Digging into the Deep Basin

Field activity, production and completion trends in a volatile natural gas market

Daily Oil Bulletin

gDCdashboards

geoLOGIC SYSTEMS

Evaluate Energy

Table of Contents

Introduction	3
Defining the Deep Basin	3
Deep Basin Production	4
Natural Gas Market Trends	5
Spirit River Formation	8
Cardium Formation	17
Insights	23
Appendix 1	24
Appendix 2	25
Appendix 3	26

Introduction

It's been 45 years since Canadian Hunter Exploration's John Masters and Jim Gray pieced together the geological puzzle of the Deep Basin gas play, turning the complex stack of over a dozen potential target zones lying beneath 67,000 square kilometres of rugged foothills and forest in western Alberta into one of the province's most enduring gas plays.

In the decades since Masters' technical work revealed the estimated 440 trillion cubic feet of natural gas resource trapped deep below the 700 kilometre stretch of land running east of the foothills front from south of Grande Prairie to south of Edmonton, other geoscientists have built on that knowledge, creating new play types and driving reserves and production.

The latest iteration of the Deep Basin began in 2009 with the application of horizontal drilling and multistage fracturing to the Spirit River and Cardium formations. Nearly 11 trillion cubic feet of natural gas has been produced from wells drilled in the last 12 years, with current production of around 3 billion cubic feet per day[1].

This report examines licensing, drilling, completions and production trends in these two formations and sub-members across 66 fields in the context of a volatile and uncertain North American natural gas market. It includes analysis of:

- Natural gas markets
- Licensing and drilling trends
- Drilling price sensitivity
- Production trends
- Historical and current 1P90s
- Production price sensitivity
- Trends in completions designs

DEFINING THE DEEP BASIN

- For the purposes of this study we are capturing data for natural gas activity, production and completions activity in the Cardium and the Spirit River (Falher, Notikewin, Wilrich members) formations from 66 fields (see Appendix 1) in the Deep Basin.
- Activity data includes natural gas licensing and drilling activity through December 01/2019 to November 30/2021
- Production data includes active natural gas wells drilled from the beginning of the unconventional gas era starting January 1/2009 to October 31/2021
- Completions data includes a sampling of active wells completed in the five-year timeframe from January/2017 to September/2021.

AUTHOR: **DARRELL STONEHOUSE**

Darrell Stonehouse is the technical editor at geoLOGIC systems ltd. Darrell has 23 years' experience covering the oil and gas industry, serving as editor of *Oilweek, Oil & Gas Inquirer,* and *Oil & Gas Quarterly*.

SOURCES OF DATA

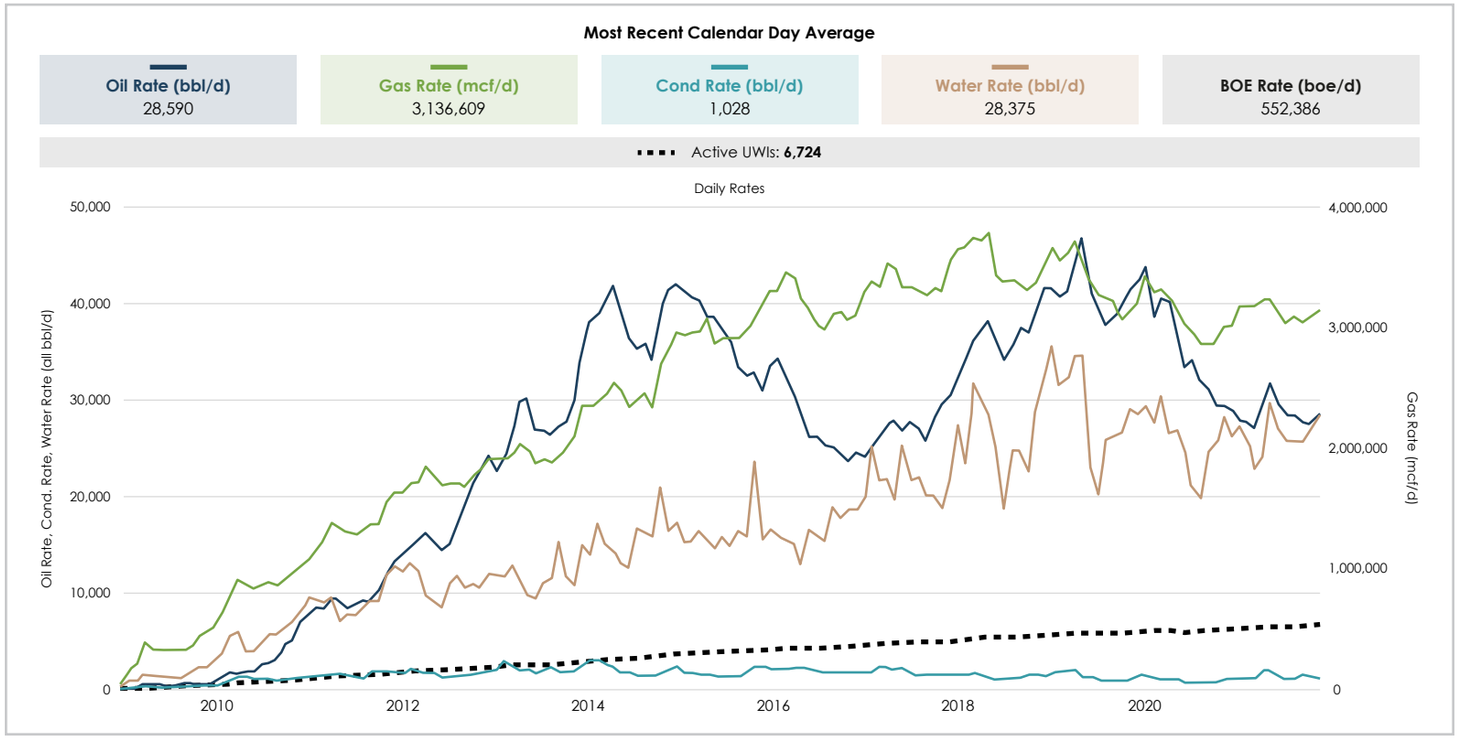
This Deep Basin Report is created using data from the ***Daily Oil Bulletin***, **gDC Dashboards** and **Evaluate Energy**.

[1]Source: gDC Dashboards: Production

Deep Basin Production

Production from the Deep Basin increased sharply throughout volatile natural gas markets from 2009 until natural gas prices declined significantly in 2018. Production peaked at around 3.7 bcf/d in 2018-2019 before declining to current levels. Driving this change was the application of unconventional resource drilling and completions technologies to the Spirit River and Cardium formations. Production from the Spirit River sub-members reached around 2.7 bcf/d in 2018 before declining to current levels.

The overall production increase is impressive given the declines in traditional Deep Basin formation production. Production from comingled wells producing from multiple formations declined from 500 mmcf/d in 2012 to only 166 mmcf/d in 2021. The Bluesky and Dunvegan formations saw declines of 100 mmcf/d and 50 mmcf/d, respectively.



Natural Gas Production by Formation

Formation	Production (mcf/d)
Bluesky	76,530
Cadomin	11,712
Cardium Sandstone*	400,096
Commingled	166,502
Dunvegan	106,553
Gething	19,542
Glauconitic Sandstone	91,186
Spirit River	21,143
Falher Member*	762,426
Notikewin Member*	484,763
Wilrich Member*	903,592
Nikanassin	10,230
Viking Sandstone	81,927
Total	3,136,202

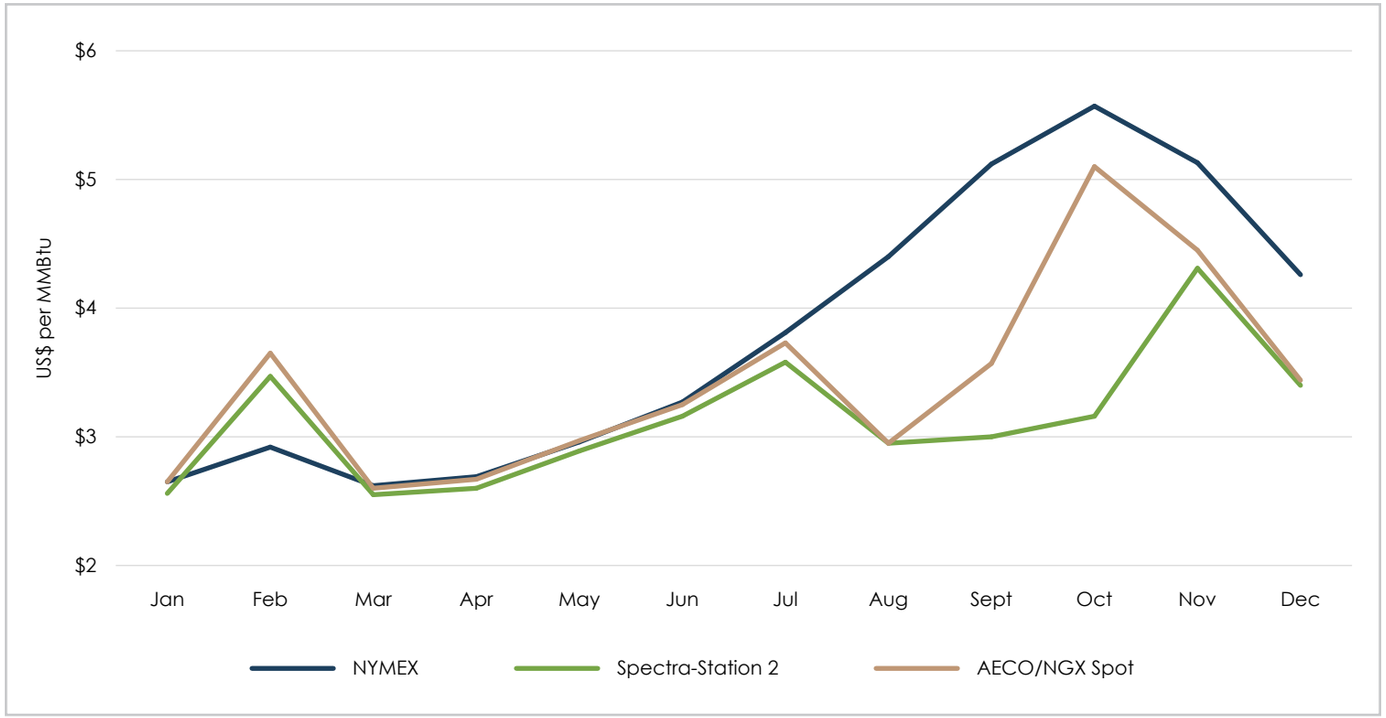
*Highlighted formations are covered in the report
Production data for October 31/2021.
Source: gDC Dashboards

Natural Gas Market

PRICES

Given Deep Basin natural gas production is dry outside of some key Cardium fields, natural gas prices drive drilling and production increases. Natural gas prices in October and November 2021 reached levels not seen in a decade across North America. Warm early winter weather in the U.S., however, has tempered prices as gas storage has filled to just below five-year averages. The trend remains positive. NYMEX average prices in the first 11 months of 2021 are up almost 78% compared to the previous year. AECO/NGX average prices are up 61% in the same time period.

