#### Western Canada Resource Plays: The Phoenix Awaits\*

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#### **Abstract**

Resource plays using horizontal drilling and multi-stage hydraulic fracturing technologies continue to dominate the Canadian oil and gas landscape outside of the oil sands areas. Canadian Discovery Ltd. continuously analyzes western Canada resource plays, spanning Cretaceous to Devonian reservoirs and extending across British Columbia, Alberta, Saskatchewan and Manitoba. This presentation provides a geoscientific and well completions overview of recent resource play activity, results and trends. The crash in oil and gas prices at the end of 2014 had a significantly negative impact on the number of wells drilled in 2015. In 2014, just over 7,500 wells were rig released from January to June; less than half that number of wells (approximately 3,600) were rig released during the same time period in 2015. Despite the price crash, several plays remain active—albeit at much lower numbers compared to 2014. High-activity plays such as the Montney, Spirit River and Viking will be discussed, along with up-and-coming plays such as the Charlie Lake, Dunvegan, and Midale as well as other Mississippian carbonate plays.

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Western Canada Resource Plays: The Phoenix Awaits!

June 22, 2016

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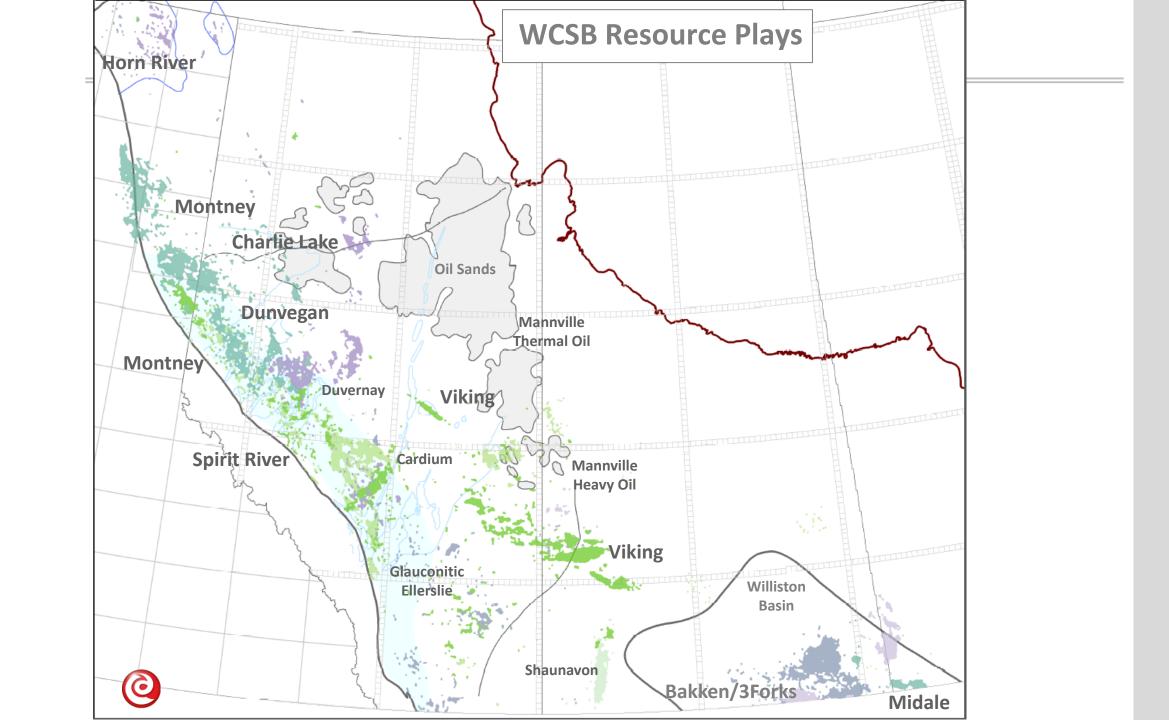
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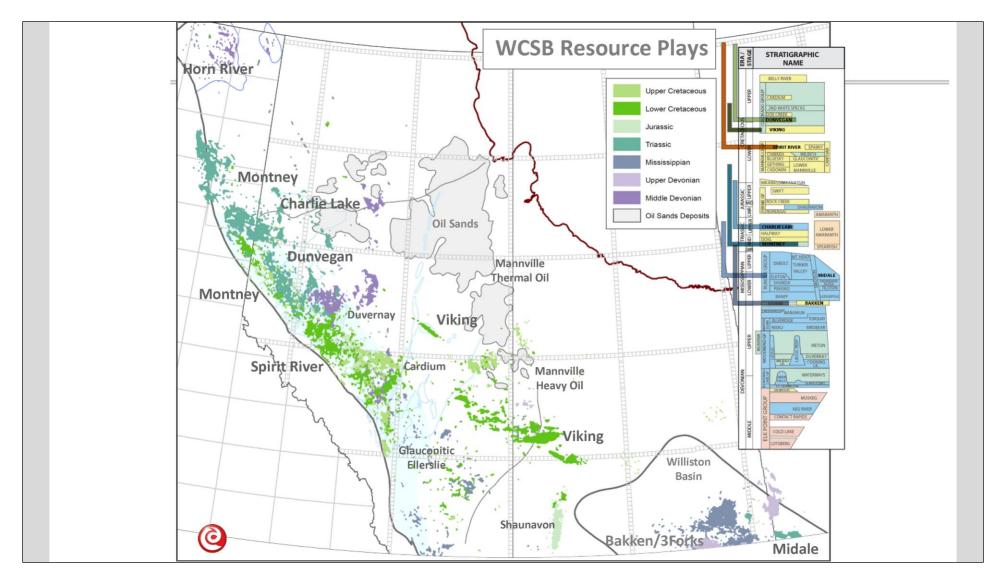
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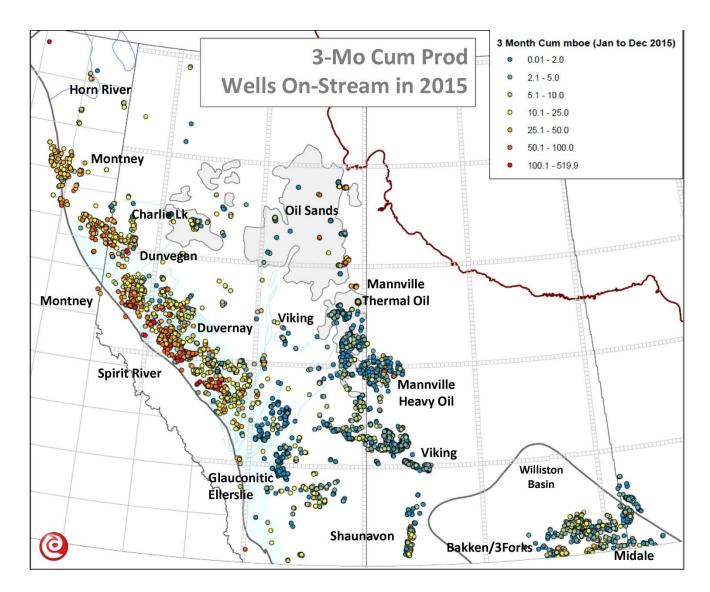
- 2015 WCSB Production Highlights
- Hot Resource Plays—Activity and Completions
- Developing Resource Plays
- Wrap Up



