

# Fracture Stimulation IS EFFECTIVE

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Development of oil and gas in the Rival and Midale subintervals (Madison Group) in Burke County has seen nearly continuous drilling and production activity since shortly after the discovery of oil and gas in North Dakota and can serve as a case study for future redevelopment in other Madison fields (fig. 1). Over the long and diverse history of oil and gas development in Burke County, activity progressed from conventional vertical development to localized water flooding, to exploring and developing downhole potential in the Bluell subinterval in the early 1980s, ultimately evolving into an open hole horizontal play in the late 1990s. In 2012, the implementation of unconventional-style hydraulic fracture stimulation rounded out this play as a microcosm of the last 70 years of technological advances in the oil and gas industry. The success of the recent development implementing fracture stimulation bodes well for the remaining resource potential of the immediate area and other Madison fields in western and north-central North Dakota.

In 1955, four years after the discovery of oil in North Dakota, the Gunnar Opseth #1 well (NDIC 945) was producing ~800 barrels of oil per month from the Midale and upper Rival carbonate reservoirs in what would become the Coteau Field in southeastern Burke County. In the following years, 36 fields were discovered, and four distinct development strategies were applied to these conventional carbonate reservoirs (fig. 2).

The first decade of development in northern Burke County saw a flurry of activity (fig. 2), with nearly half of the total number of vertical wells drilled and completed in the first stage of development (484 producers - 194 dry holes). By 1960, there were 15 named fields in the region and unitization efforts were undertaken in the early to late 1960s (Anderson et al., 1960; Lindsay, 1985). The years that followed saw drilling activity and production decline in Burke County, except for a period of increased drilling in the early 1980s, which saw an increase in production primarily due to the development of the Bluell subinterval in the Flaxton Field (Voldseth, 1986), and some other peripheral Rival – Midale development (fig. 3).

Period	Subperiod	Stage	North Dakota Nomenclature	
Carboniferous	Mississippian	Visean	Charles Formation	Poplar Interval
				Ratcliffe Interval
		Tournaisian	Mission Canyon Fm.	Frobisher-Alida Interval
				Tilston Interval
Devonian	Fam.	Bakken Fm.	Lodgepole Fm.	
			Bottineau Interval	