Natural Gas Price Trends (2021)



Source: *Daily Oil Bulletin*

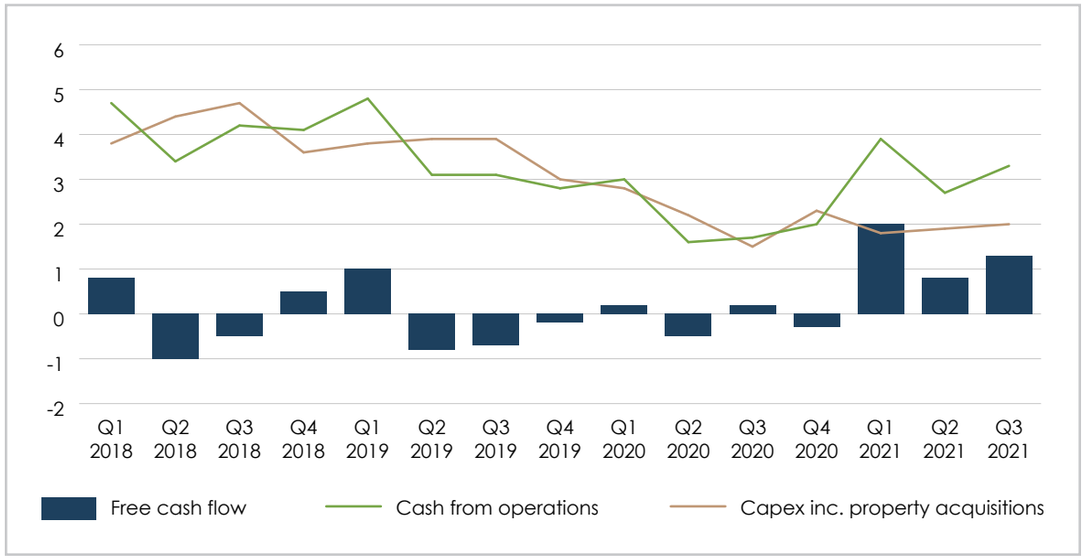
Natural Gas Market

CAPITAL EXPENDITURES

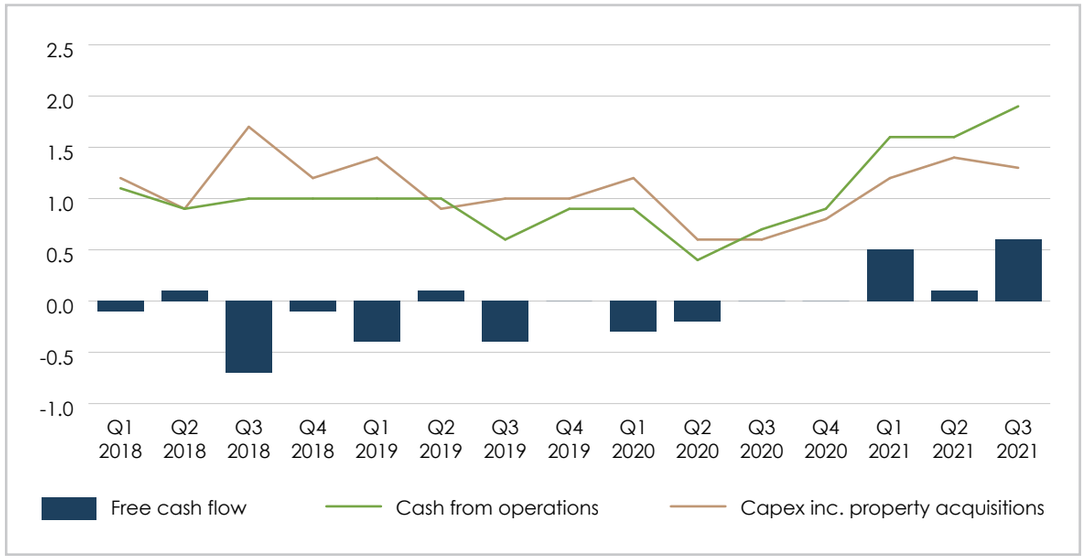
Q3/2021 capital expenditures indicate U.S. gas producers are slow to respond to natural gas pricing incentives, which is positive for both future pricing and Deep Basin growth opportunities. Capital expenditures have remained flat at around $2 billion per quarter for the first three quarters of 2021, well below the pre-pandemic average of $3.8 billion between 2018 and Q1/2020.

Capital expenditures by Canadian gas producers began increasing in the final quarter of 2020 but spending retreated somewhat in Q3/2021 as two large producers reduced budgets. Q4/2021 spending will also be muted as operators exhaust annual drilling budgets and field operations stagnate for the Christmas break.

Free Cash Flow: U.S. Gas Producers 2018-2021 ($ Billion)



Free Cash Flow: Canadian Gas Producers 2018-2021 (C$ Billion)



Source: Evaluate Energy

Bullish or Bearish on Prices?

So where are prices headed in 2022?

The bullish case for higher near-term and mid-term prices rests on a number of positive structural changes to the North American market. U.S. LNG export capacity will increase by 2 bcf/d in 2022 as new trains come onstream and debottlenecking of existing facilities is completed. LNG demand, combined with increased power demand, has increased overall demand by 5.3 bcf/d from November 2020 to 2021.

Canadian operators have increased exports to the U.S. by 1 bcf/d in 2021, taking advantage of this demand growth. Further export opportunities out of the Deep Basin and Montney region should develop as the 3.2 bcf/d expansion of the NGTL system is completed in 2022. The expansion will add 600 mmcf/d of capacity through the West Gate system reaching the western U.S. and 1.3 bcf/d of capacity on the East Gate system reaching the Great Lakes region.

The bearish case rests on uncertainties, including a warm winter with fewer heating days and a resurgence of the COVID-19 pandemic.

Productivity improvements in the U.S. could also impact Canadian pricing. The U.S. continues to see supply increases despite capital discipline with production up 4 bcf/d in November compared to 2020. While U.S. rigs targeting natural gas have remained flat at 102 rigs through November, the number of rigs is up 33% compared to 2020, indicating capital budgets could be thawing.

Two views on natural gas prices

Bulls	Bears
U.S. LNG exports to increase 2 bcf/d in 2022 for total export capacity of 14 bcf/d	A warmer than normal early winter in the U.S. has reduced storage withdrawals, bringing storage levels near the five-year average going into the heating season
U.S. demand in November was up 5.2 bcf/d compared to the same time period of 2020, driven by the power and LNG sectors	U.S. continues to see supply increases despite capital discipline with production up 4 bcf/d in November compared to 2020
Canadian exports to the U.S. are up 1 bcf/d in November compared to 2020, totalling 5.3 bcf/d	While U.S. rigs targeting natural gas have remained flat at 102 rigs through November, the number of rigs is up 33% compared to 2020
Alberta NGTL expansion adding 3.2 bcf/d of egress to be completed in 2022	Warm early winter weather has cut propane demand and prices, making liquids-rich gas less profitable
U.S. operators maintained capital discipline despite high prices in Q3/2021 with expenditures still below prepandemic levels	The new Omicron COVID-19 variant could impact economic performance, reducing demand
Despite prices declining in November AECO remains 61% higher than in 2020, and NYMEX prices are 78% higher	Added costs due to new U.S. methane emissions reduction rules could impact gas profitability

Spirit River

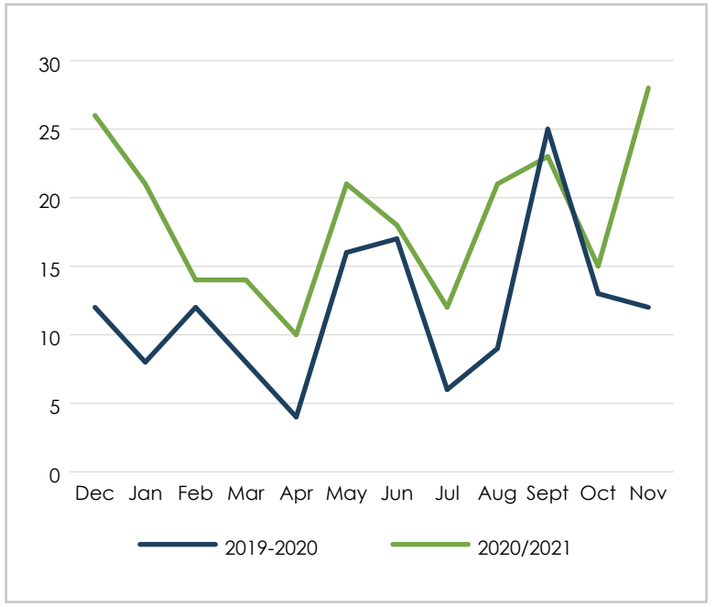
LICENCES

Well licensing in the Spirit River formation increased by 57% in the 2020-2021 time period compared to the previous year as operators responded to increased natural gas prices.

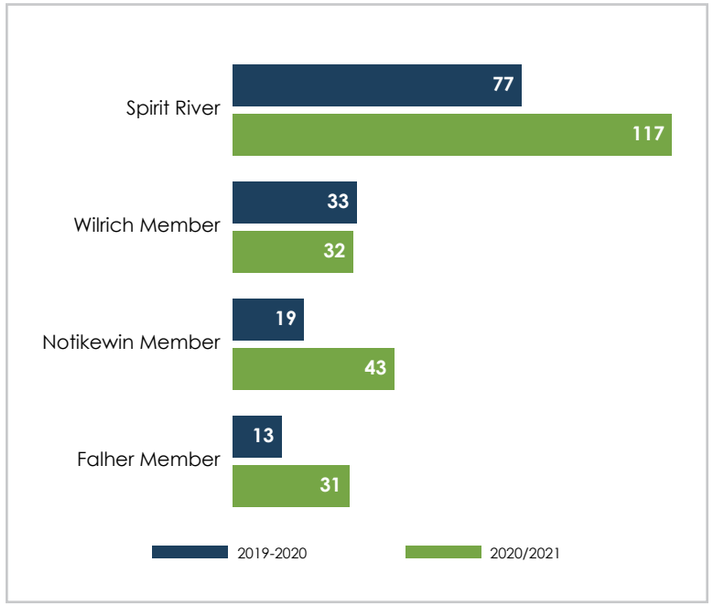
While the majority of wells licensed targeted the general Spirit River formation, those that indicated specific sub-members show large increases in the Falher and Notikewin licences. Wilrich licences remained flat.

The two largest operators in the Spirit River continued to drive licensing activity, with Tourmaline Oil Corp. and Peyto Exploration & Development Corp. accounting for 70% of licences in the 2020-2021 period.

