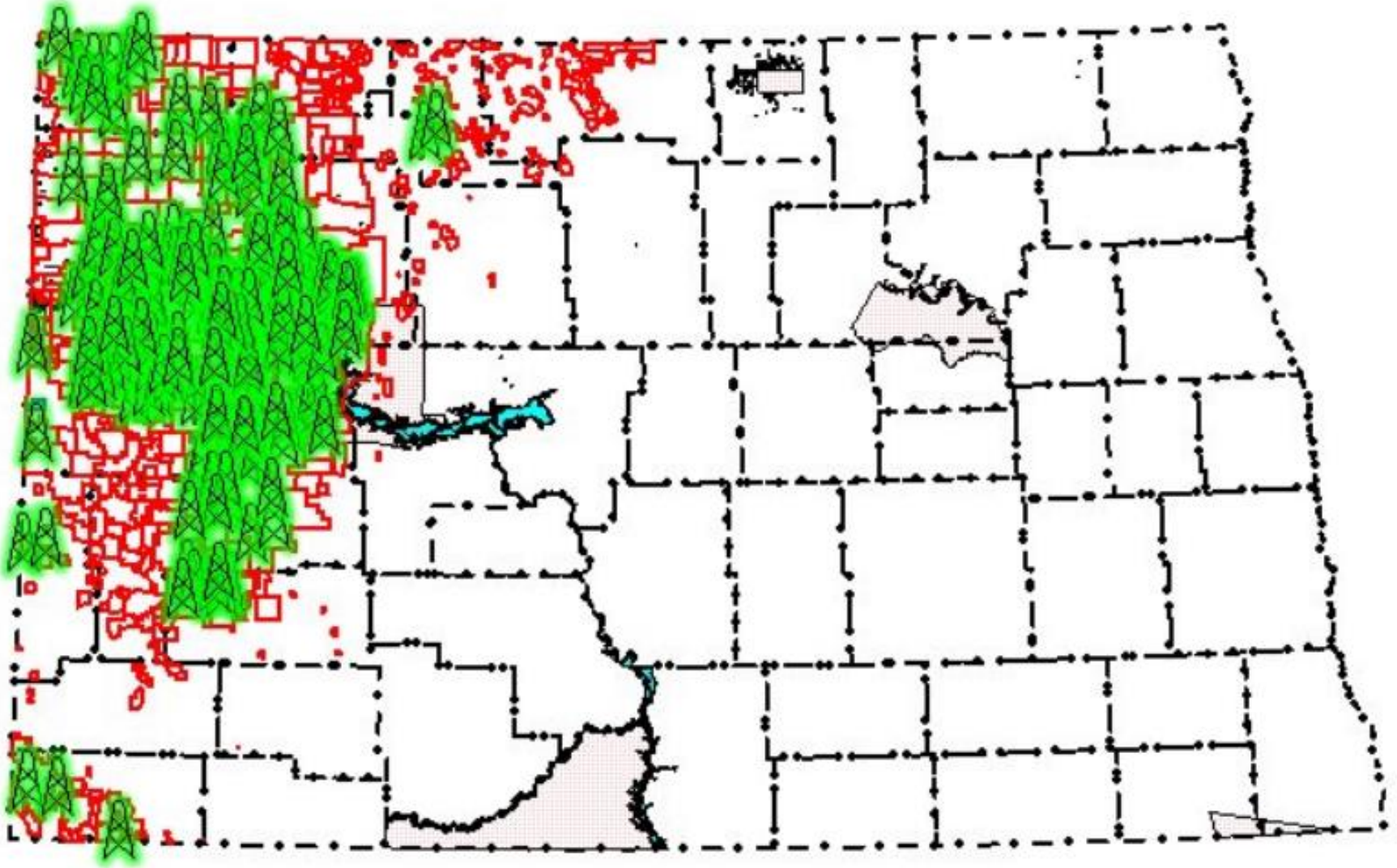


First 60 Day Average Bakken Horizontal Production by Well

July 2015



NORTH DAKOTA – 191 DRILLING RIGS – DECEMBER 2014