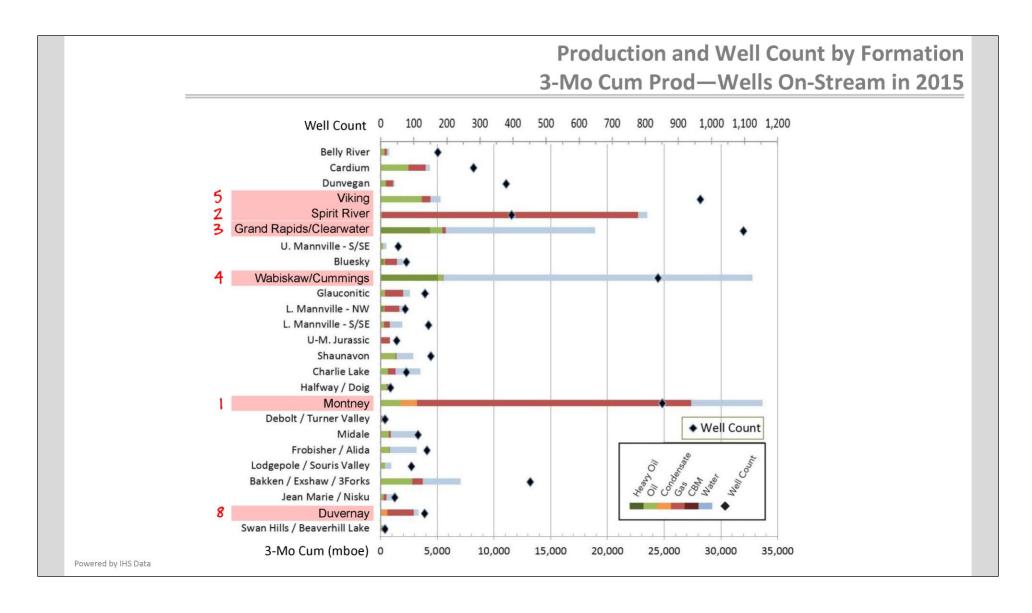


Presenter's notes: This map shows the current extent of resource plays in the Basin. They span the width of the basin from the Horn River in NEBC to Waskada in SW MB and the stratigraphic column from the Upper Cretaceous to the Middle Devonian. The biggies include the Montney, Spirit River, the Viking, and the Bakken/Three Forks. The developing plays are the Charlie Lake, the Dunvegan and the Midale. Other notable plays include the Duvernay, the Glauconitic and Ellerslie in southern Alberta. The sticks on the strat column are for the chosen seven and indicate the average TVD and lateral length. You can see that there is huge variation especially between the deep and long Spirit River wells and the shallow, short Viking wells.

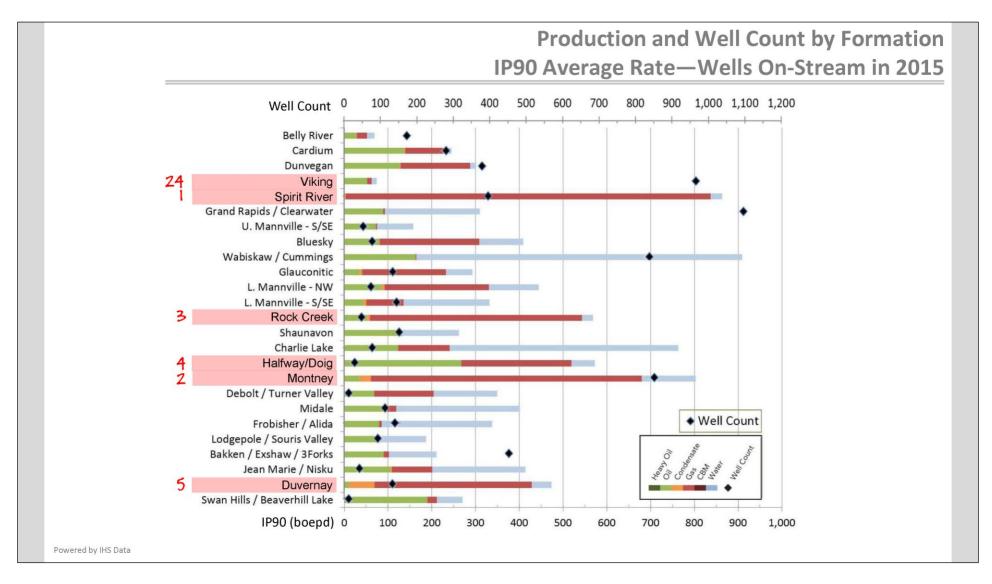
# **2015 Production Highlights**



Presenter's notes: This map shows the 3-month cumulative production in mboe for the wells that went on-stream in 2015. Though 3 months is a short time frame, it allows for normalization and some meaningful comparison to take place. Gas has been converted to BOE using a 6:1 ratio. The Montney, Spirit River, and to a some extent, the Dunvegan, account for some of the very good gas and condensate wells in NEBC and western Alberta. The Duvernay shows up in the Kaybob and Willesden Green areas. The Glauconitic and Ellerslie have been consistent producers in southern Alberta. Moving into Saskatchewan, the Shaunavon produces from both the upper clastics and lower carbonate units. There are some nice Midale, Bakken/Three Forks wells in SE Sask. Although rates in the Viking are not as high as other plays, it is economic and there are a lot of wells drilled. On the heavy oil side of things, some of the biggest producers in the basin are Mannville SAGD wells from the Cold Lake and Athabasca regions.