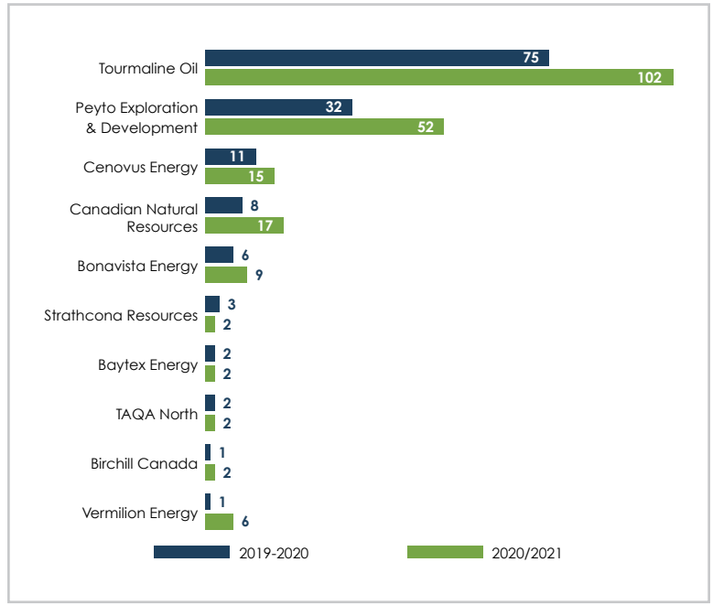
Total Well Licences



Well Licences by Formation



Well Licences by Operator



Source: gDC Dashboards

Spirit River

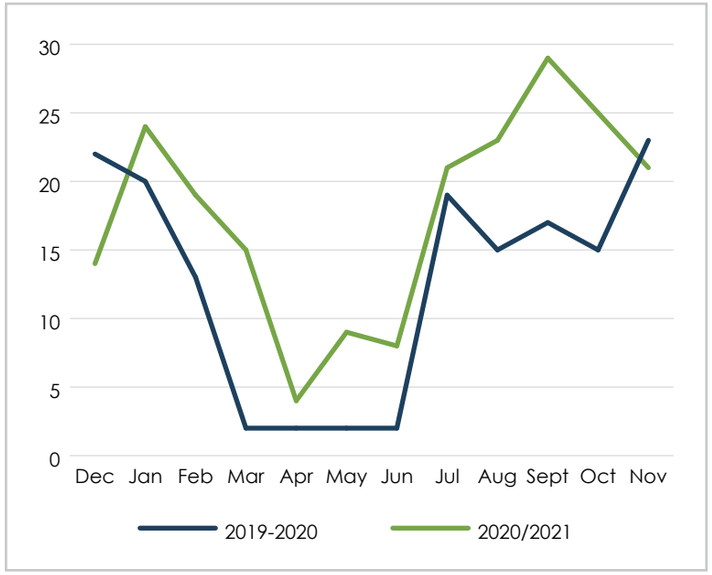
DRILLING

Spirit River drilling activity increased by 40% in the 2020-2021 time period compared to the previous year.

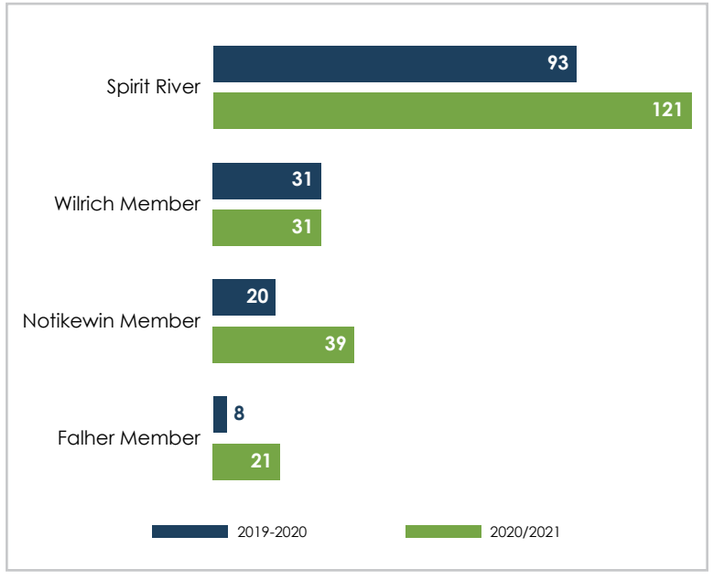
The majority of wells targeted the general Spirit River formation, those that indicated specific sub-members showed large increases in Falher and Notikewin activity while Wilrich activity remained flat. Notikewin well counts almost doubled from 20 to 39 wells while Falher targets increased from eight to 21.

The two largest operators in the Spirit River continued to drive drilling activity, with Tourmaline Oil Corp. and Peyto Exploration & Development accounting for 77% of wells drilled in the 2020-2021 period.

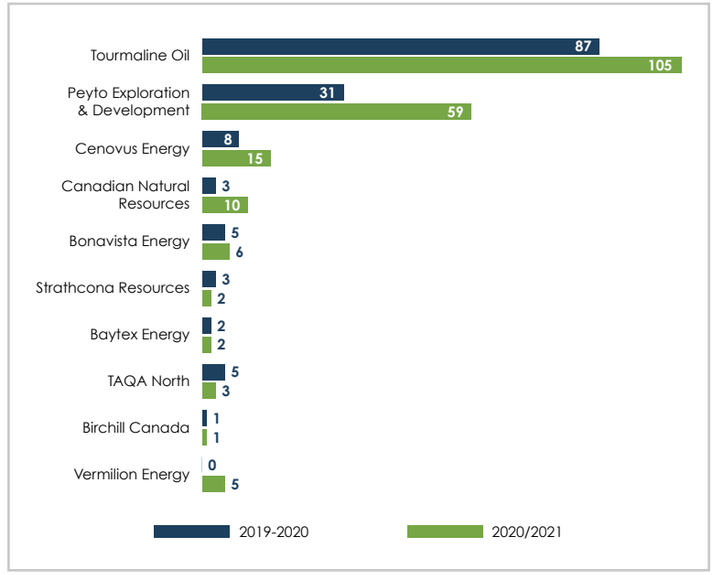
Total Wells Drilled



Wells Drilled by Formation



Well Drilled by Operator



Source: gDC Dashboards

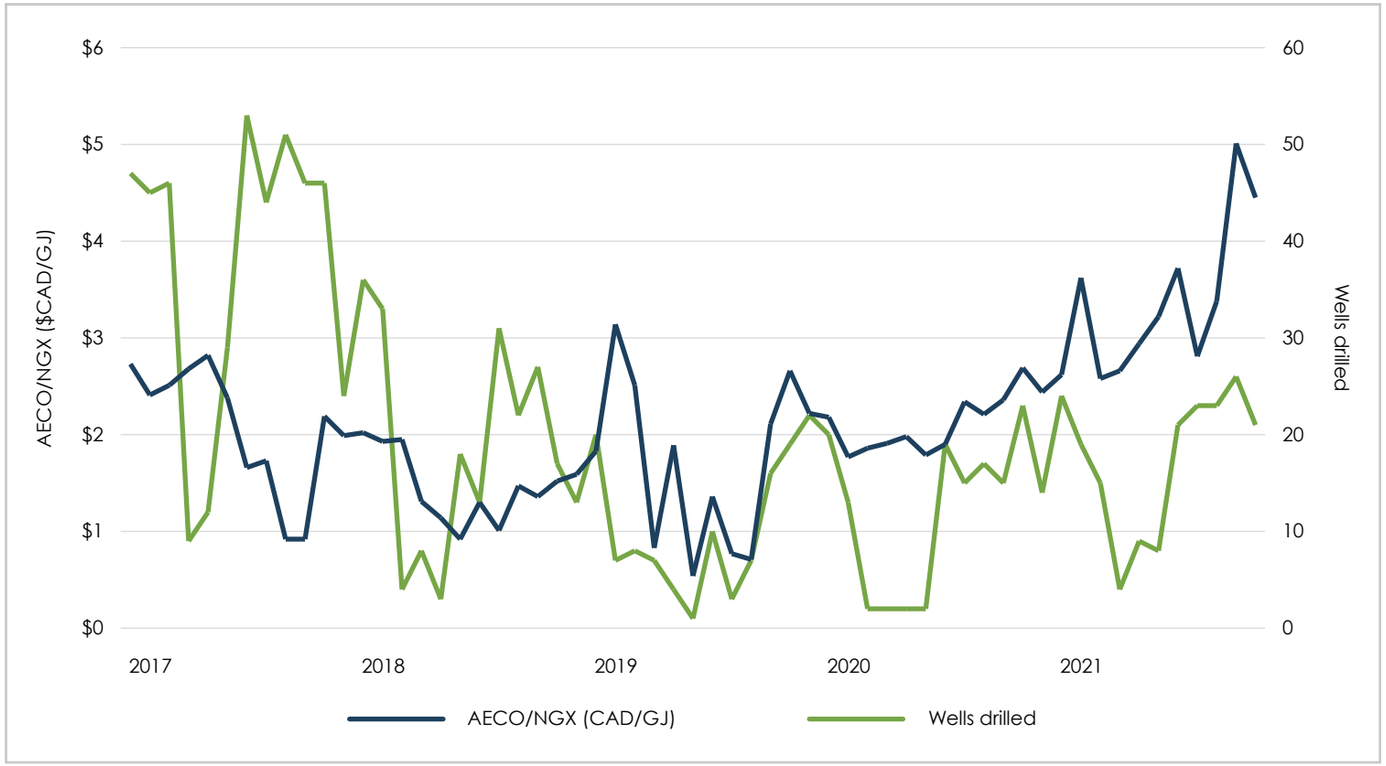
Spirit River

DRILLING PRICE SENSITIVITY

Spirit River drilling activity is influenced by non-financial factors such as spring break-up and other weather-related issues.

With mostly dry gas production, natural gas pricing has a significant impact on activity. Development costs for the main operators in the play are among the lowest in Western Canada. Forward prices in the $2.50-$3.00/GJ range provide adequate returns to increase drilling. Prices under $2.00/GJ result in a retreat in activity.

Spirit River Drilling Sensitivity to Gas Prices



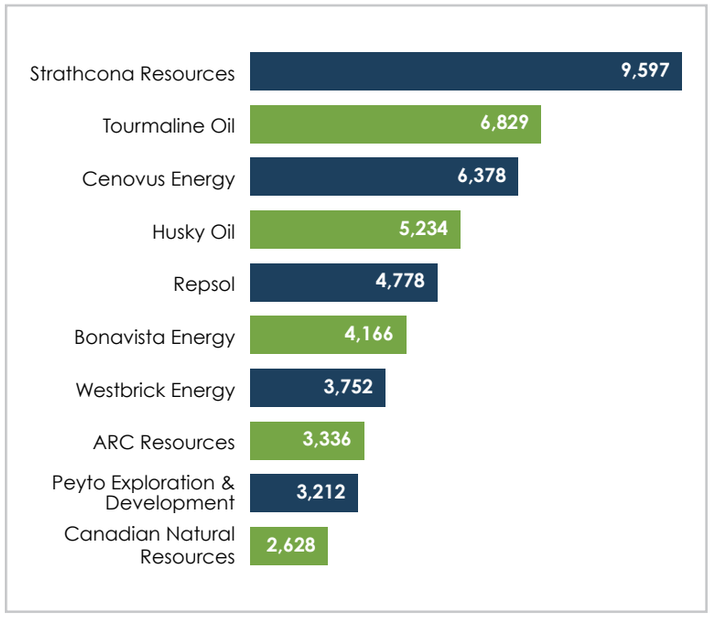
Source: Daily Oil Bulletin/gDC Dashboards

Spirit River

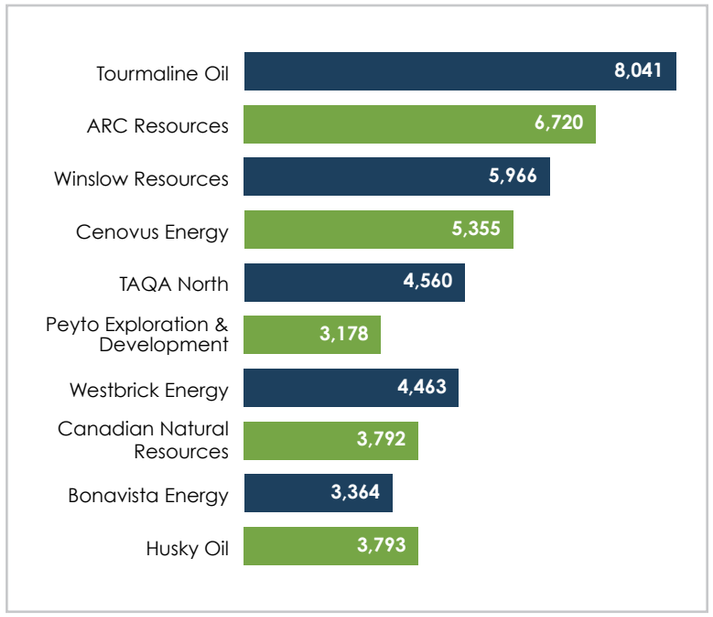
IP90S

Looking at the IP90s of operators that have moved from exploration to development shows the three Spirit River sub-plays perform similarly over time. Wells drilled by these operators from 2009-2021 show both Wilrich and Falher wells with average IP90s of around 5,000 mcf/d, with the Notikewin averaging slightly less at around 4,500 mcf/d.