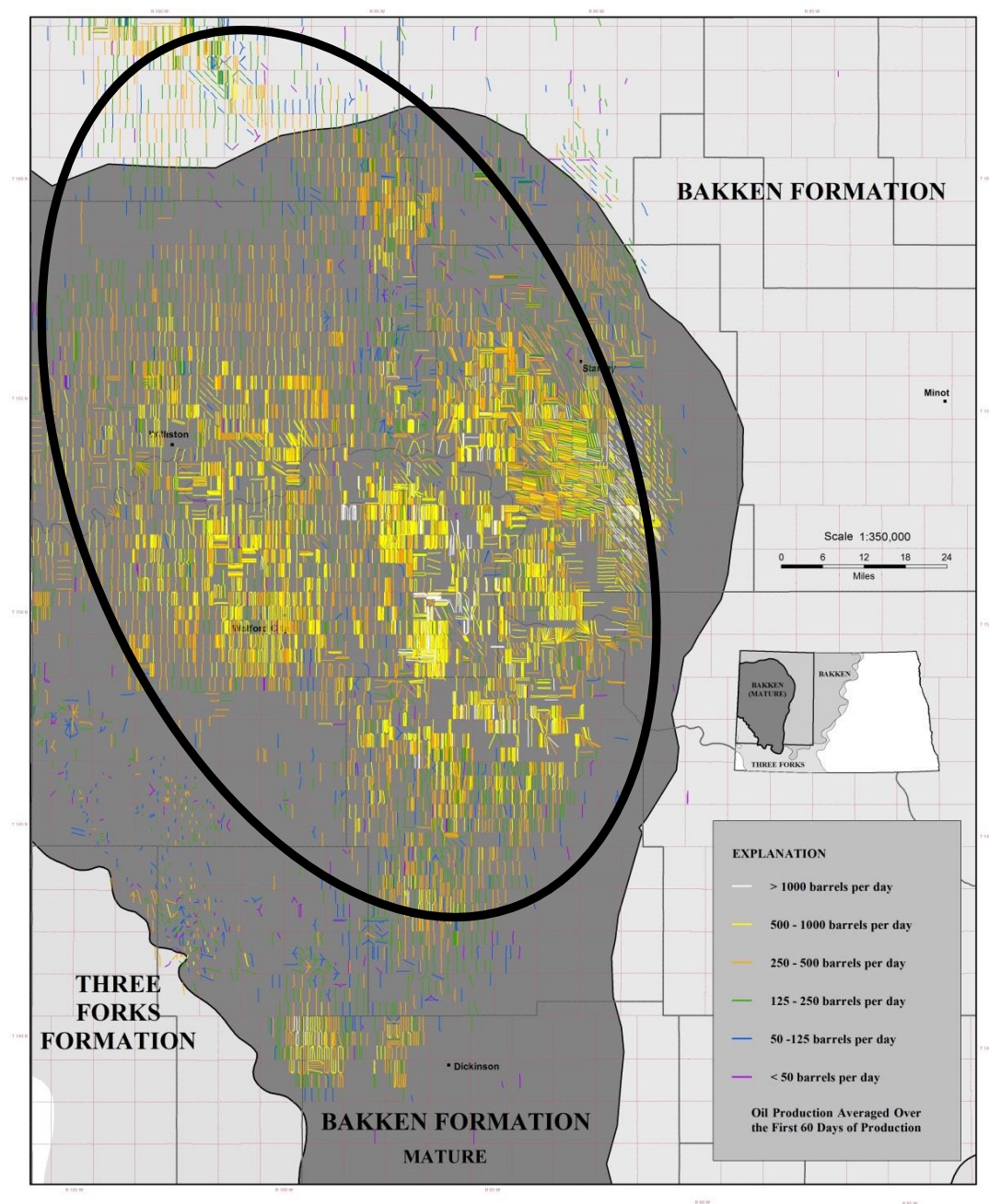


**Current drilling activity is focused
in Mountrail, Dunn, McKenzie, and Williams Counties.**

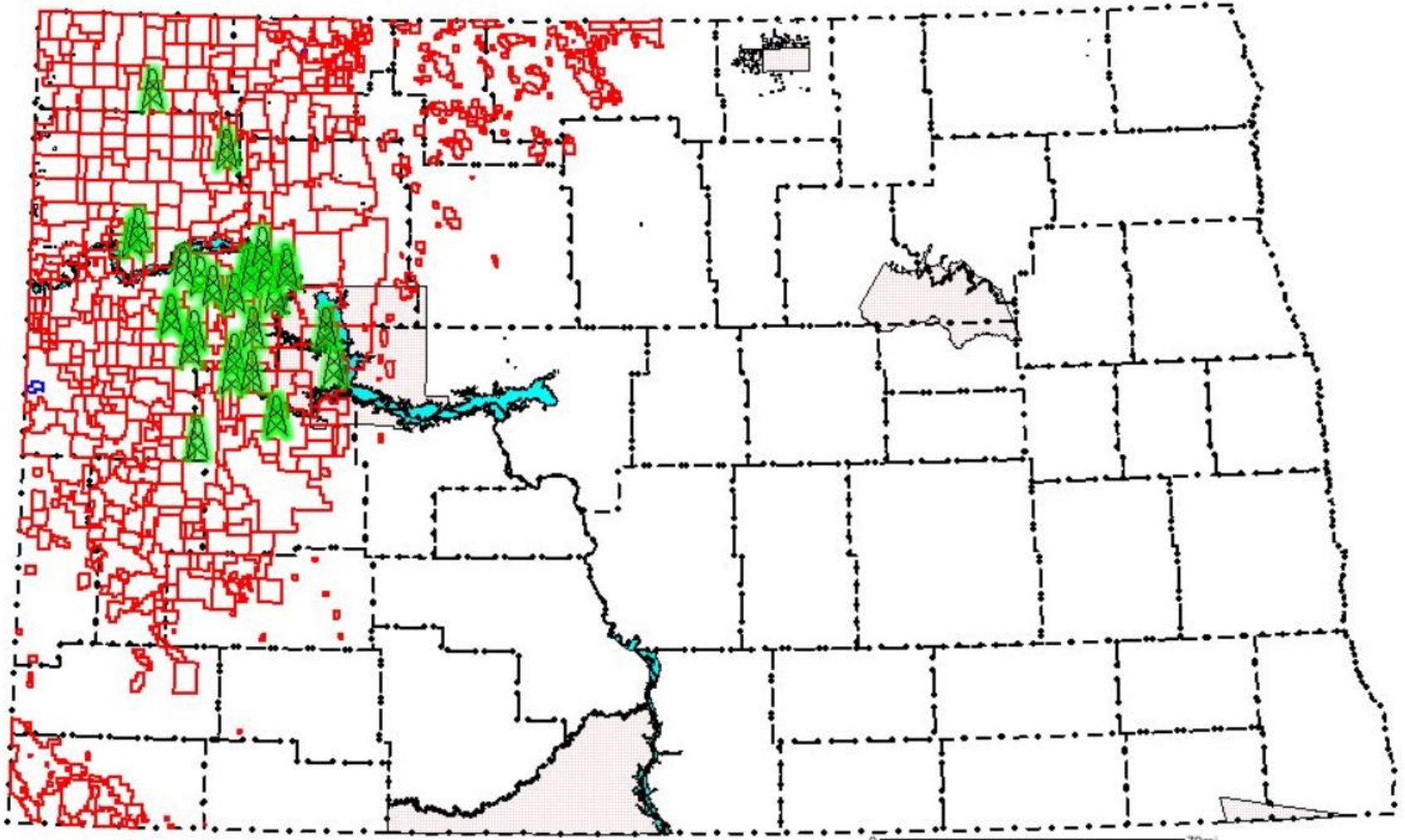