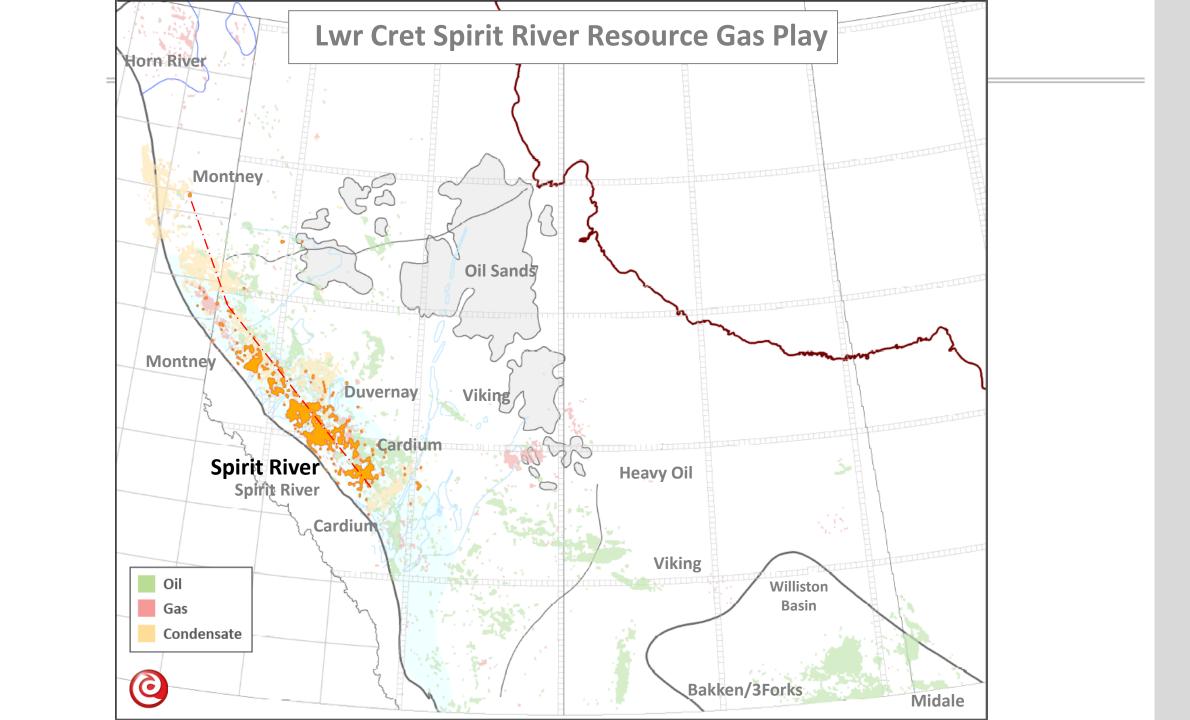


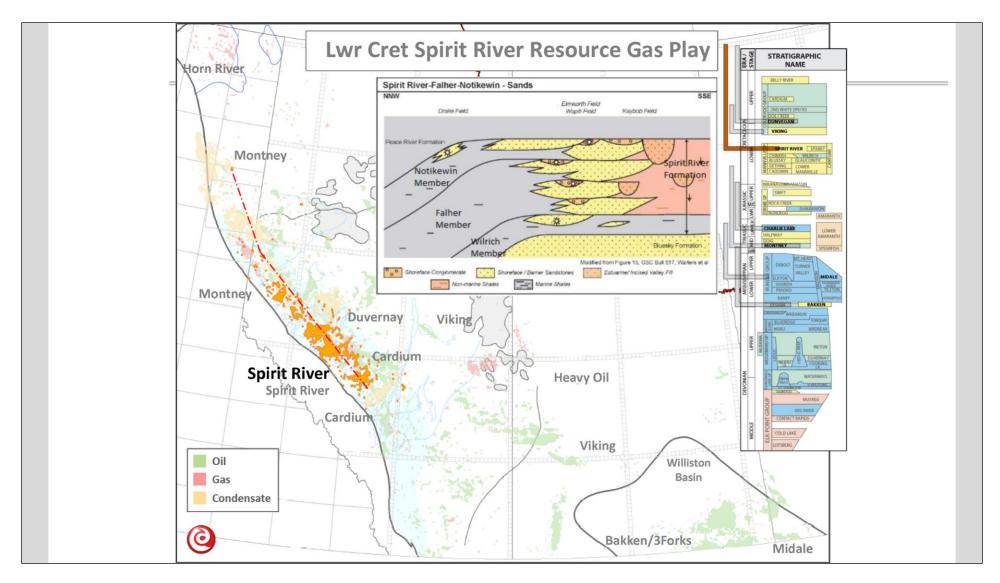
Presenter's notes: In this graph, all the various production intervals are aggregated into formations or zones and are graphed by three-month cumulative production differentiated by fluid. Well count is symbolized by black diamonds. The formations are sorted stratigraphically. Only the top 25 zones are shown. Note that the data are from public sources and the condensate is likely underreported. The Montney was the top hydrocarbon producing formation in 2015, followed by the Spirit River and its equivalents in NE Alberta, the Grand Rapids and Clearwater, which produce heavy oil. Another heavy oil producer, the Wabiskaw / Cummings is at number 4 and the Viking rounds out the top 5. The Duvernay is at number 8.



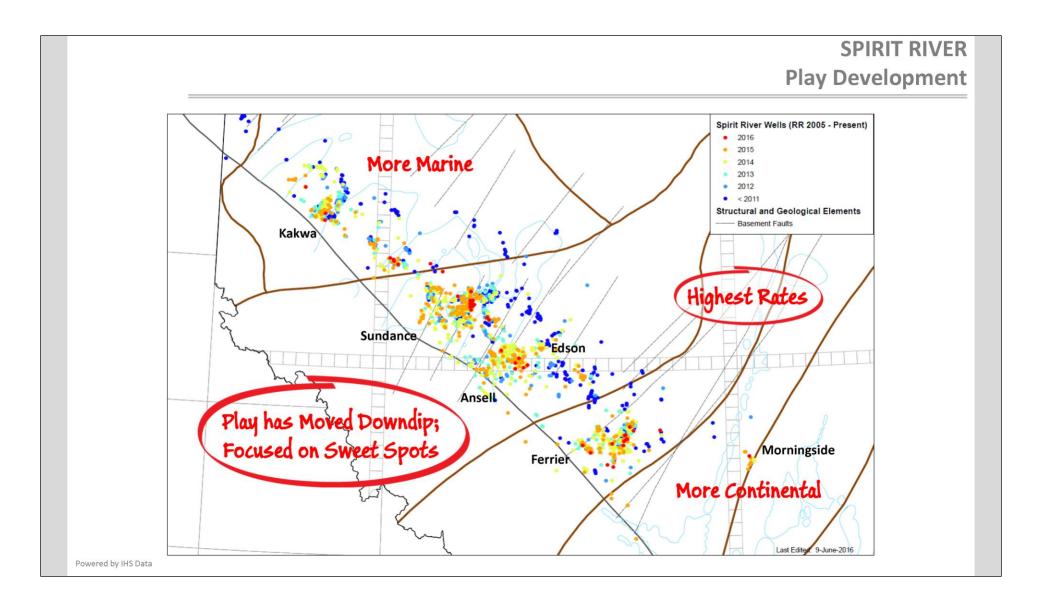
Presenter's notes: This graph represents the average IP90 rate for wells in the aggregated formations. The picture is somewhat different on a per well basis. The Spirit River comes in at number one, the Montney at 2. Two plays with relatively few wells are at 3 and 4, the Jurassic Rock Creek and the Triassic Halfway/Doig. The Duvernay is at 5. The Viking sits at 24 on this graph.

# **Hot Resource Plays**

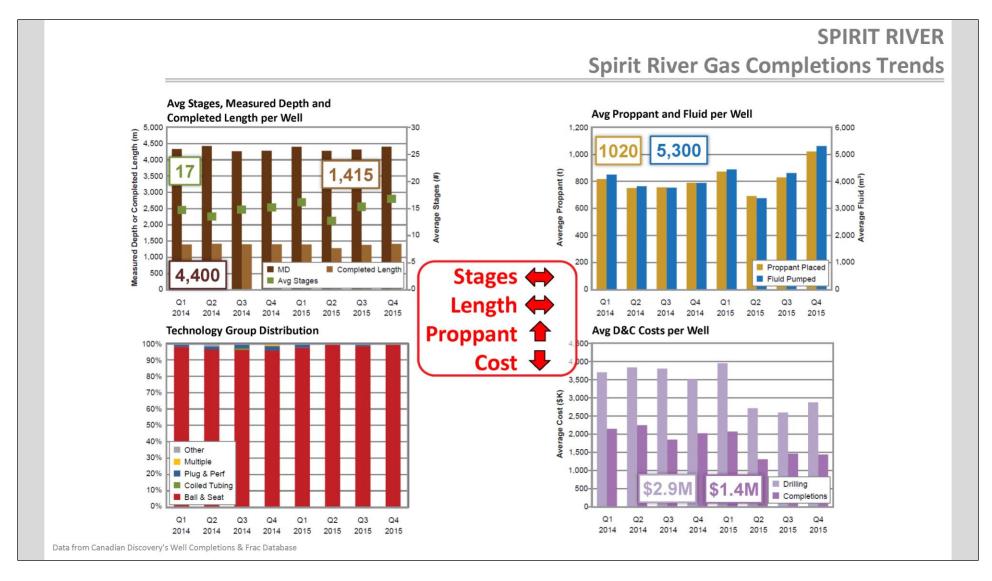




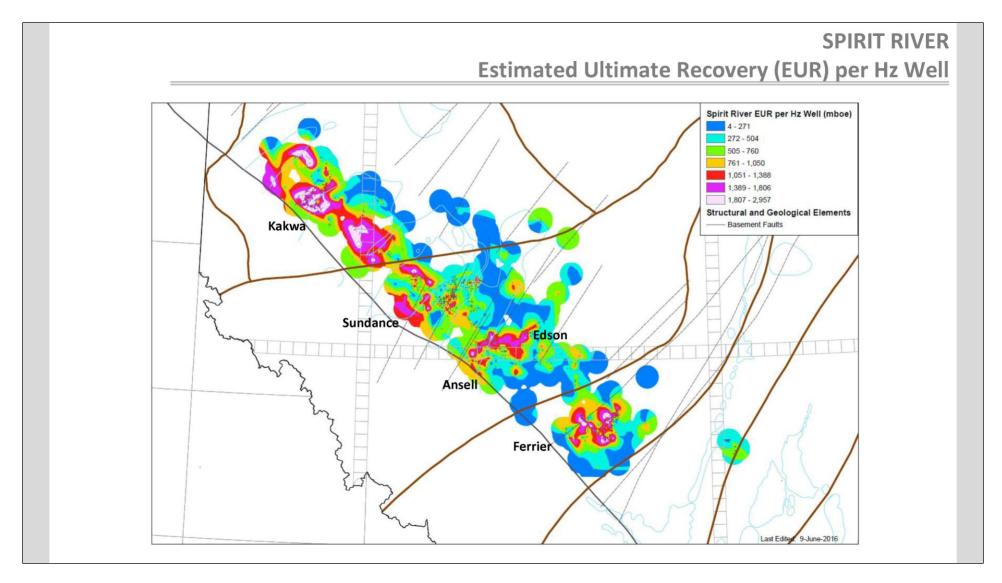
Presenter's notes: The Lower Cretaceous Spirit River play is located in the Deep Basin of western Alberta. The line of the cross-section is in red. The formation comprises three members, the Wilrich, Falher and Notikewin and becomes more continental towards the southeast. The sands are stacked, gas-charged and variably liquids-rich. The stick shows that the wells are deep with long laterals.



