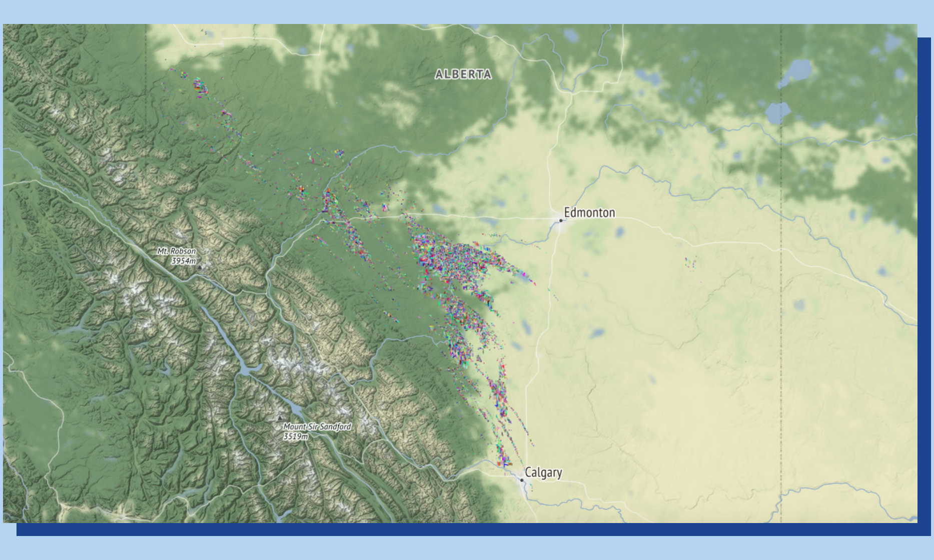
Comeback in the Cardium?

The Cardium formation is one of the jewels of Alberta's oil industry. Discovered in 1953, conventional oil production peaked at over 170,000 bbls/d in 1971, accounting for over 15% of provincial supply. It declined to 34,000 bbls/d by 2009 but rebounded to 122,000 bbls/d in 2014 as unconventional drilling and completion techniques were applied. Declines again set in as oil prices collapsed in early 2015. Today, production stands at around 63,000 bbls/d.

Decades of drilling targets remain. New targets are being added to rebuild oil output and expand gas and liquids production. Longer term, the Cardium's future lies in CO2 enhanced oil recovery (EOR). The next phase of EOR will depend on emerging carbon capture, use and storage (CCUS).

Daily Oil Bulletin | Data provided by: Evaluate Energy gDCdashboards DOB Docs geoXPLORER

Cardium has plenty in the tank



More than **17,500 wells** have been drilled yet only **12%** of roughly **16 billion barrels** of oil originally in place has been recovered. An estimated **5.2 trillion cubic feet** of associated or solution gas remains in place. The unconventional gas potential throughout the entire formation (including the Deep Basin) may be many times higher.

Original Oil in Place	Cumulative Oil Produced	Cumulative Total Production	Recovered to Date
16.25 billion barrels	**2.1** billion barrels	**3.35 billion** BOE	**12%**

Source: gDC Dashboards: Alberta Oil Pools

New players boost confidence

Key deals in the past five years include **Whitecap Resources**' acquisitions of NAL Resources and TORC Oil & Gas, and Spartan Delta Energy's acquisition of **Bellatrix Exploration's** assets. These players build on the expertise of specialist operators like Yangarra Resources, Obsidian Energy and Bonterra Energy in developing Cardium tight oil resources.

MAJOR CARDIUM DEALS

Acquirer	Target Company or Assets	Total Acquisition Cost ($millions)
Whitecap Resources	NAL Resources	147,500
Whitecap Resources	TORC Oil & Gas	900,000
Spartan Delta Energy	Bellatrix Exploration	87,600
Richocet Oil & Gas	ARC Resources	100,000
InPlay Oil Corp.	Prairie Storm Resources	42,296

Source: Evaluate Energy

Oil activity returning to Cardium

Activity is bouncing back after the Covid-19 pandemic. Oil well licensing **doubled year-over-year** in 2021, with **drilling up 87%**. Forty-nine oil wells were licensed in Q1 2022 compared to 35 last year.