First 60 Day Average Bakken Horizontal Production by Well

July 2015



NORTH DAKOTA – 27 DRILLING RIGS – APRIL 2016

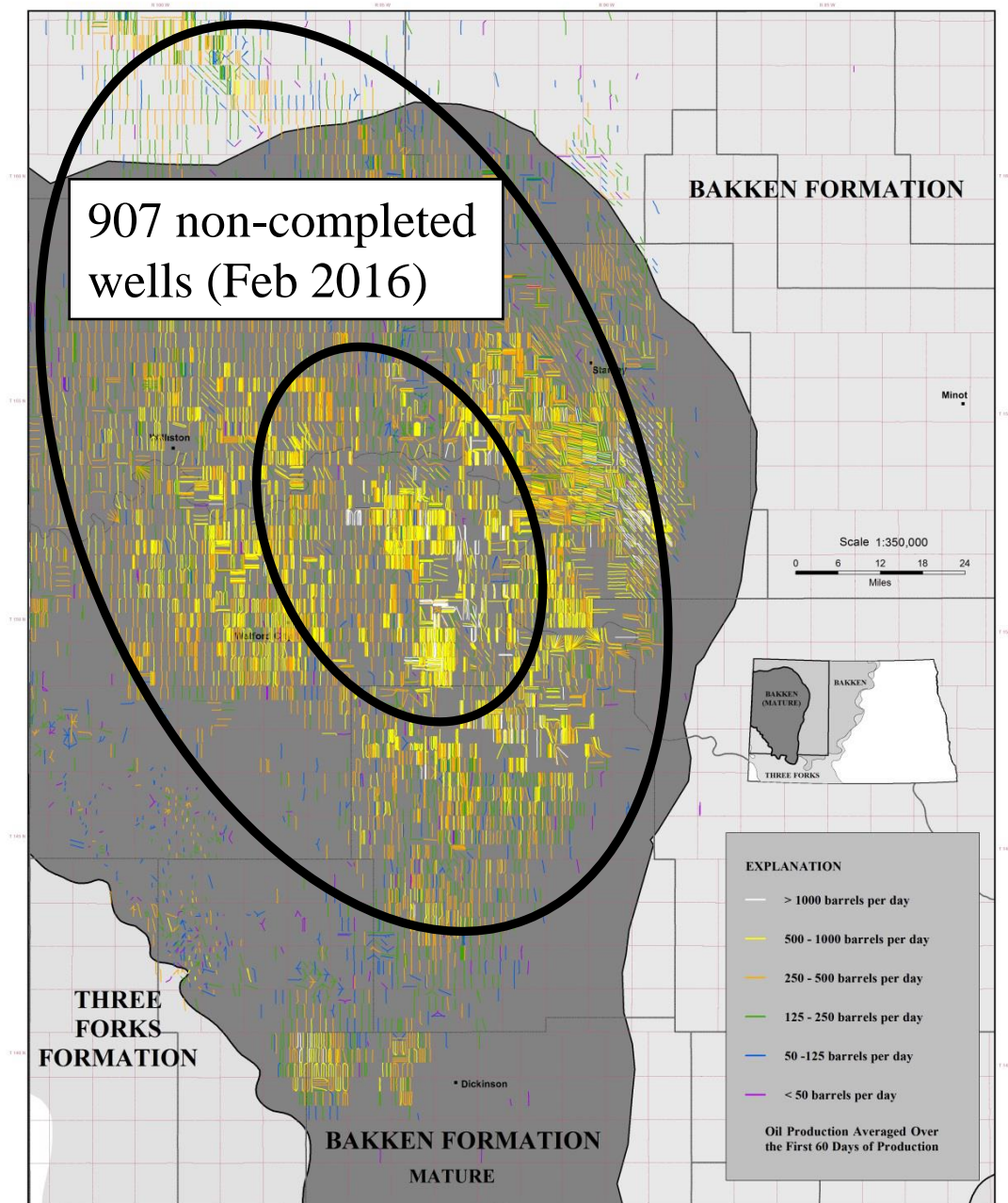


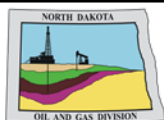
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First 60 Day Average Bakken Horizontal Production by Well