**Poplar Interval**

- undiff.
- Flat Lake
- Alexander
- Berentson
- Midale

**Ratcliffe Interval**

- Rival
- Bluell
- Sherwood
- Mohall
- Glenburn
- Wayne
- Landa

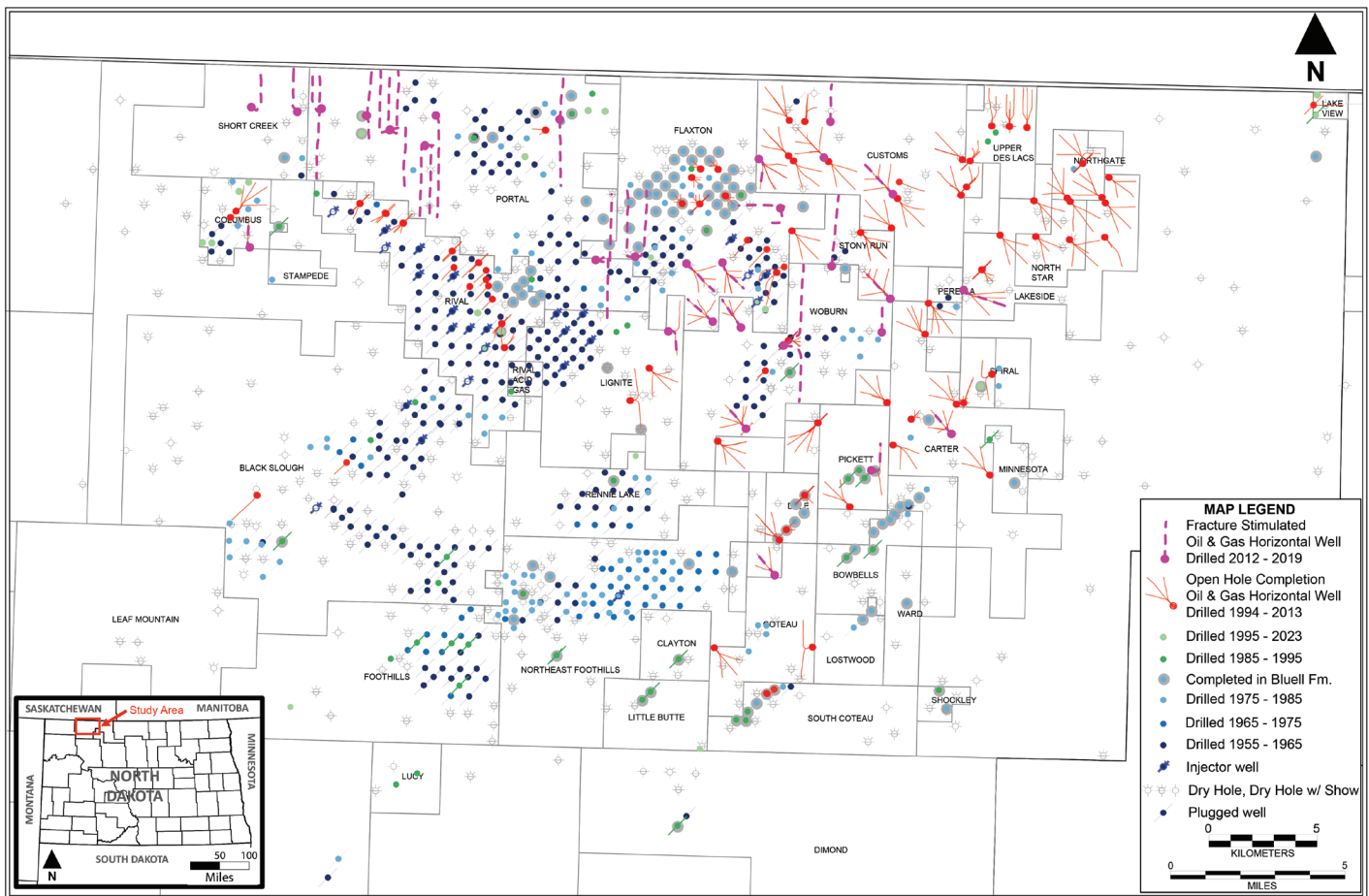
**Tilston Interval**

- Flossie Lake
- Whitewater Lake
- Virden
- Scallion

**Bottineau Interval**

- Upper Member
- Middle Mbr.
- Lower Member
- Pronghorn Mbr.

**FIGURE 1.** Simplified stratigraphic column of the lower Mississippian and upper Devonian section in the Williston Basin, North Dakota, highlighting the location of the Midale, Rival, and Bluell subintervals of the Madison Group. The pink star highlights the Midale and Rival subintervals, the primary producing intervals discussed here. Modified from Nesheim and Onwumelu, 2022.



**FIGURE 2.**

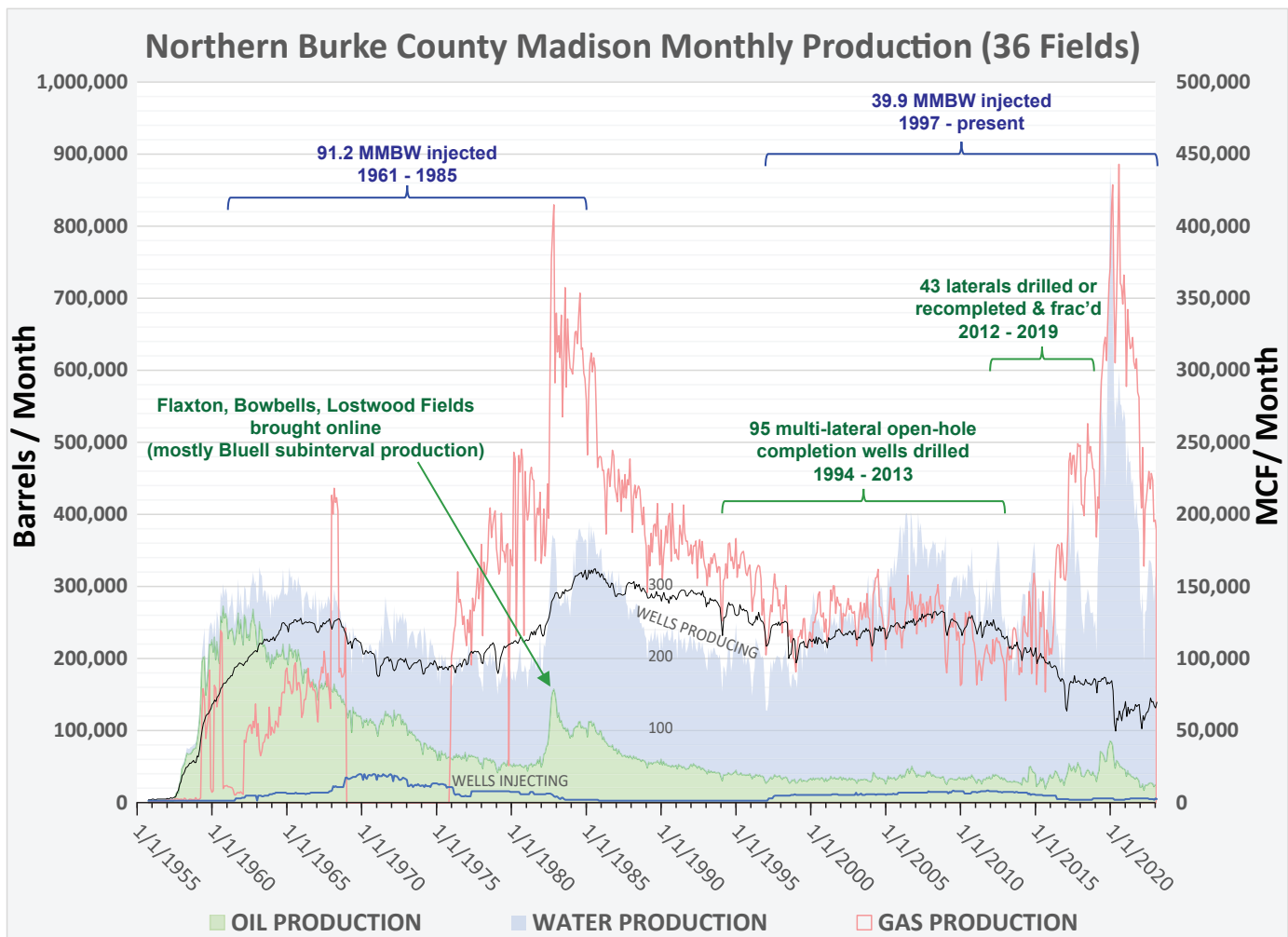
Drilling activity in northern Burke County by decade. Most vertical and horizontal wells target the Rival and/or Midale subintervals; light gray circles highlight wells completed in the Bluell subinterval.