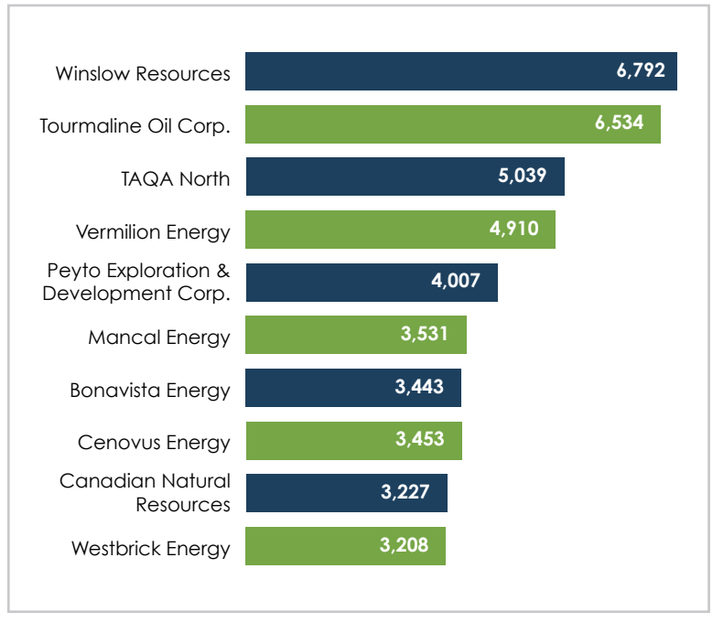
Average IP90 for wells 2009-2021 by Operator - Wilrich
(IP90 Gas Rate per Well (mcf/d)



Average IP90 for wells 2009-2021 by Operator - Falher
IP90 Gas Rate per Well (mcf/d)



Average IP90 for wells 2009-2021 by Operator - Notikewin
IP90 Gas Rate per Well (mcf/d)



Source: gDC Dashboards

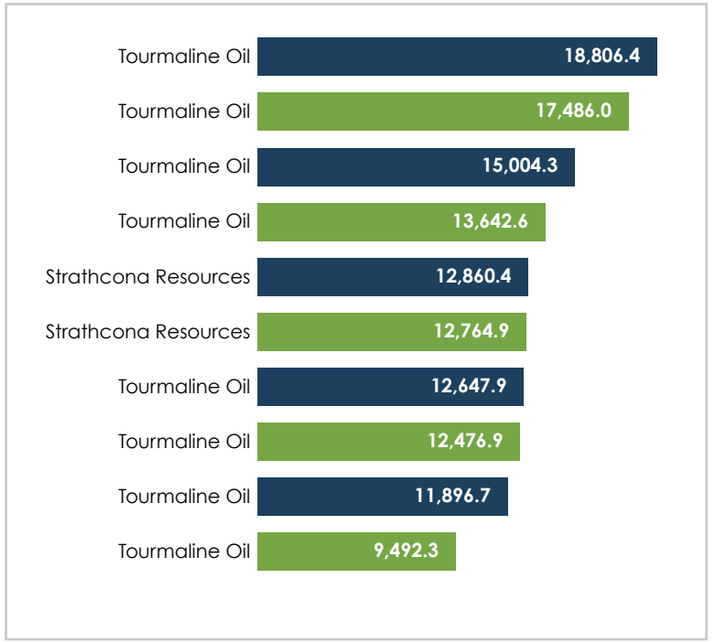
Spirit River

TOP 2021 WELLS

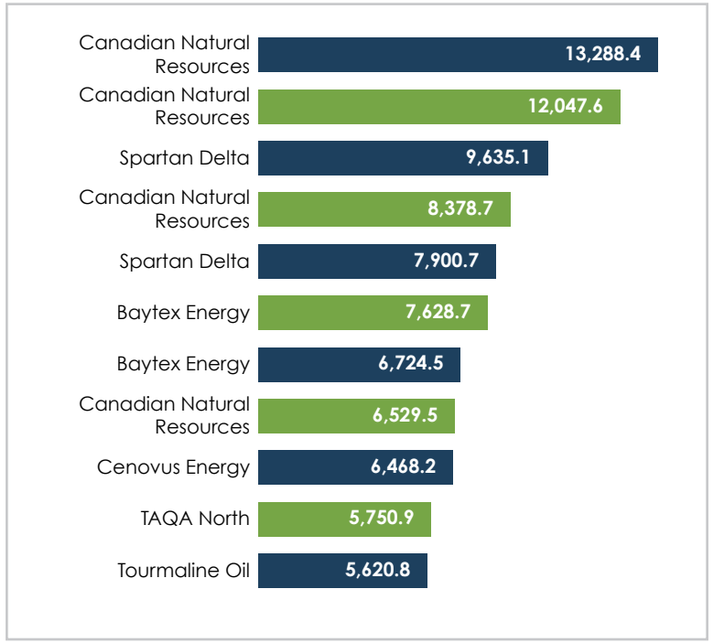
While average IP90s over time are similar there is wide variability in the performance of individual wells, driven by reservoir quality and improving drilling and completions designs. As operators fine-tune development programs they can zero in on sweet spots.

In 2021, the top 10 Wilrich wells had an average IP90 of almost 14,000 mcf/d while Falher and Notikewin wells had average IP90s of around 8,100 mcf/d.

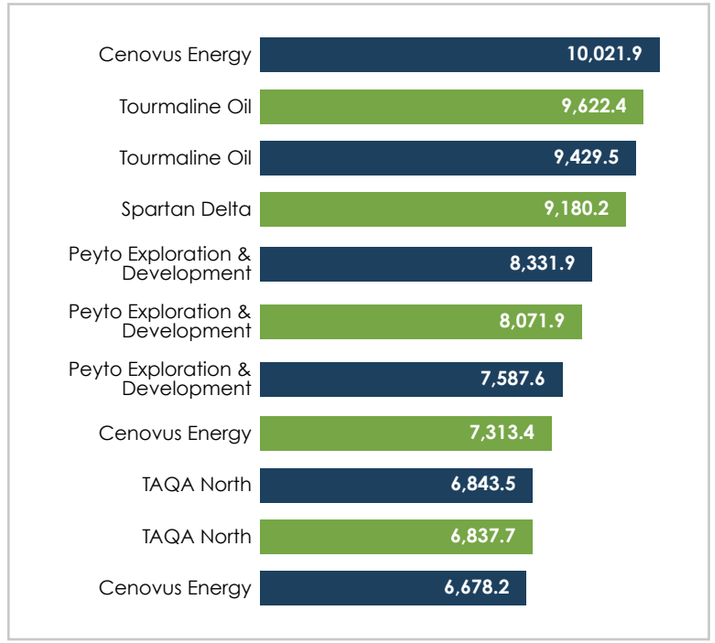
Top IP90 Wells: 2021 - Wilrich
(IP90 Gas Rate per Well (mcf/d)



Top IP90 Wells: 2021 - Falher
IP90 Gas Rate per Well (mcf/d)



Top IP90 Wells: 2021 - Notikewin
IP90 Gas Rate per Well (mcf/d)

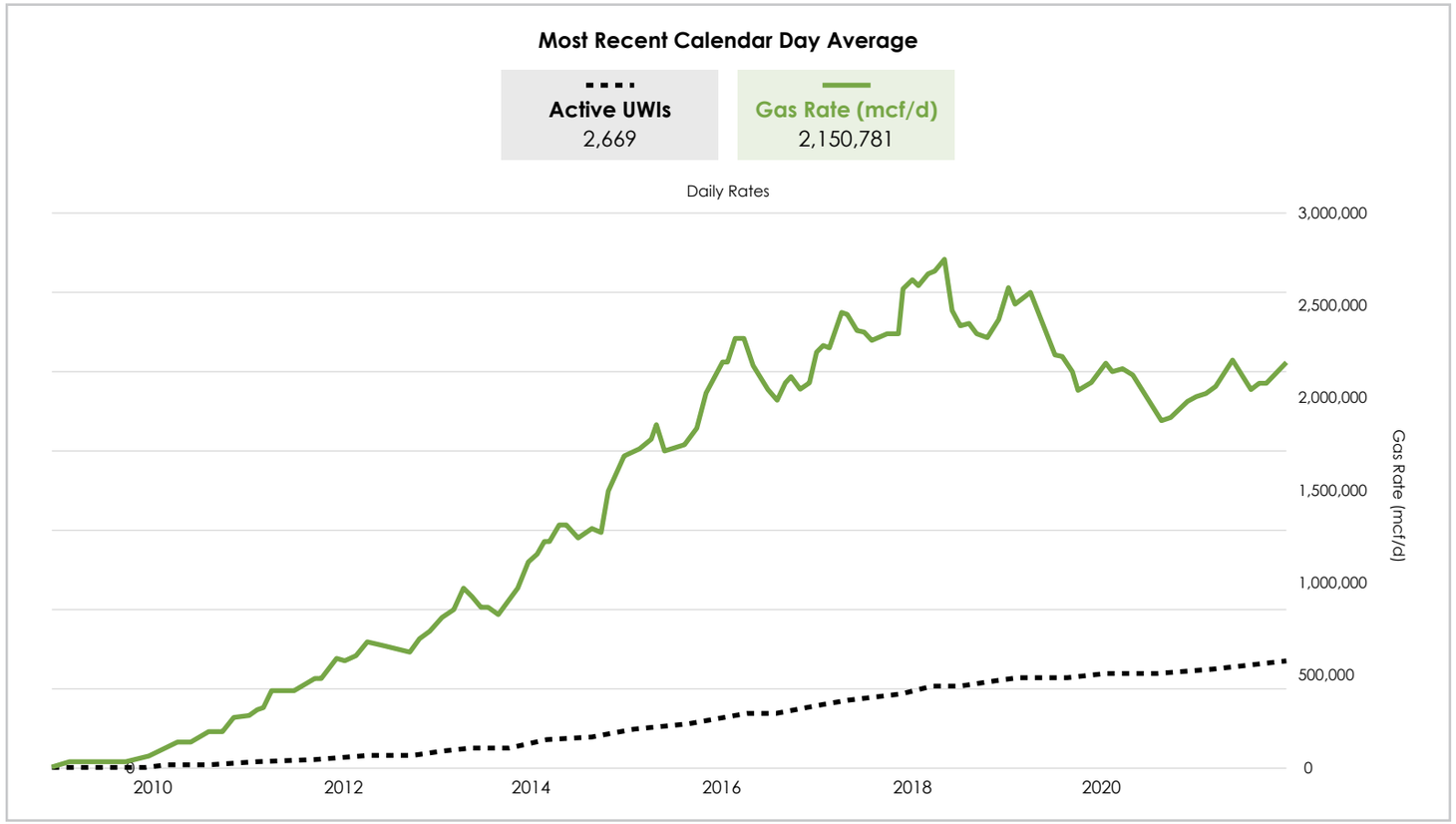


Source: gDC Dashboards

Spirit River

PRODUCTION

Spirit River production is down 22% from its peak in 2018 as drilling activity has failed to keep pace with high decline rates. Falher production is down 30%, Wilrich production is down 23%, and Notikewin production is down 18%.