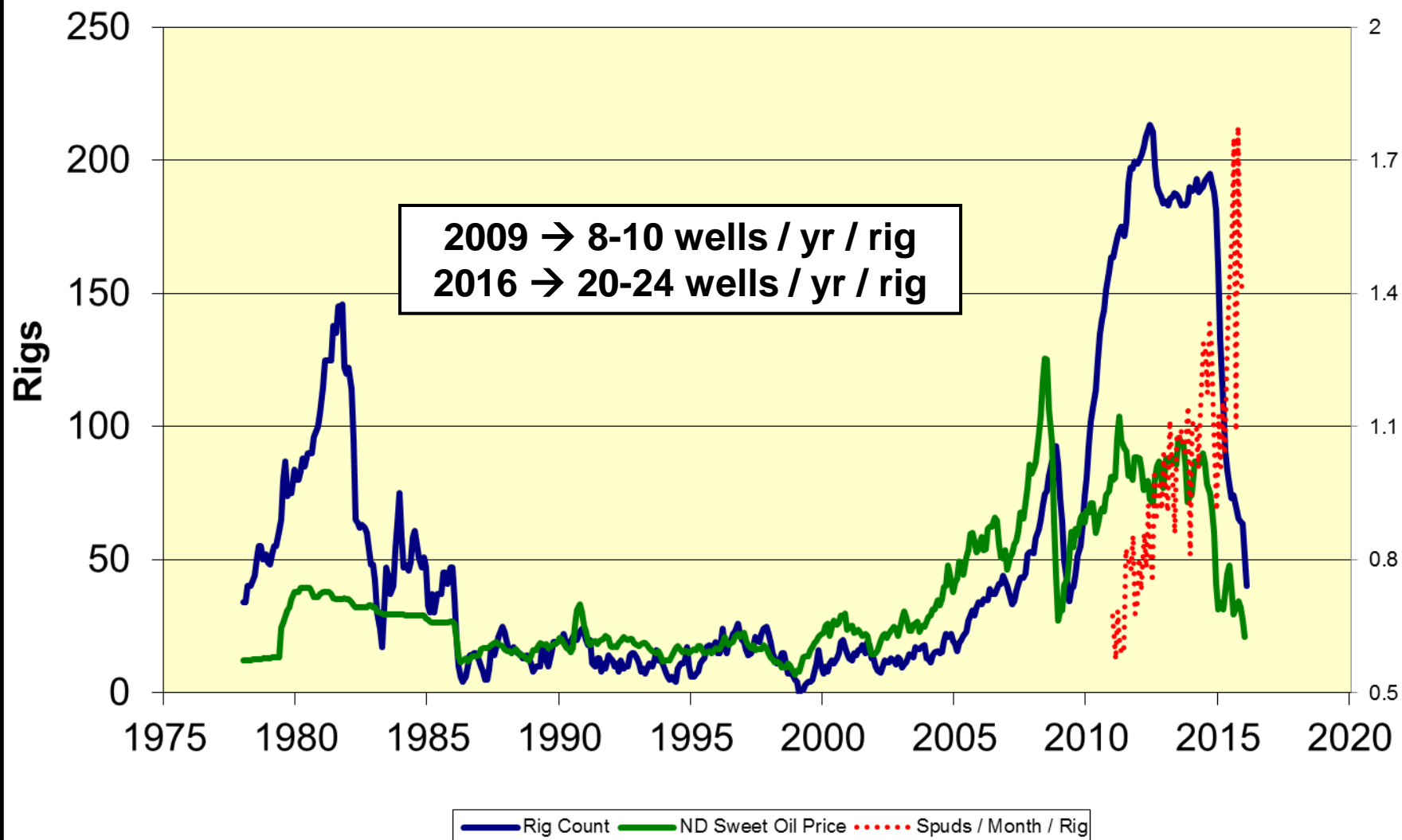
July 2015





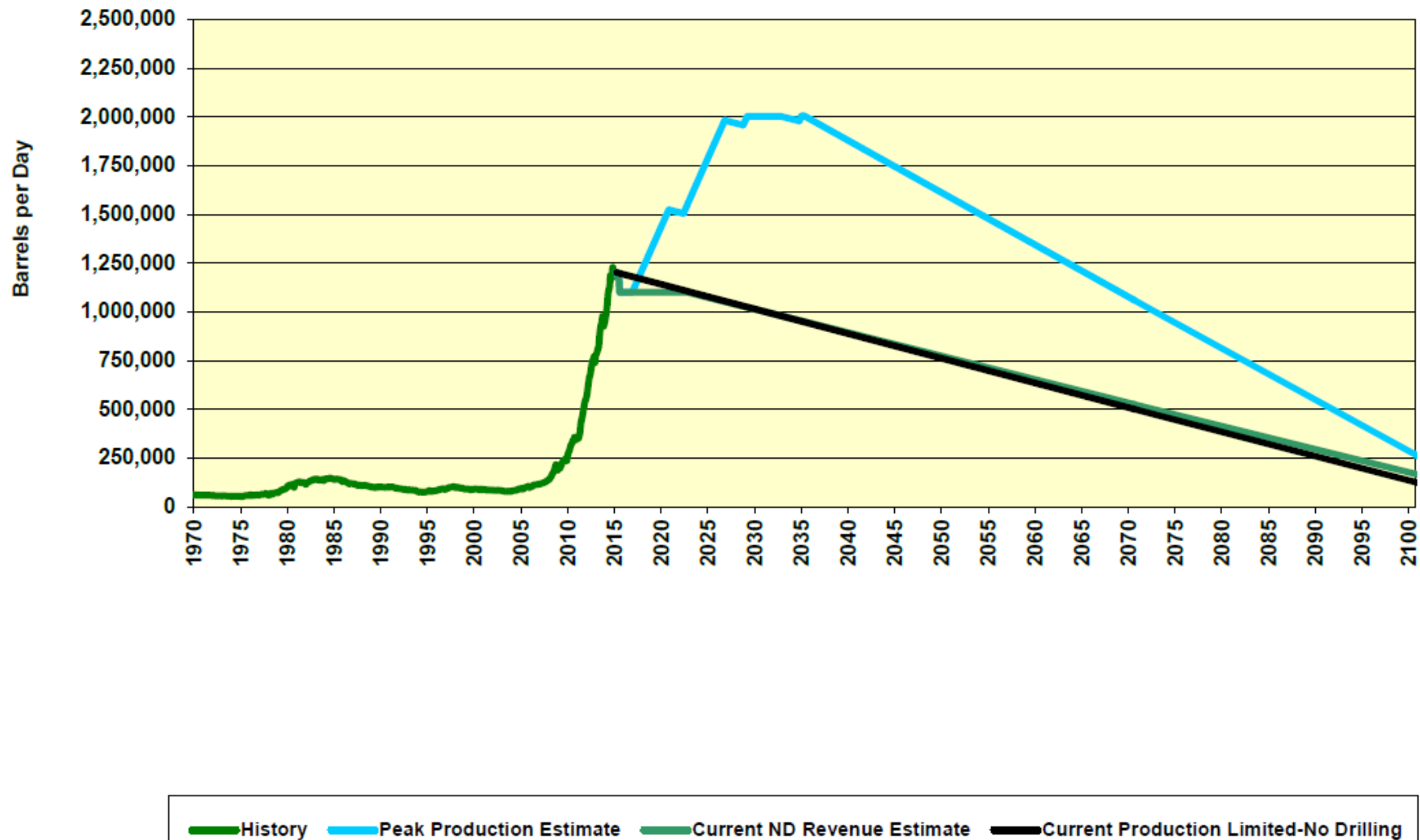
North Dakota Average Monthly Rig Count

2009 → 8-10 wells / yr / rig
2016 → 20-24 wells / yr / rig





North Dakota Oil Production



WELLS

- **13,012 wells producing (Feb 2016)**
 - **10,898 Bakken (84%)**
- **40,000 additional development wells**
 - **100 rigs – another 20 years**
- **Bakken Pool: 4 targets = more wells**

Unitization and Enhanced Oil Recovery

- Unitization Process
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- **Bakken EOR Potential**

Bakken/Three Forks EOR Potential

- **Pilot projects**
 - **CO₂ injection**
 - **water injection**
 - **projects small-scale and usually inconclusive**
 - **further testing must be conducted**
- **> 300 billion barrels OOIP**
 - **every 1% of EOR = 3 billion barrels**
 - (note: cum oil prod from 1951-2015 = 3.3 bil bo)**

Reclaimed Location