Gas well licensing recovered from **21 wells in 2017** to reach **62 wells in 2021**. Fifty-four were drilled in 2021 as higher gas prices led Deep Basin operators to switch from liquids-rich Cardium targets to the more productive Spirit River formation. Overall activity remains well shy of 2013 when 623 wells were licensed and 714 wells drilled.

WELL LICENSING (2017-2021)

Source: gDC Dashboards

	2017	2018	2019	2020	2021
Oil	245	275	200	97	196
Gas	21	75	56	58	62

TOP 10 OIL LICENSEES (2017-2021)

Source: gDC Dashboards

1	Whitecap Resources	185	6	InPlay Oil Corp.	55
2	Bonterra Energy	130	7	Tamarack Valley Energy	51
3	Yangarra Resources	119	8	Baccalieu Energy	43
4	Obsidian Energy	104	9	Orlen Upstream	35
5	Ridgeback Resources	77	10	Tourmaline Oil Corp.	35

WELLS SPUD

Source: gDC Dashboards

	2017	2018	2019	2020	2021
Oil	226	277	212	102	191
Gas	34	62	67	44	54

TOP 10 OIL DRILLERS (2017-2021)

Source: gDC Dashboards

1	Whitecap Resources	199	6	Tamarack Valley Energy	59
2	Bonterra Energy	142	7	InPlay Oil Corp.	53
3	Yangarra Resources	117	8	Baccalieu Energy	45
4	Obsidian Energy	91	9	Tourmaline Oil Corp.	37
5	Ridgeback Resources	65	10	Ricochet Oil Corp.	31

Production recovering to pre-pandemic levels

Cardium production declined 13% in 2020 as Covid-19 kept crews out of the field and operators shut-in production. It grew by 2,400 boe/d to exit 2021 at **over 188,000 boe/d**. Oil production increased by **3,300 bbls/d**, while gas production declined slightly. Nearly **80%** of current production is from **unconventional wells** drilled after 2009.

CARDIUM PRODUCTION (YEAR-END EXIT RATES 2017-2021)

Source: gDC Dashboards

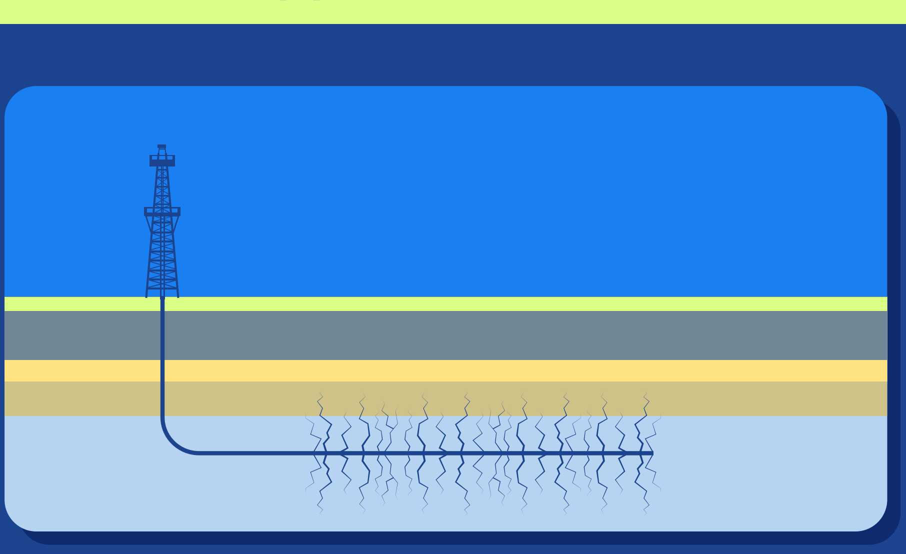
	2017	2018	2019	2020	2021
Oil (bbls/d)	75,728	82,580	78,520	60,514	63,811
Gas (mcf/d)	700,832	777,843	801,250	749,440	742,780