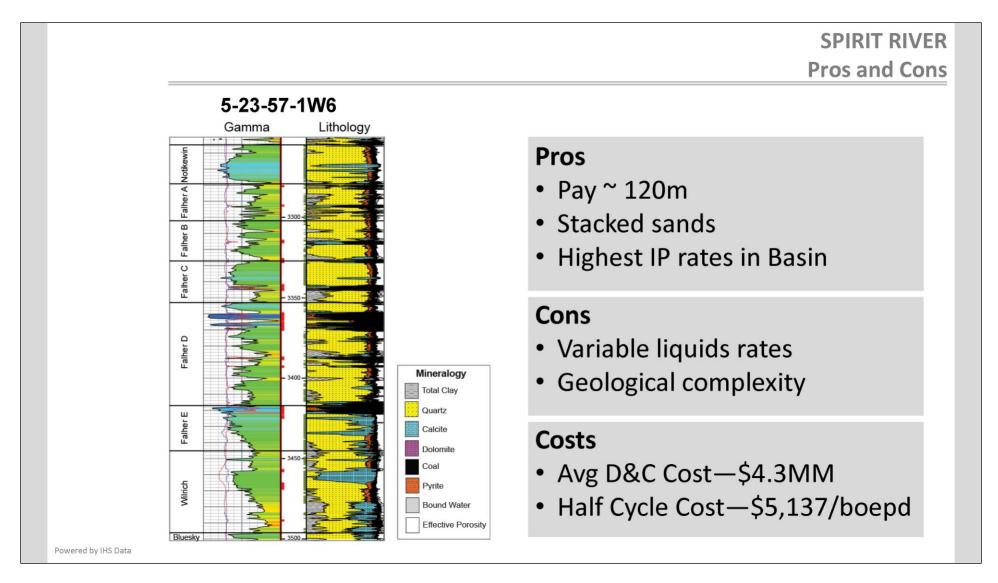
Presenter's notes: This map tracks the Spirit River drilling activity since 2005. Drilling in 2015 and 2016 (shown with orange and red dots) is focused in several sweet spots at Kakwa, Sundance, Edson, Ansell and Ferrier. Note the recent development at Morningside. Spirit River wells have some of the highest initial rates in the Basin.



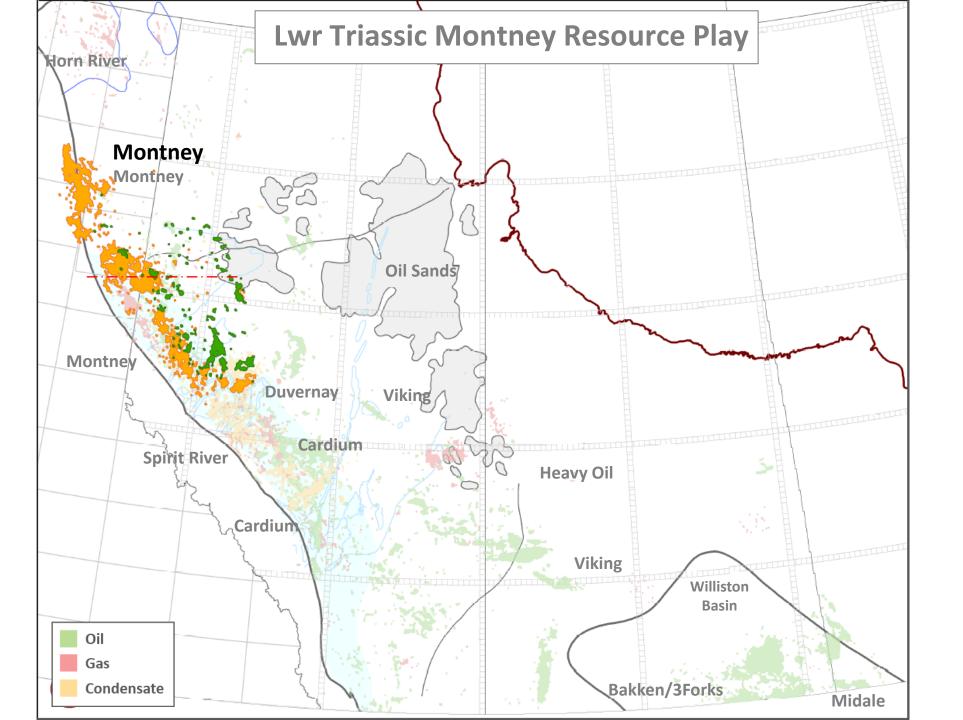
Presenter's notes: These graphs track completions trends over two years (eight quarters) from January 2014 to December 2015 and focus on several key completions parameters. The Spirit River play is maturing and completions strategies are changing relatively slowly. Operators have settled upon ball and seat isolation technologies in red. The number of stages (green squares), measured depth (dark brown bars) and completed length (light brown bars) have settled into a narrow range. Fluid volumes (blue bars) and proppant tonnages per well (yellow bars) are trending up. Drilling (light) and completions (dark) costs declined markedly in 2015. An average well cost about \$4.3MM to drill and complete.

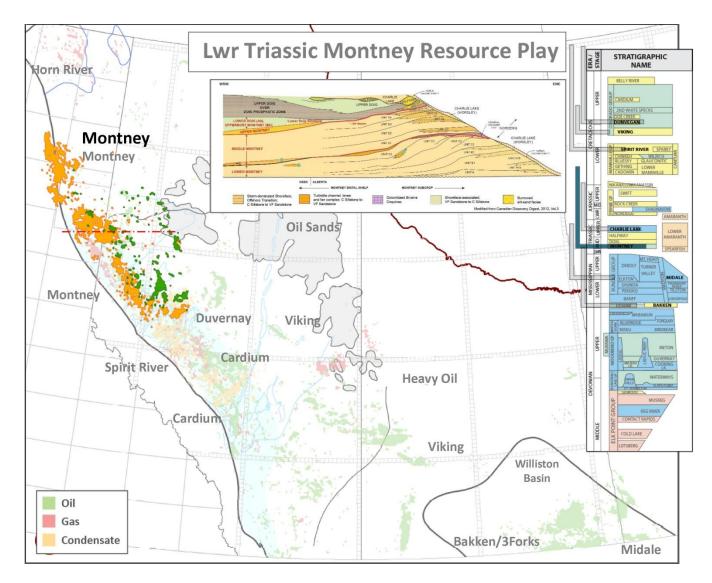


Presenter's notes: CDL has produced type curves for horizontal wells for various plays and used them to forecast Estimated Ultimate Recoveries per well. Gas was converted to BOE at the 6:1 ratio. Hot colours are largest EURs. For this map, EURs for the Notikewin, Falher and Wilrich, each of which have different sweet spots, have been combined for an overall look at the Spirit River. In general, the best EURs are coming from the more recent longer wells with the higher intensity fracs.