In 1994, the Taylor Layne 25H-1 (NDIC #13700) was drilled in the Rival Field as the first open-hole lateral completion. A total of 95 wells with 258 laterals, commonly multi-lateral projects, would eventually employ this development technique. This development effort had the upper Rival as its primary target, with the Midale a secondary target that would be drilled with a dedicated lateral in some projects. These wells helped to stem the production decline of the area, but had variable results.

The introduction of fracture stimulation to the area saw a staged approach where some existing open-hole laterals were recompleted as single laterals and fracture stimulated, beginning with the Ormiston Unit 1. Originally drilled as a dual lateral open hole completion in 2006, it was recompleted and fracture stimulated in 2012, resulting in a promising bump in production (see NDIC #16072 production data for details). Within two years, fracture stimulation was the dominant development strategy in the region, and 43 single lateral wells (including recompletions) were fracture stimulated through 2020. Recompletions and dedicated laterals for fracture stimulation were implemented in tandem during this period, with a campaign of recompletions in 2017 which yielded variable but promising results. Dedicated laterals with fracture stimulations averaged 15 stages, 1.5 million pounds of proppant, ~30,000 barrels of fluid, and ~7,000' in lateral length – on the smaller end of other unconventional development strategies in the Williston Basin.

As a whole, fracture stimulation has been the most effective development technique applied to the region from the stance of consistency and expediency of production (i.e., rate acceleration). Cumulative production and production rates increased with the help of fracture stimulation of undeveloped resources adjacent to existing production, notably in the Portal Field. Note the total oil production from 2015 – 2019 in Figure 3, and cumulative production values from 2012 – 2019 in Table 1. Fracture-stimulated wells made a significant contribution in production of oil and gas with fewer wells over a shorter period. Drilling activity came to a halt during the Covid-19 pandemic in 2020 with a resultant decrease in production (fig. 3).

As of December 2022, Burke County Madison fields have produced 60.4 million barrels of oil, 146.3 million barrels of water, and 107.8 billion cubic feet of gas – a long-lived development of an established resource that has provided returns for close to three-quarters of a century (Table 1). The development of the Rival - Midale Formations in northern Burke County can serve as a case study for the scale and scope of other Madison Group redevelopment. The success of fracture stimulation treatments in Burke County oil fields suggests it is an effective method to increase oil recovery in legacy fields and their surroundings, with significant room for future development in the immediate area and beyond.



**FIGURE 3.**

Historical production of oil, water, and gas for 36 Madison fields in Burke County, highlighting the impact of the four different development styles over time.

This retrospective speaks to a promising future for the continued development of the Madison Group in North Dakota – the second-largest producing formation by volume in the history of North Dakota’s journey of oil and gas development (Nesheim and Onwumelu, 2022). By developing around existing fields in Burke County, operators have demonstrated that areas where the Madison reservoirs had been uneconomic as conventional developments due to low permeability can have development potential with

new technologies (i.e., fracture stimulation). Additional details on the fracture-stimulated wells, an analysis of the geological setting and sedimentological drivers of reservoir performance, and maps of production can be found in North Dakota Geological Survey publication GI 272.

**TABLE 1.**

Cumulative production through December 2022 for the Madison Group from the 36 oil fields of northern Burke County.

Well Type	Dates	Count	Oil Production MMBO	Water Production / Injection MMBW	Gas Production BCF
Vertical Producers	1955 - 2011	607 (435 dry)	51.4	79.5	73.7
Vertical Injectors	1961 - 1985 1997 - present	28	N/A	131.2	N/A
Open-hole Multi-lateral Horizontal Producers	1994 - 2013	95 (258 laterals)	5.9	40.4	15.4
Fracture Stimulated Single-lateral Horizontal Producers	2012 - 2019	43 (15 recompletions)	3.1	26.4	18.7
<b>Totals</b>		<b>1371</b>	<b>60.4</b>	<b>146.3</b>	<b>107.8</b>

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