Source: gDC Dashboards

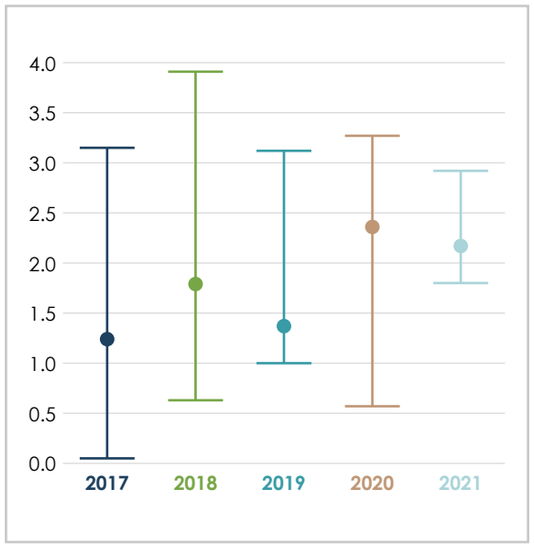
Completions Trends

FALHER

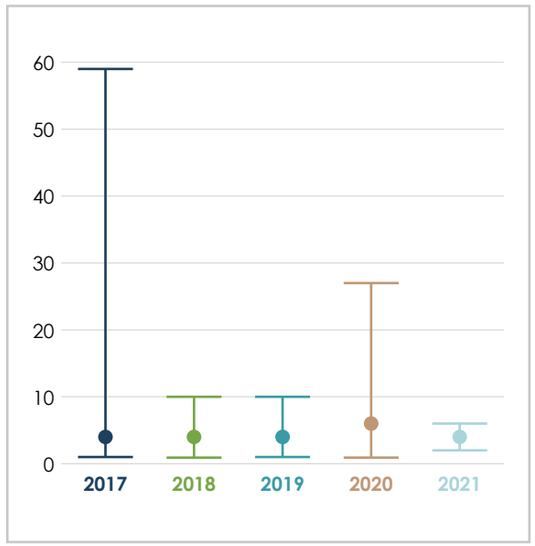
Ball and seat completions are the preferred technology in the Spirit River formation[2].

Over the last five years the Falher member has seen median completion lengths and completions stages continually increase except during the 2019 activity slowdown. Median lengths have climbed almost 60%, from 1.24 km to 2.17 km in 2021. Median stages fractured have increased by 33% from 21 stages to 34 stages.

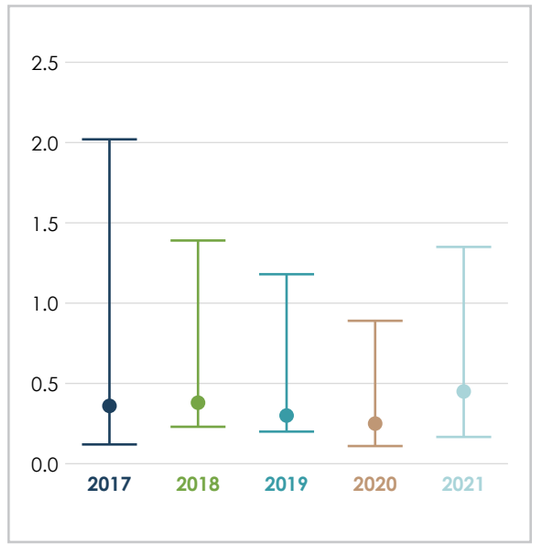
Completion Length (Kilometres)



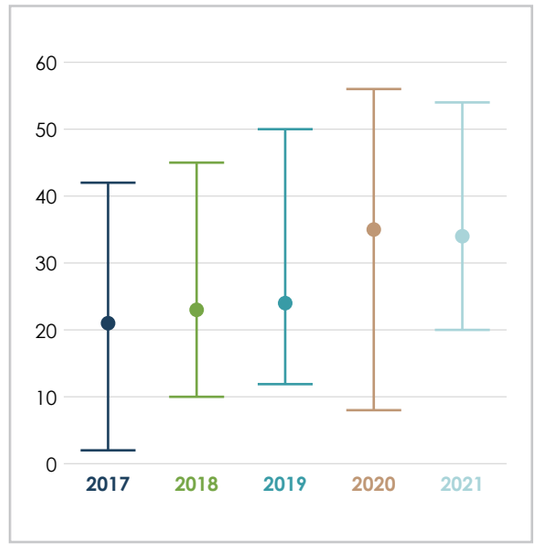
Number of Wells on a Pad



Proppant Per Metre (tonnes per metre)



Total Stages



Source: gDC Dashboards

[2] Source: gDC Dashboard: Frac Analysis

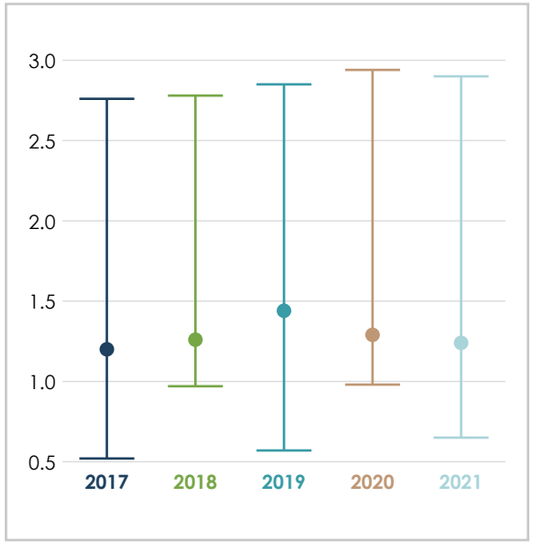
Completions Trends

NOTIKEWIN

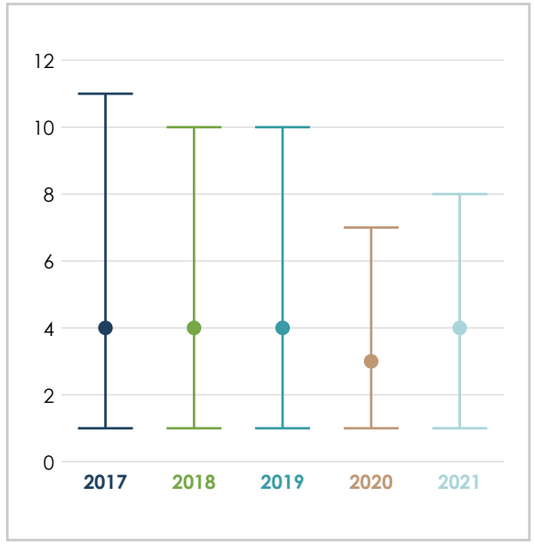
Median Notikewin completion lengths have stayed relatively stable the last five years, ranging from 1.2-1.44 km. Operators have tested longer lengths approaching 3km.

Median stage counts have increased from 16 in 2017 to the 25-stage range the last three years. This indicates stage spacing is getting tighter in the Notikewin. There was a spike in proppant per metre pumped in 2021 but it is uncertain if it indicates a trend.

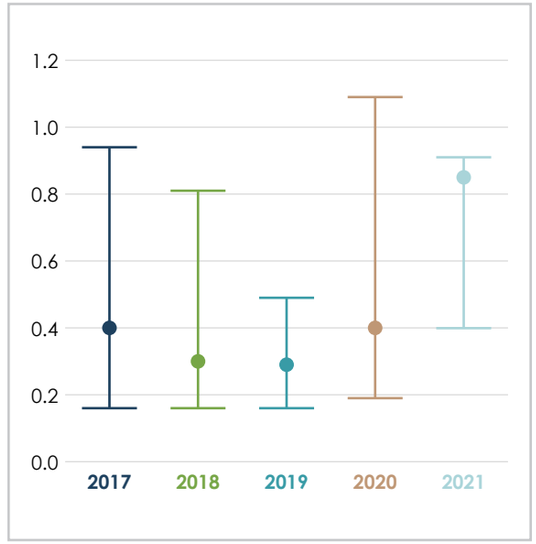
Completion Length (Kilometres)



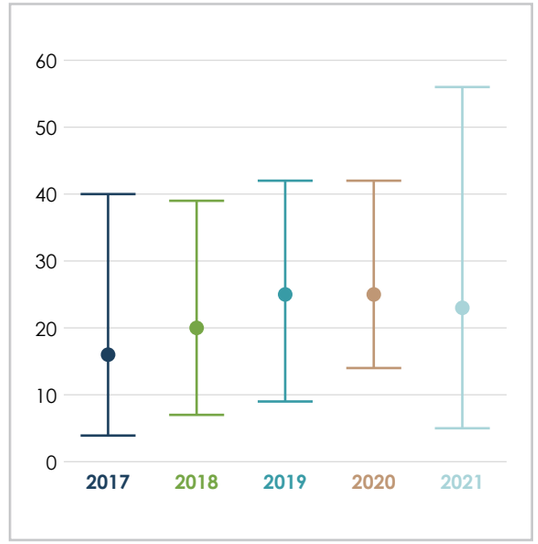
Number of Wells on a Pad



Proppant Per Metre (tonnes per metre)



Total Stages



Source: gDC Dashboards

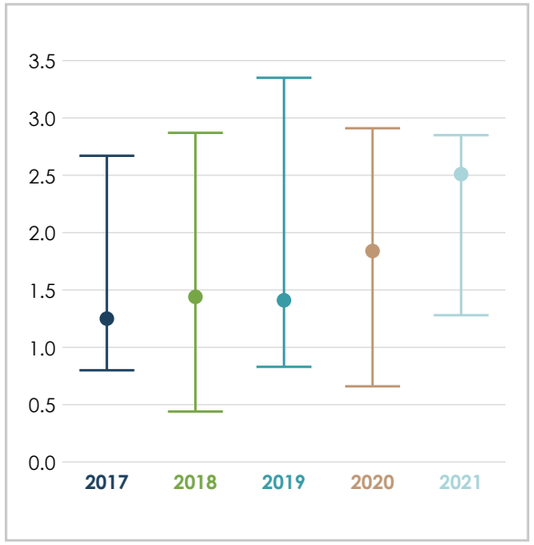
Completions Trends

WILRICH

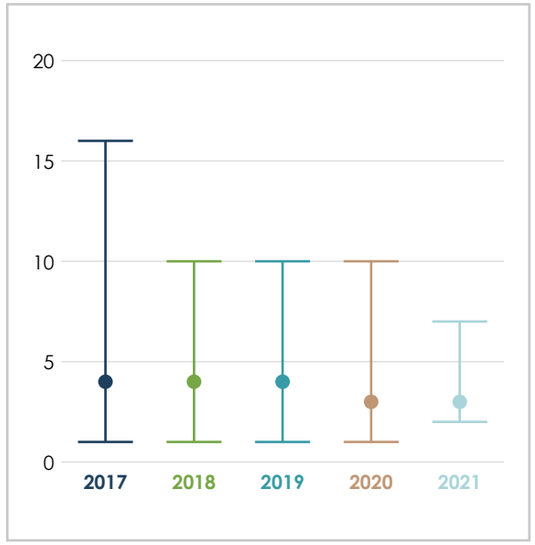
Median completion lengths have increased from 1.25 km in 2017 to 2.51 km in 2021, reflecting steady year-over-year increases. Median stages completed have increased 60% from 21 to 35 stages. There have been a number of large wells with completion lengths ranging from 2.7 to 3.35 km drilled in the last five years.