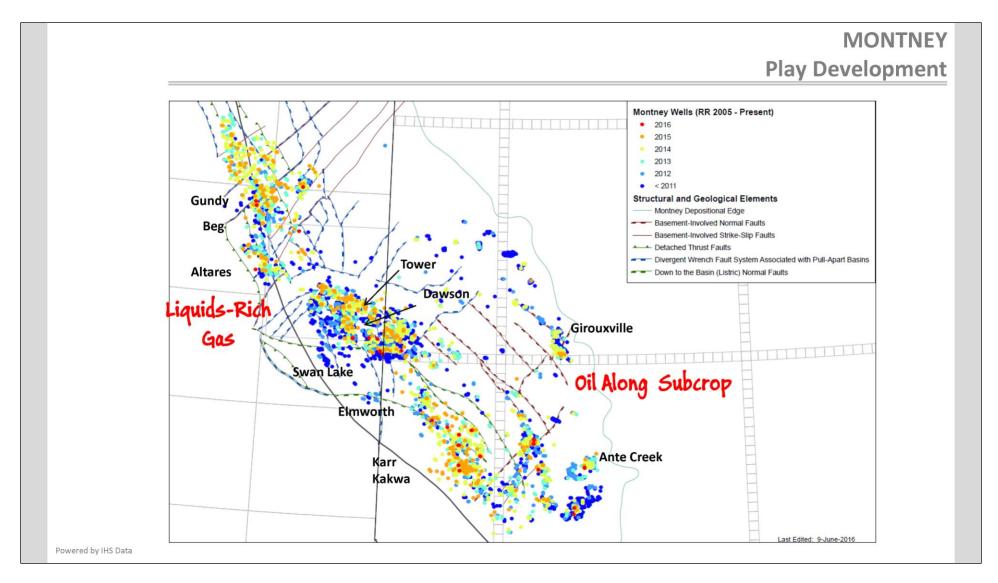


Presenter's notes: Pros: The Spirit River is characterized by a thick stacked sand section as seen on this log at Smoky. There is a marine sandstone in the Wilrich, interbedded sands, shales and coals in the Falher, and channels in the Notikewin. Pay can be up to 120m and rates are amongst the highest in the Basin. Cons: It is a relatively expensive play, liquids rates are variable and it requires detailed mapping and 3D seismic.

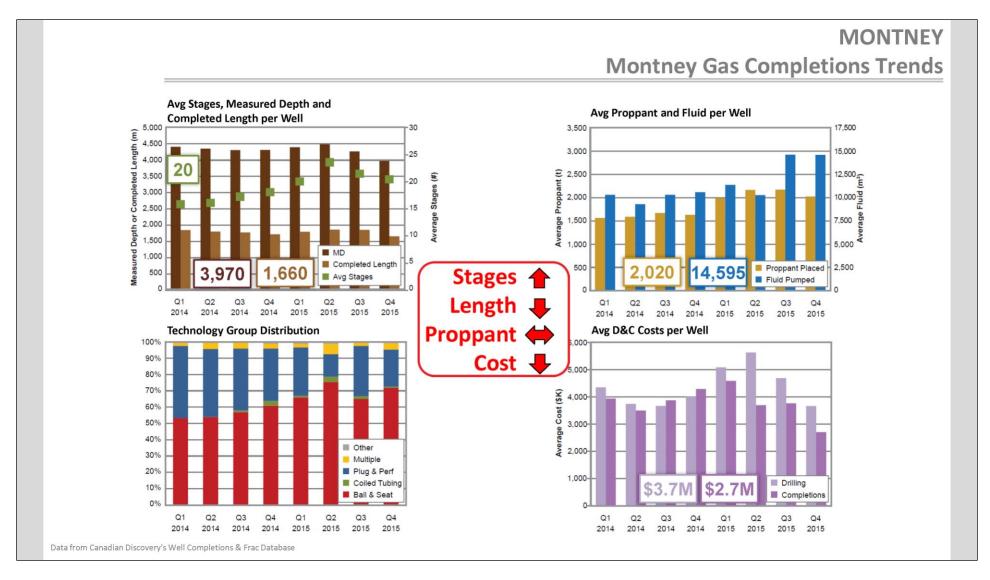




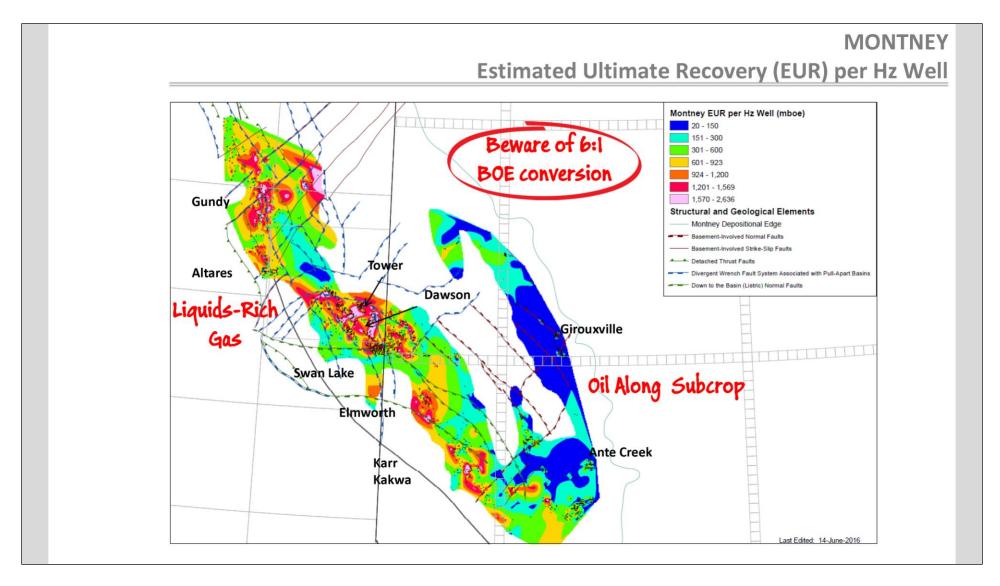
Presenter's notes: The Lower Triassic Montney comprises a wedge of sediments that thickens and becomes finer-grained towards the disturbed belt edge and subcrops in NEBC and NW AB. Oil is produced along the subcrop edge, then as the formation gets deeper liquids-rich gas and then dry gas is produced. The stick on the strat column shows that the wells are deep with long laterals.



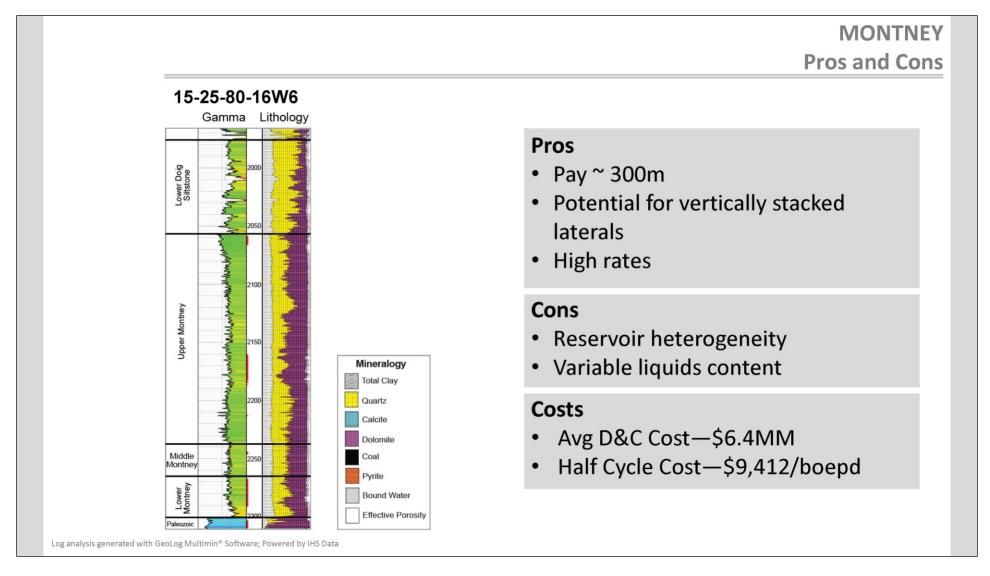
Presenter's notes: Drilling in 2015 and 2016 has focused on the deep liquids-rich areas at Montney North, Swan Lake, Elmworth and Kakwa.