TOP 10 OIL PRODUCERS (BBLS/D)

Source: gDC Dashboards

1	Whitecap Resources	10,672	6	InPlay Oil Corp.	2,767
2	Obsidian Energy	9,397	7	Yangarra Resources	2,394
3	Bonterra Energy	6,869	8	Baccalieu Resources	1,911
4	Ricochet Oil Corp.	5,504	9	Tamarack Valley Energy	1,650
5	Ridgeback Resources	4,996	10	Tourmaline Oil Corp.	1,475

Different approaches to manufacturing oil



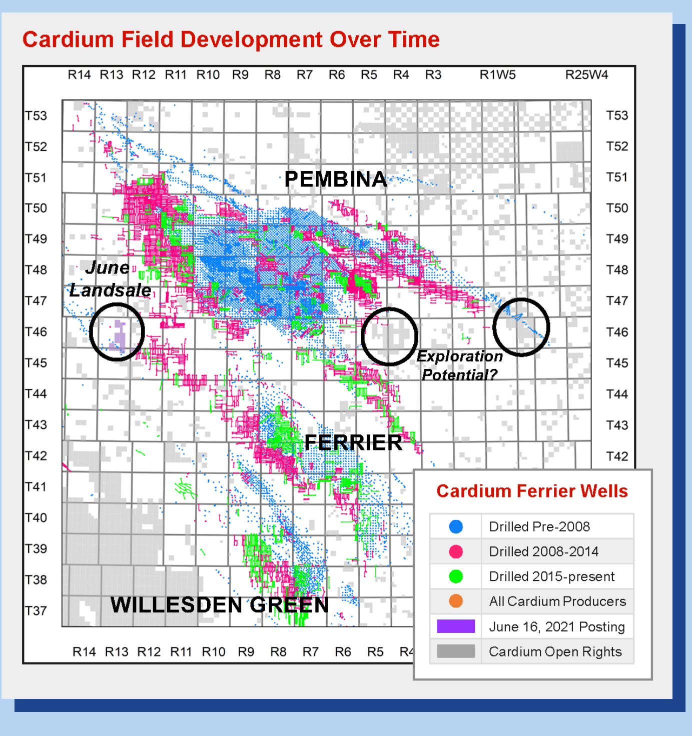
Drilling and completions in the Cardium oil play have reached the manufacturing stage. Depending on the operator, stage of development and geology, drilling 1-mile, 1.5-mile or 2-mile horizontal wells are the standard. The number of fracturing stages has remained relatively constant on an operator basis, with some operators choosing more intensive well stimulation processes.

SAMPLES OF DIFFERENT COMPLETION STRATEGIES

	Completed Lengths (km)	# of Stages	Oil IP 90s	Gas IP 90s
Bonterra Energy	1.5	30	124	194
Yangarra Resources	3.0	140	210	769

Source: gDC Dashboards

Technology increases drilling opportunities



Advances in completions technology have increased potential drilling targets in the Cardium. geoXPLORER analysis shows from 2008-2014 operators focused on the higher porosity cleaner sands of the Upper Cardium shoreface. Since 2015 operators have targeted both the Upper and Lower Cardium shoreface in tighter sands including bioturbated sections of the Lower Cardium. The lower shoreface play's success rides on higher stage counts (>100 stages) over two mile laterals.

Cardium delivers low-risk returns

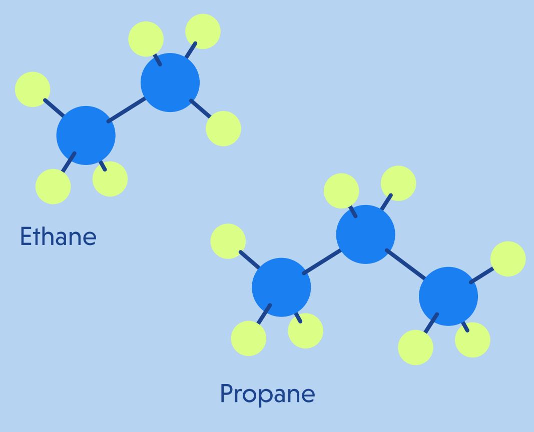
Higher commodity prices translated into strong operating netbacks for Cardium operators in the final quarter of 2021. That trend should continue throughout 2022. At **WTI $90/bbl** most operators are reporting payouts in the **5-7 month range**.