Tourmaline Oil Corp., the most active company in the Wilrich, has seen its median completion lengths grow from 1.22 km to 1.89 km over the last five years. Stage counts have increased from 24 stages to 35 stages.

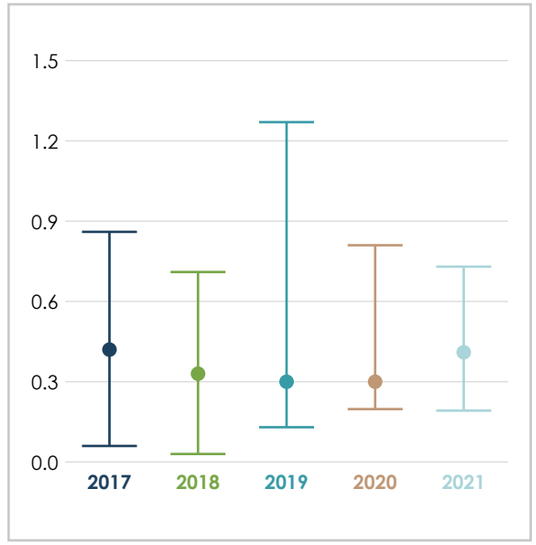
Completion Length (Kilometres)



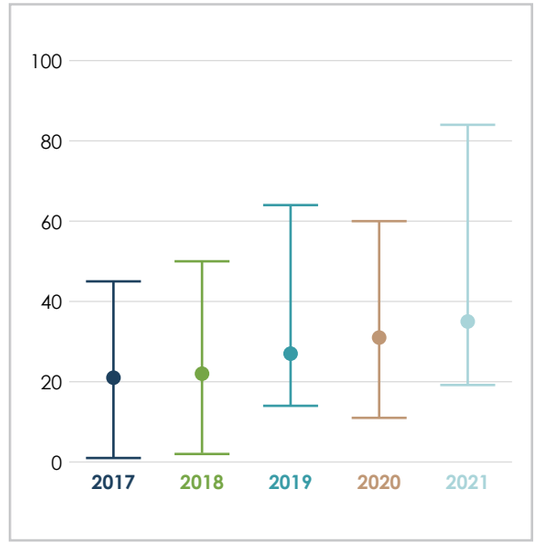
Number of Wells on a pad



Proppant Per Metre (tonnes per metre)



Total Stages



Source: gDC Dashboards

Cardium

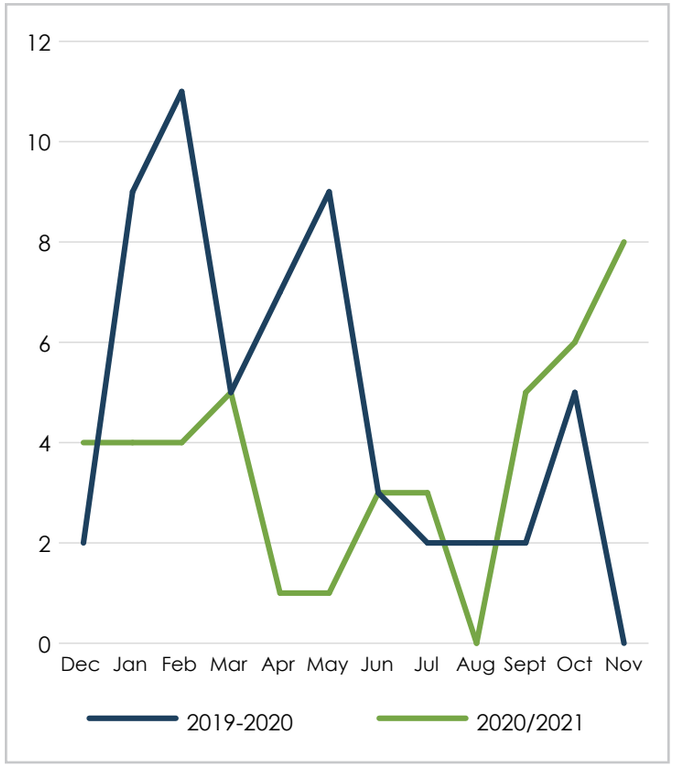
LICENCES

Well licensing activity in the Cardium formation declined by 23% in 2020-2021 compared to the previous year as operators responded to increased natural gas prices.

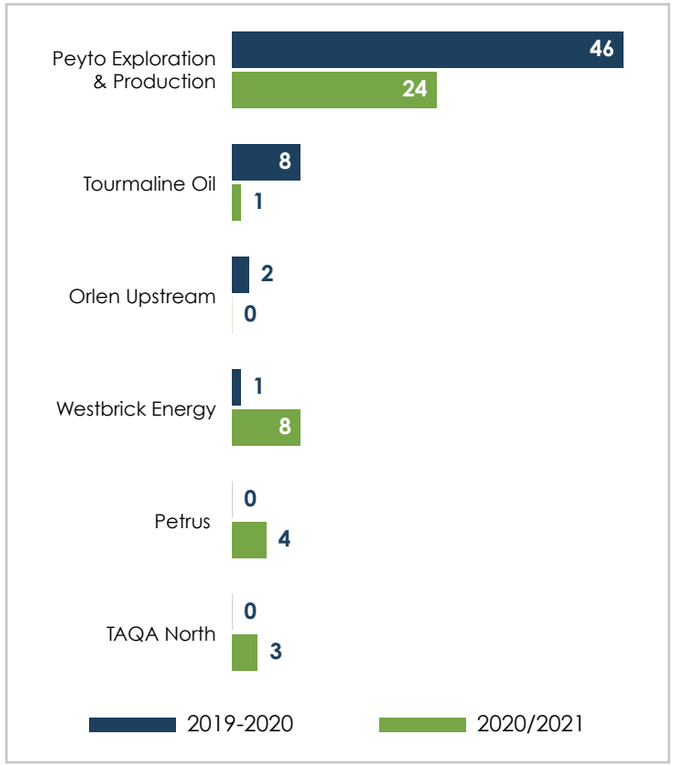
Many Deep Basin operators choose to target liquids-rich areas of the Cardium that are more economic in times of lower natural gas prices, and switch activity to the Spirit River when prices recover.

Peyto Exploration & Development, the dominant Deep Basin Cardium operator, is one example. It licensed 46 wells in the Cardium in the 2019/2020 time-period and 24 wells in 2020/2021. Peyto licensed 52 wells in the Spirit River in 2020/2021, up from 32 in the previous time period.

Total Well Licences



Well Licences by Operator



Source: gDC Dashboards

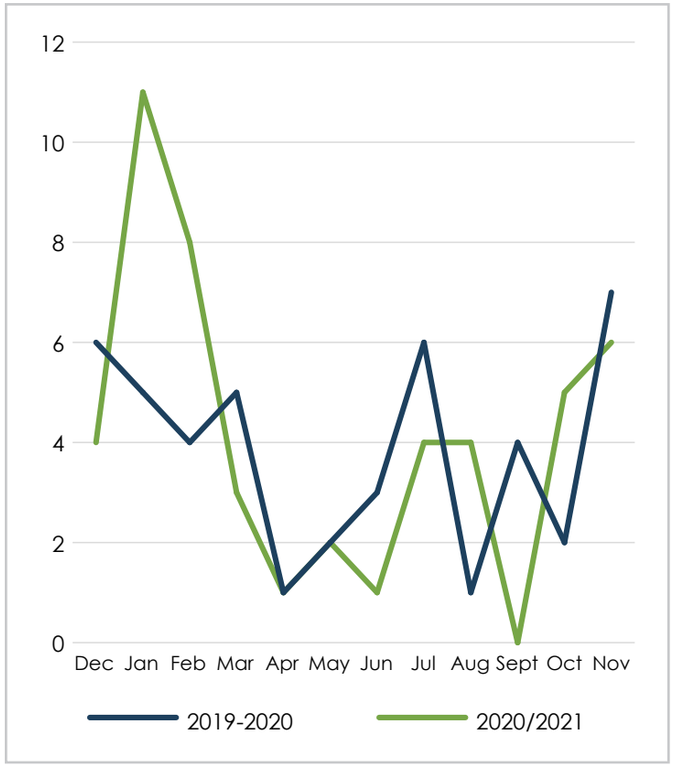
Cardium

DRILLING

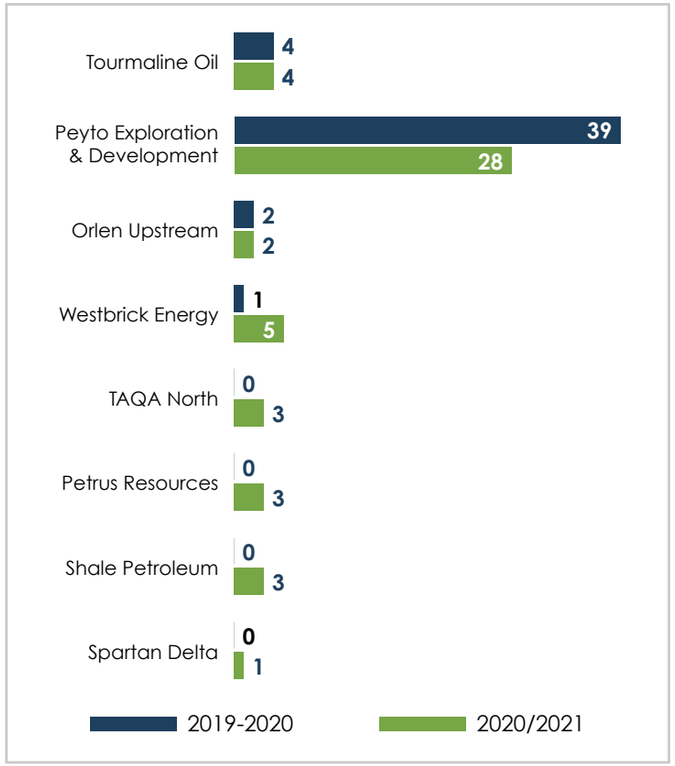
Drilling activity in the Cardium formation stayed relatively stable, increasing 6.5% year-over-year.

While Peyto drilled 11 fewer wells in 2020-2021 compared to the previous year, other operators expecting higher gas and liquids prices directed capital to the Cardium. The warm start to winter has lessened the NGL advantage in the Cardium as propane demand and prices have declined in the U.S. market.