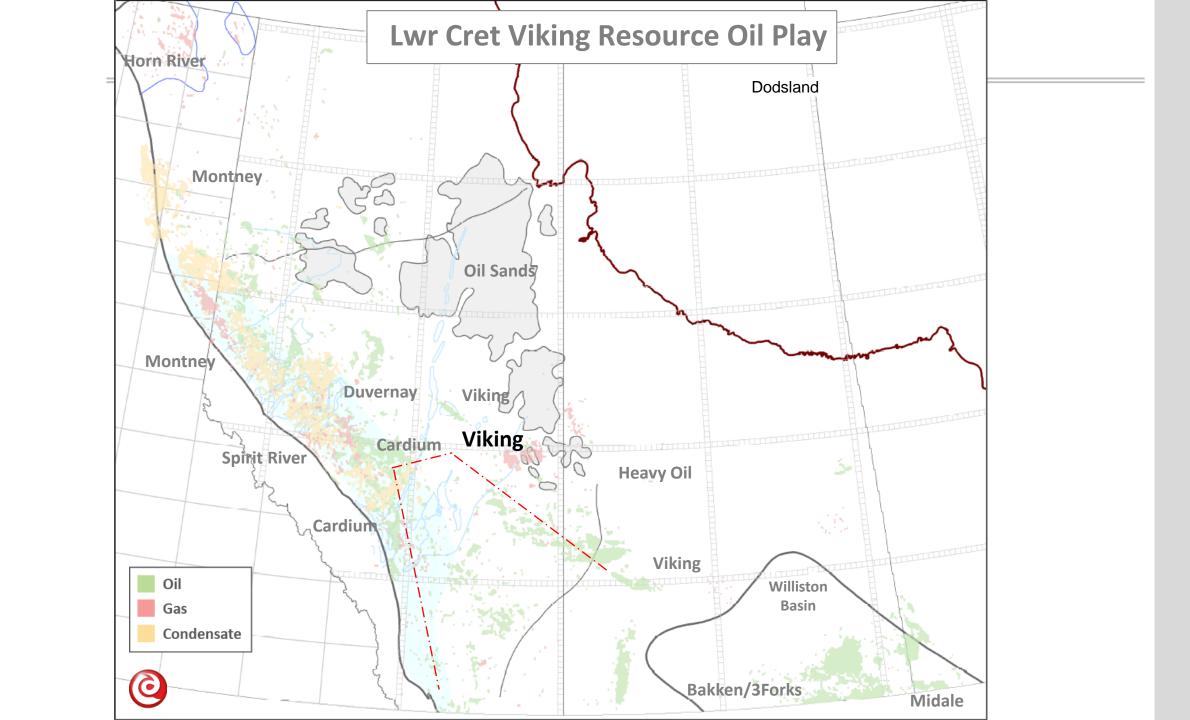
Presenter's notes: In the Montney gas plays, ball & seat isolation technologies (red) continue to gain share versus plug and perf technologies (blue), completed length has held steady while the measured depth and number of stages had gone up and back down. The amount of proppant placed has stabilized while the fluid pumped per well has gone up, mostly due to the use of slickwater. Drilling and completions costs declined throughout 2015, with an average well coming in at \$6.4MM

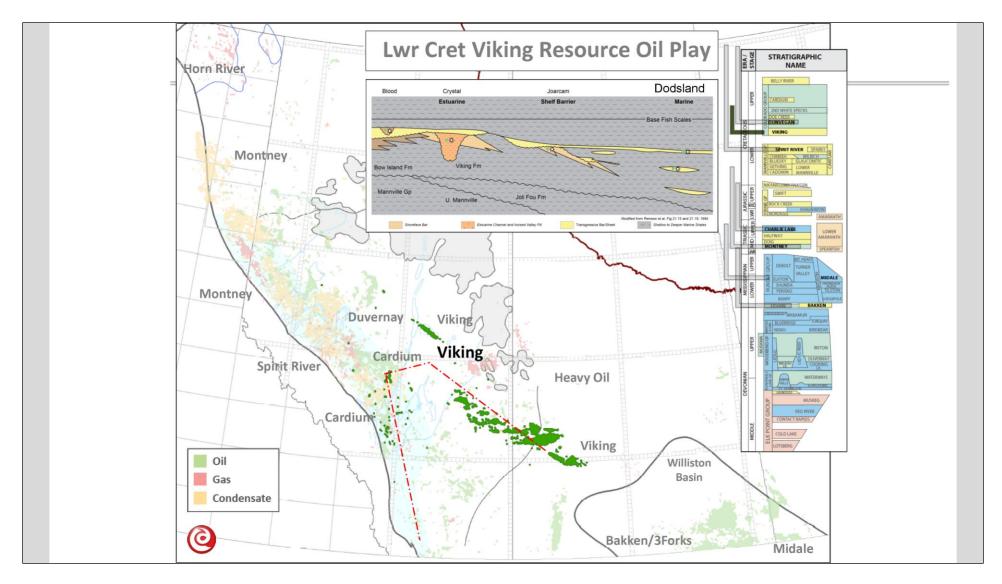


Presenter's notes: The most prolific areas of the Montney are in the siltstones of the distal shelf gas play at Montney North, Dawson, Elmworth and Kakwa, and especially where operators are using high intensity fracs. Beware of the 6:1 conversion as it makes the oil plays look less than they are.

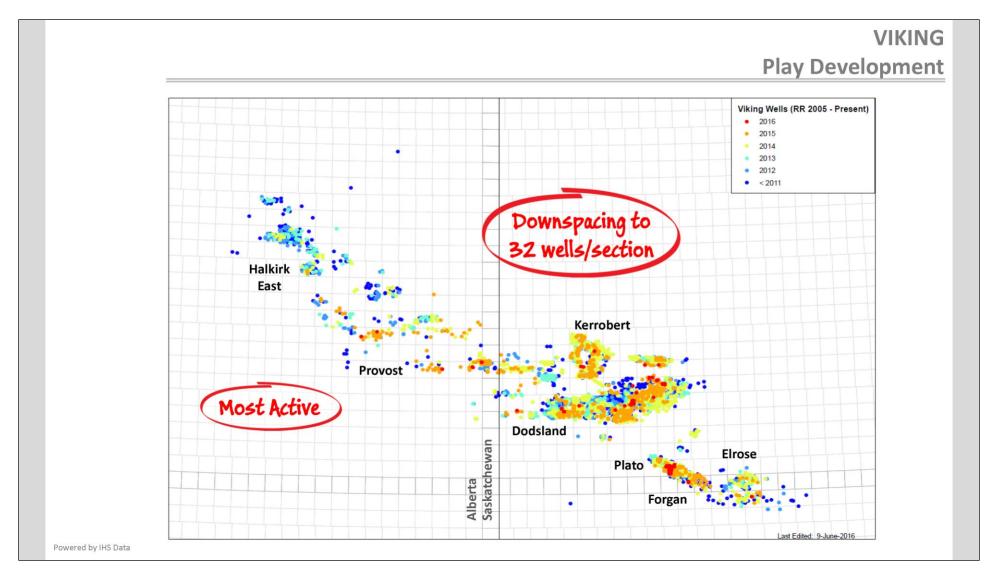


Presenter's notes: Pros: The Montney reservoir, in general, is very thick. In this log from a Dawson well, pay is calculated throughout the entire 300m section and, indeed, operators are completing in all four units. Rates in the distal shelf gas play can be very high. Cons: There is considerable reservoir heterogeneity, the liquids content is variable and the wells are costly.