YANGARRA RESOURCES Q4/2021 OPERATING NETBACKS

Source: DOB Docs/Yangarra Q4/2021 Financial Report

Sales Price	Royalties	Production	Transportation	Operating Netback
$51.22	$3.55	$6.32	$1.09	$40.26

NGL demand could drive future activity



Cardium natural gas and natural gas liquids (NGLs) production has steadily increased over the last 70 years – most recently as an alternative target in the Deep Basin when NGL prices drive up natural gas drilling. Production sits at around **750 mmcf/d** from a recent peak of 801 mmcf/d two years ago.

NGL demand is expected to rapidly increase as petrochemical and export capacity comes onstream. Almost **65,000 incremental bbls/d** of propane and **112,000 bbls/d** of ethane could be needed if all expansion projects proceed.

EXPANSION PROJECTS

Source: DOB Docs

Petrochemicals

Inter Pipeline HPC Project
Feedstock: **Propane**
Capacity Increase: **22,000 bbls/d**

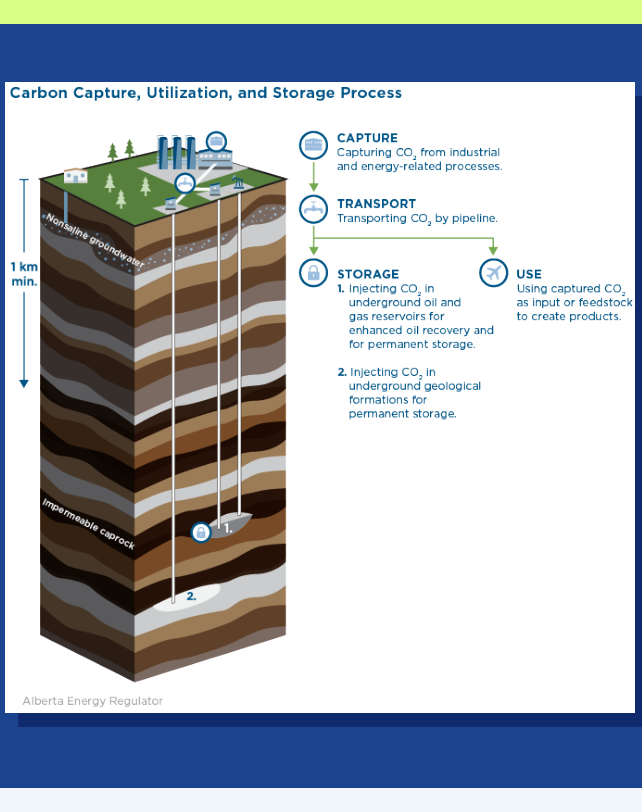
Dow Chemical Expansion
Feedstock: **Ethane**
Capacity Increase: **120,000 bbls/d**

Export Terminals

AltaGas Ridley Island Propane Export Terminal (RIPET)
Feedstock: **Propane**
Capacity Increase: **22,000 bbls/d**

Pembina Pipeline Prince Rupert Export Terminal
Feedstock: **Propane**
Capacity Increase: **20,000 bbls/d**

Will CCUS revitalize oil production?



CO_2 enhanced oil recovery (EOR) could help drive future oil production. In the early 2000s, numerous studies and a CO_2 pilot project took place in the Cardium before new drilling and completions technologies shifted the focus. Studies predicted CO_2-driven EOR could recover as much as **500 million barrels** from the Pembina alone.

With carbon capture and transportation infrastructure in place in central Alberta and six new hubs being considered, CO_2 EOR could return to the forefront. This idea is bolstered by the increased presence of **Whitecap Resources**, which has similar EOR projects in Saskatchewan and Alberta.