Total Well Licences



Well Licences by Operator



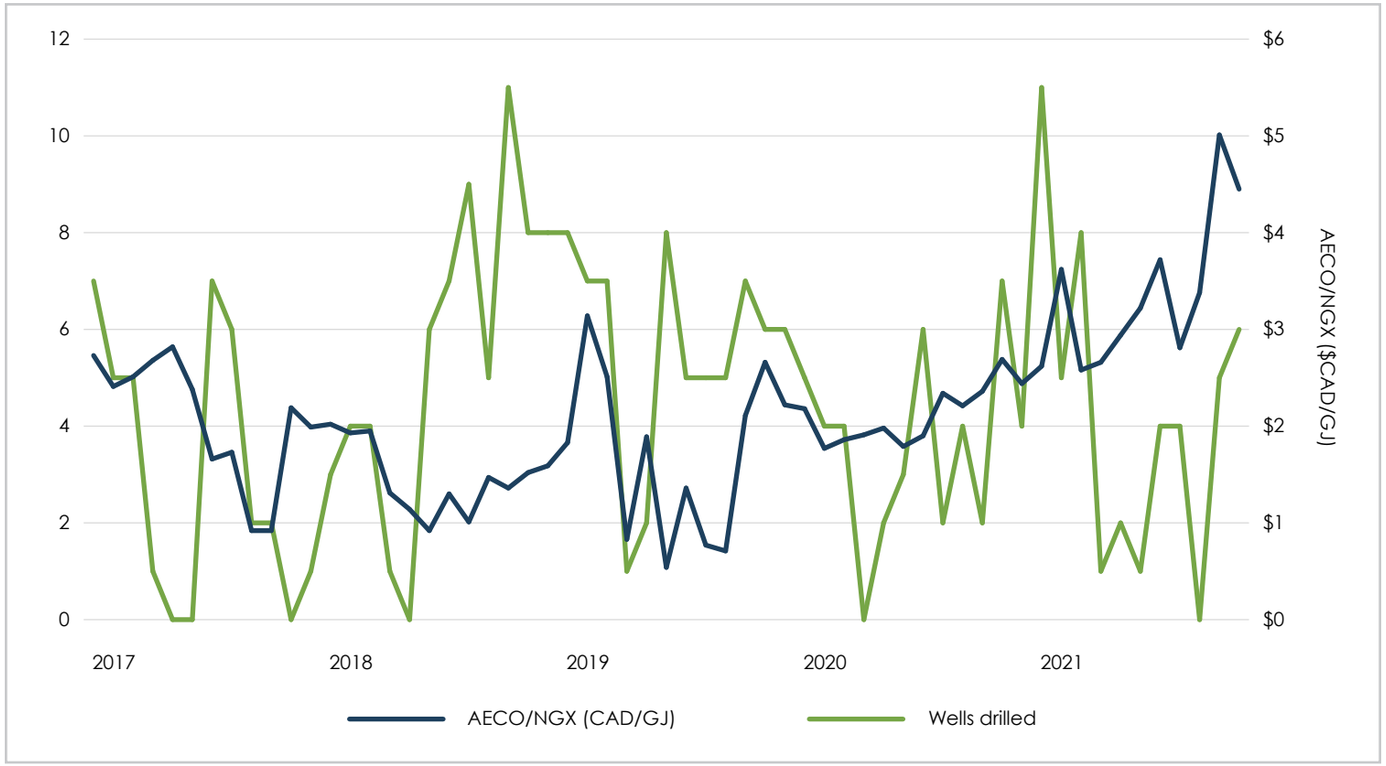
Source: gDC Dashboards

Cardium

DRILLING PRICE SENSITIVITY

As natural gas prices declined in 2018, drilling in the Cardium increased as operators focused on liquids-rich targets rather than dry gas targets in the Spirit River.

Higher prices in late 2021 resulted in increased Cardium drilling as operator sitting on the sidelines with predominantly Cardium assets began investing capital.



Source: Daily Oil Bulletin/gDC Dashboards

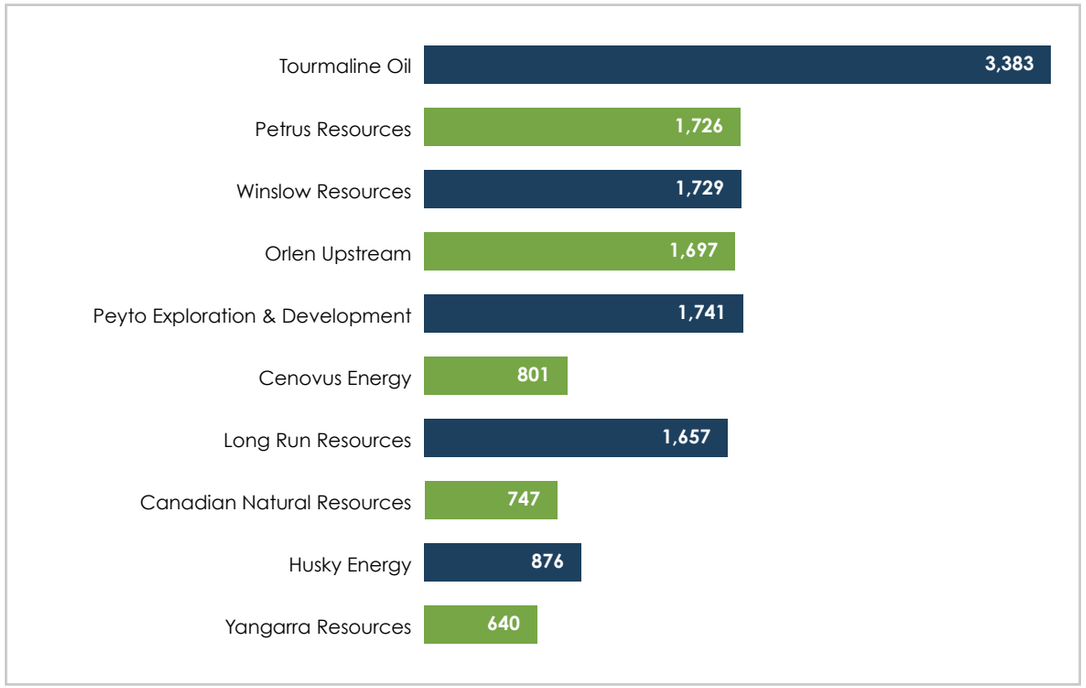
Cardium

IP90S

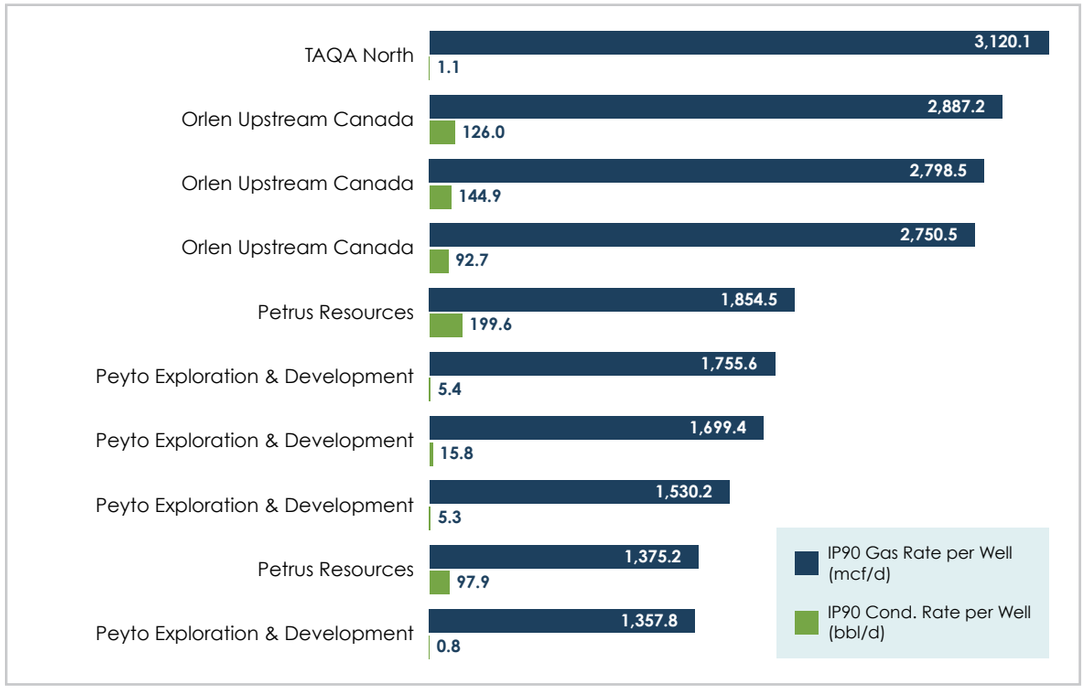
Cardium IP90s on wells drilled by major operators since 2009 are significantly less than comparable IP90s in the Spirit River. The average IP90 in this group of wells is 1,500 mcf/d, less than one third of Spirit River wells.

Higher natural gas liquids and field condensate production greatly increases the economics of Cardium wells. Peyto estimates its Cardium acreage can produce 45 bbls of NGLs per mmcf of natural gas. As the top 10 2021 wells indicate, field condensate production can also increase Cardium economics, particularly in the Ferrier field.

Cardium IP90s
(Average for wells drilled 2009-2021)



Cardium Top Wells 2021 (IP90)
IP90 Gas Rate per Well (mcf/d), IP90 Cond. Rate per Well (bbl/d)

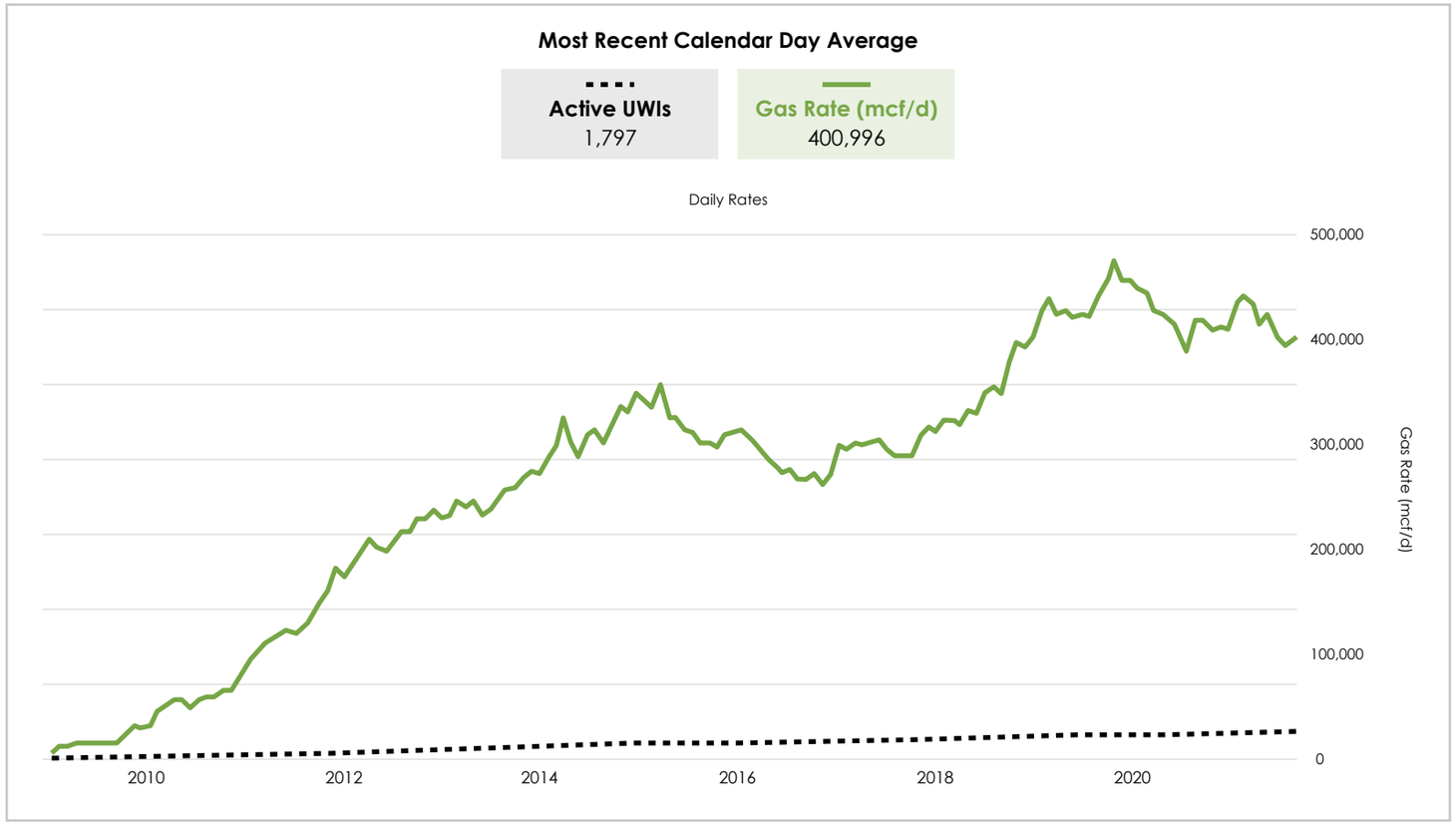


Source: gDC Dashboards

Cardium

PRODUCTION

Cardium natural gas production increased rapidly in 2018-2019 as operators focused on liquids-rich targets in the Deep Basin. Production has now levelled off as higher gas prices have made the Spirit River more economical. A number of smaller operators with Cardium assets, however, are helping stem production declines.