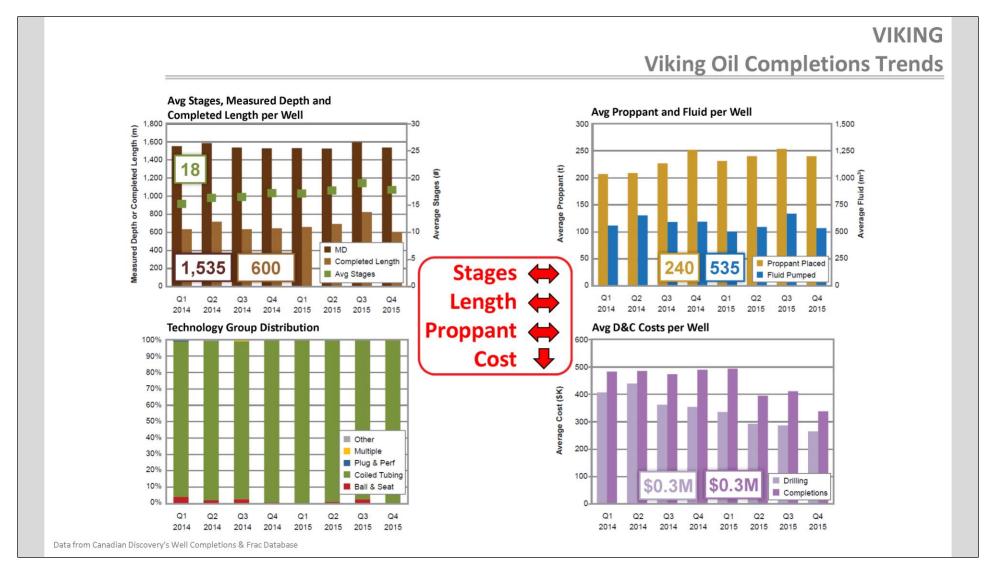




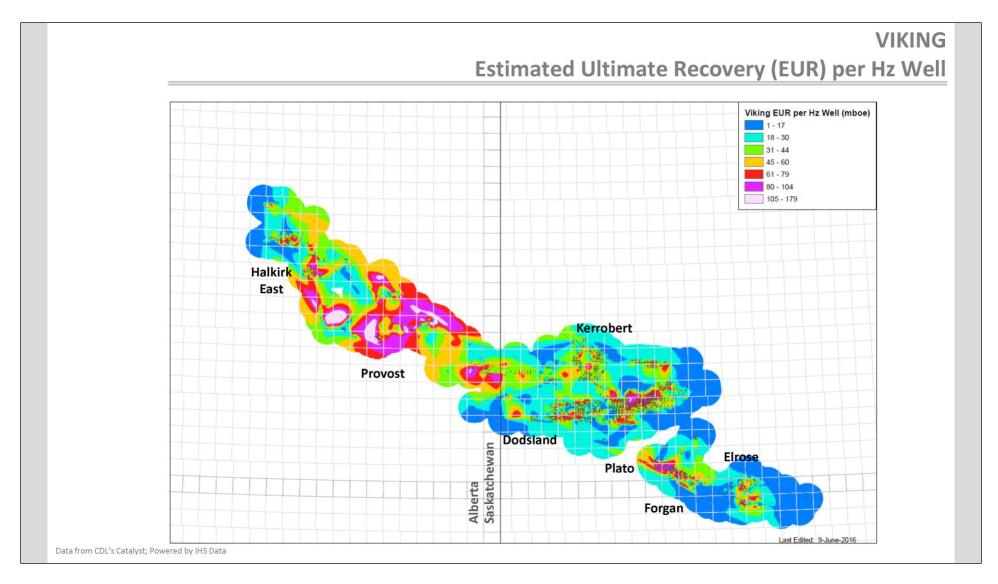
Presenter's notes: The Lower Cretaceous Viking is widespread across western Canada and has produced conventionally since early '50s. The Viking becomes more marine to the northeast. The resource oil plays are concentrated at Redwater, AB and Dodsland, Sask. These areas are distal as you can see on the cross-section and the reservoirs fine-grained. Stick says the wells are shallow and short.



Presenter's notes: The Dodsland play is the most active in the basin in terms of wells drilled. The Kerrobert, Dodsland, Plato and Forgan areas in Saskatchewan have seen a lot of drilling over the last two years. Activity in Alberta is concentrated at Provost. Note that some operators are downspacing to 32 wells/section.

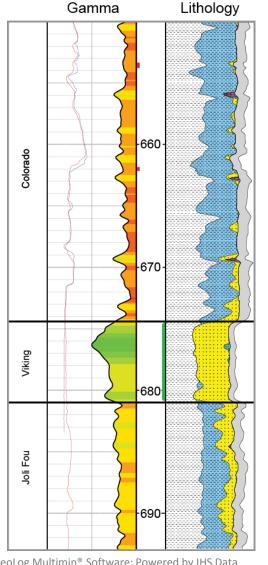


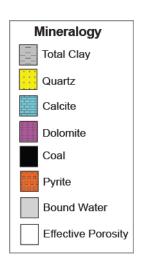
Presenter's notes: This play is mature and operators have their recipes for completions using coiled tubing isolation technologies and approx 18 stages. Costs continue to plunge and an average well is a bargain at about \$600K!



Presenter's notes: With respect to EURs, the best wells are in he Provost area where the Viking is just a little deeper, and at Plato and in the eastern parts of Dodsland.

### 3-23-31-21W3





### **Pros**

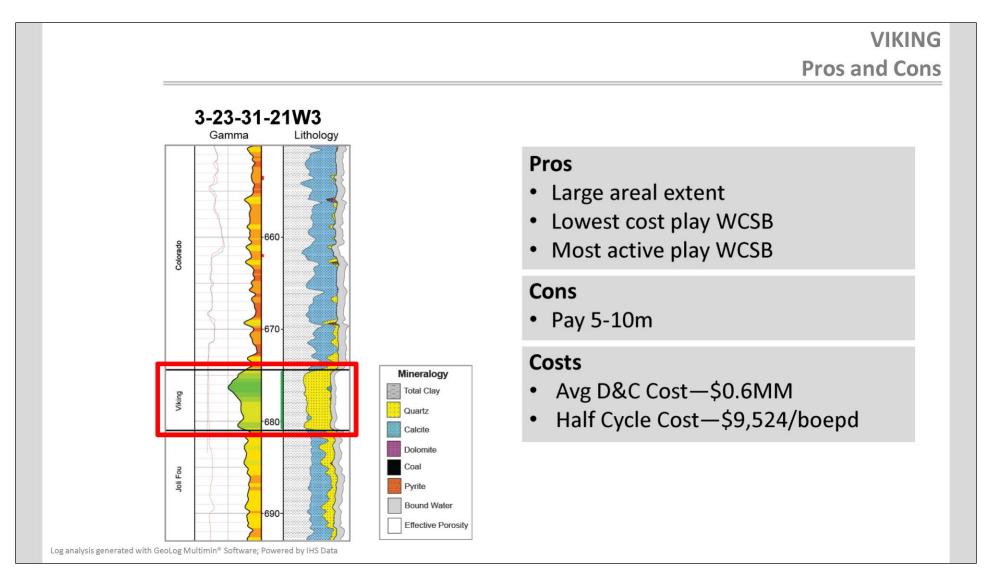
- Large areal extent
- Lowest cost play WCSB
- Most active play WCSB