Source: gDC Dashboards

Cardium

COMPLETION TRENDS

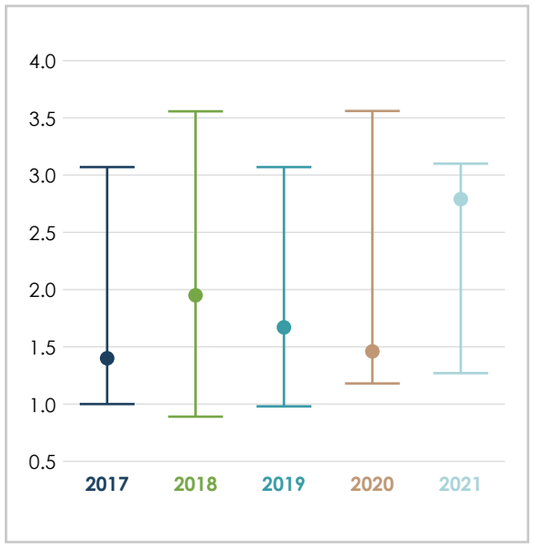
Sliding Sleeve is the dominant completions technology in the Cardium formation in the Deep Basin[3].

Median completions lengths have been increasing the last five years from 1.4 km to 2.79 km.

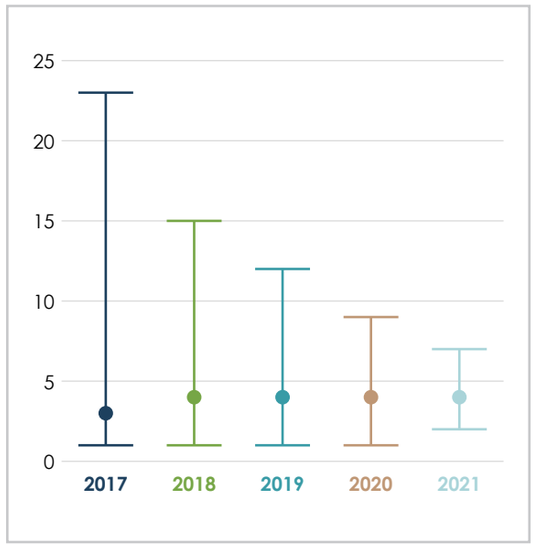
Median stages have increased from 32 stages to 69.

Driving these increases have been operators drilling long horizontals with tight stage spacing in the liquids-rich Ferrier area. Orlen Upstream is an example. Its median stage count climbed from 26 stages in 2017 to 104 stages in 2020. It has drilled wells with completion lengths over 3 km. Median proppant intensity increased from 0.42 tonnes per metre to 0.71 tonnes per metre.

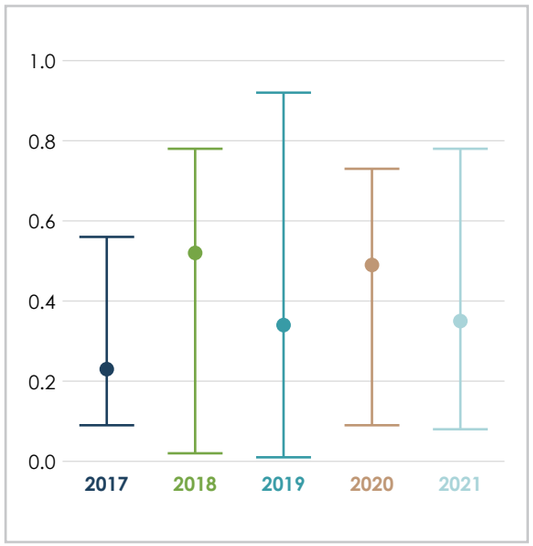
Completion Length (Kilometres)



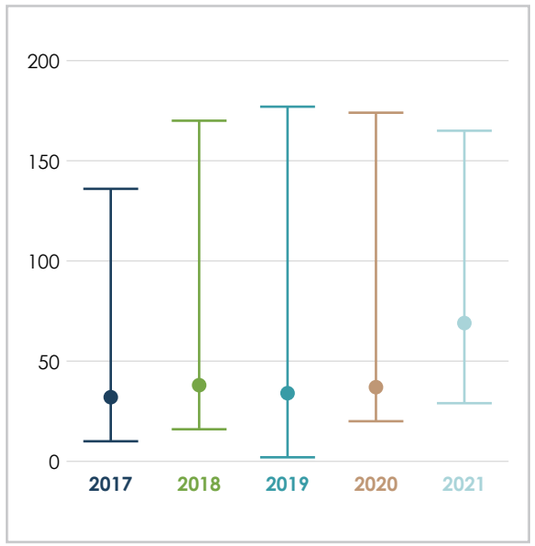
Number of Wells on a pad



Proppant Per Metre (tonnes per metre)



Total Stages



Source: gDC Dashboards

[3] Source: gDC Dashboards: Frac Analysis

KEY INSIGHTS

- While North American natural gas prices have retreated from 10-year highs in October/November 2021, they remain over 60% higher than in 2020 heading into 2022. NYMEX contracts are trending downward into early spring, but levels continue in the US$3.50/mmBTU range. This supports Deep Basin drilling activity.

- Record high European gas prices continue to pull U.S. production into LNG exports, increasing overall North American demand. Canadian exports to the U.S. increased by 1 bcf/d in 2021, and should increase further as new pipeline capacity comes onstream in 2022.

- At least 10 of Alberta's 18 coal-fired generators are expected to convert to natural gas prior to the Alberta government's 2023 deadline for phase out of coal generation, creating opportunity in local markets for increased Deep Basin supply.

- Well licensing in the Spirit River formation increased by 57% in 2021 compared to the previous year as operators gain confidence that higher pricing is sustainable. Drilling activity increased by 40% in 2021 compared to the previous year.

- Dominant Deep Basin operators are moving capital from the Cardium to the Spirit River formation to take advantage of higher natural gas prices. However, many smaller operators are increasing capital spending targeting their Cardium assets. Increasing NGL exports and the startup of the Heartland Petrochemical complex should support this strategy.

- Cardium drilling should also be supported by unused processing capacity in the Deep Basin.

- Deep Basin operators continue to increase lateral lengths and stage counts to drive well productivity. Top operators are leveraging 3D seismic and data gained over the last decade of drilling and completing wells to focus in on premium targets. These high deliverability wells should enable operators to quickly respond to market signals.

- Many fields drilled early in the unconventional resource revolution that began in 2009 are now in decline. Operators are shifting development to new areas.

APPENDIX 1

Deep Basin Fields

Anderson	Edson	Marsh	Shaw
Ansell	Elmworth	Medicine Lodge	Simonette
Basing	Ferrier	Minehead	Sinclair
Berland River	Findley	Moberly	Smoky
Berland River West	Grande Cache	Narraway	Solomon
Bigstone	Grizzly	Netook	Stolberg
Brazeau River	Groat	Nosehill	Sundance
Brown Creek	Hanlan	Palliser	Voyager
Cabin Creek	Hinton	Peco	Wapiti
Carrot Creek	Kakwa	Peppers	Waskahigan
Chambers	Karr	Pine Creek	West Pembina
Chime	Kaybob South	Pinto	Whitehorse
Chinook Ridge	Lambert	Placid	Wild River
Columbia	Lator	Resthaven	Willesden Green
Cutpick	Latornell	Ricinus West	
Dalehurst	Leland	Rosevear	
Dimsdale	Lynx	Saxon	

APPENDIX 2

Deep Basin Operators

Operator	Total Wells	Active Wells
Tourmaline Oil Corp.	1650	1557
Peyto Exploration & Development Corp.	1141	1099
Canadian Natural Resources Limited	587	467
Bonavista Energy Corp.	417	399
Cenovus Energy Inc.	312	230
Husky Oil Operations Limited	295	237
Whitecap Resources Inc.	292	260
Repsol Oil & Gas Canada Inc.	225	210
Winslow Resources Inc.	213	209
Obsidian Energy Ltd.	188	155
Yangarra Resources Corp.	181	164
Orlen Upstream Canada Ltd.	155	135
Long Run Exploration Ltd.	134	117
TAQA North Ltd.	126	119
Westbrick Energy Ltd.	112	88

Operator	Total Wells	Active Wells
Paramount Resources Ltd.	105	83
Strathcona Resources Ltd.	95	60
Tangle Creek Energy Ltd.	86	75
ARC Resources Ltd.	74	61
InPlay Oil Corp.	63	51
Petrus Resources Corp.	58	54
Entrada Resources Inc.	55	51
XTO Energy Canada ULC	44	25
Baccalieu Energy Inc.	41	37
Prairie Storm Energy Corp.	40	36
Vermilion Energy Inc.	39	31
Mancal Energy Inc.	37	27
Spartan Delta Corp.	33	28
Persist Oil And Gas Inc.	31	21
Harvest Operations Corp.	30	22

Operator	Total Wells	Active Wells
Baytex Energy Ltd.	25	24
Shanghai Energy Corp.	23	22
Bonterra Energy Corp.	20	20
Spoke Resources Ltd.	19	14
2214896 Alberta Ltd.	16	13
Canlin Energy Corp.	16	15
AlphaBow Energy Ltd.	15	6
Birchill Canada Corp.	13	12
Outlier Resources Ltd.	13	9
Tidewater Midstream and Infrastructure Ltd.	11	8
Calgary Oil and Gas Intercontinental Group Ltd.	10	10
I3 Energy Canada Ltd.	10	7
Spur Petroleum Ltd.	10	9

* Companies listed have 10 or more unique well identifiers
Production data for October 31/2021.
Source: gDC Dashboards

APPENDIX 3

Deep Basin Production by Major Fields

Field	Production (mcf/d)
Ansell	178,264
Brazeau	100,972
Edson	256,808
Ferrier	425,668
Lambert	41,729
Leland	116,567
Kakwa	336,352
Minehead	109,266
Nosehill	53,068
Resthaven	125,052
Smokey	160,026
Sundance	302,924
Wapiti	77,544
Wildriver	245,997
Willeden Green	220,313
Total	2,750,550

Production data for October 31/2021.
Source: gDC Dashboards

Daily Oil Bulletin

gDC dashboards

geoLOGIC SYSTEMS

Evaluate Energy