# Cons

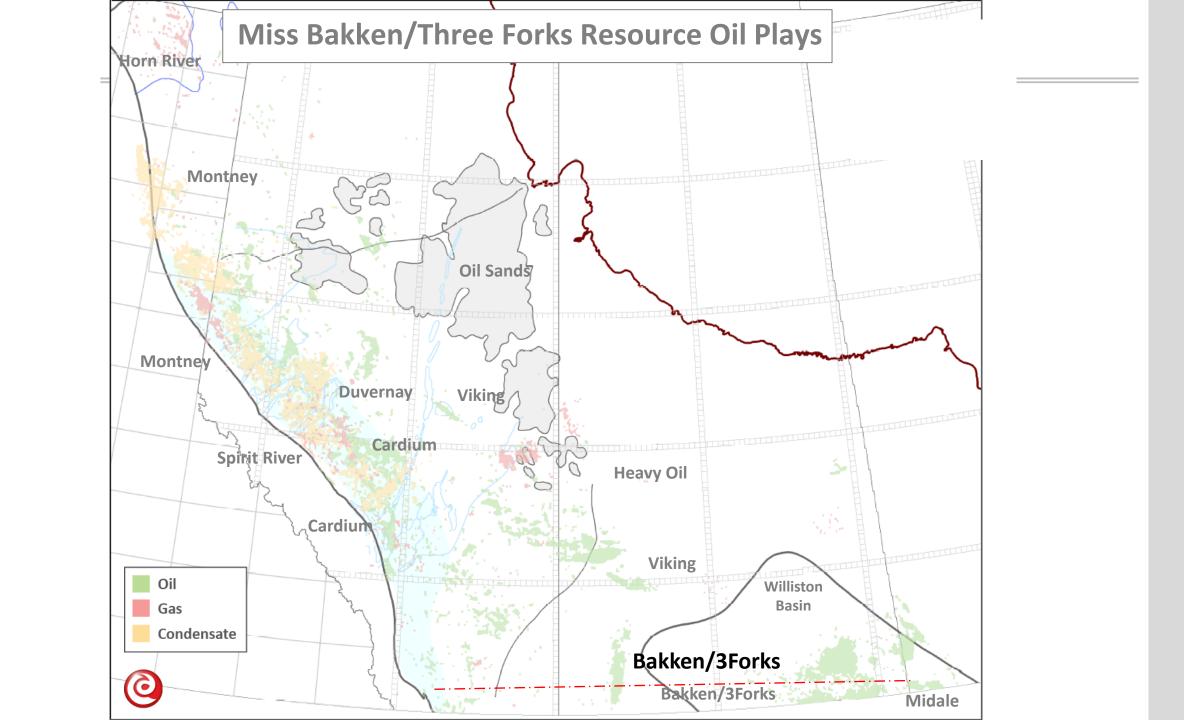
• Pay 5-10m

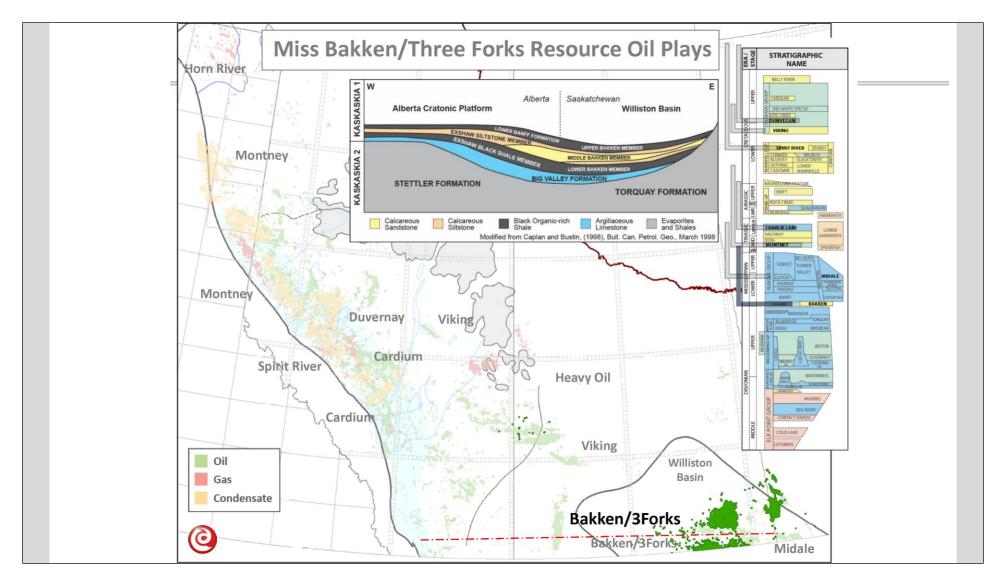
# **Costs**

- Avg D&C Cost—\$0.6MM
- Half Cycle Cost—\$9,524/boepd

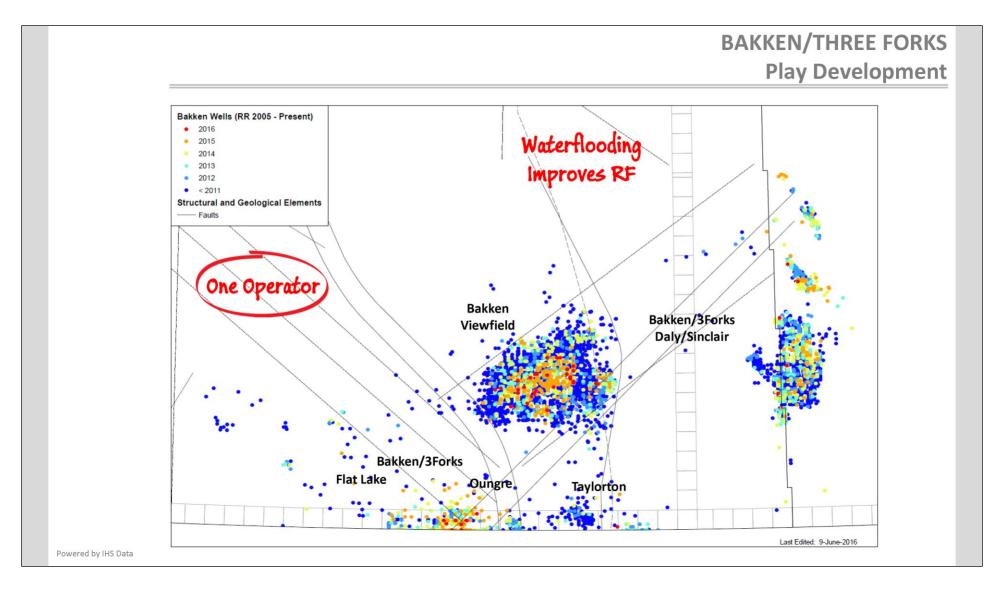


Presenter's notes: Pro-side, the Viking covers a large area and the wells have the lowest cost to drill and complete. Looking at the cons - This is a typical Viking well at Kindersley. The upper "cleanest" sand was initially developed conventionally by verticals, while the resource development is producing the lower, less "clean" sand as well. 6m of pay calculated in this well so pay is thin.

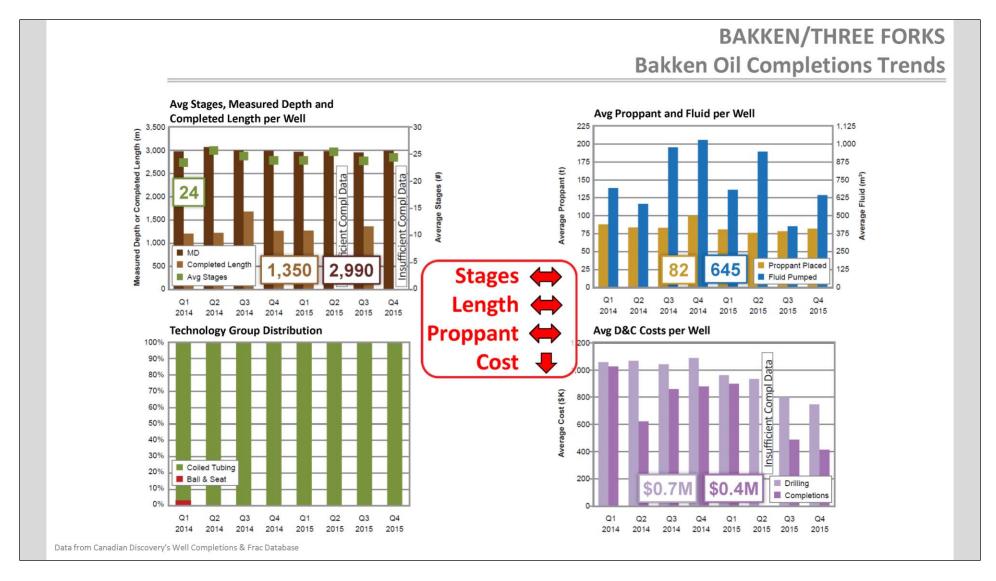




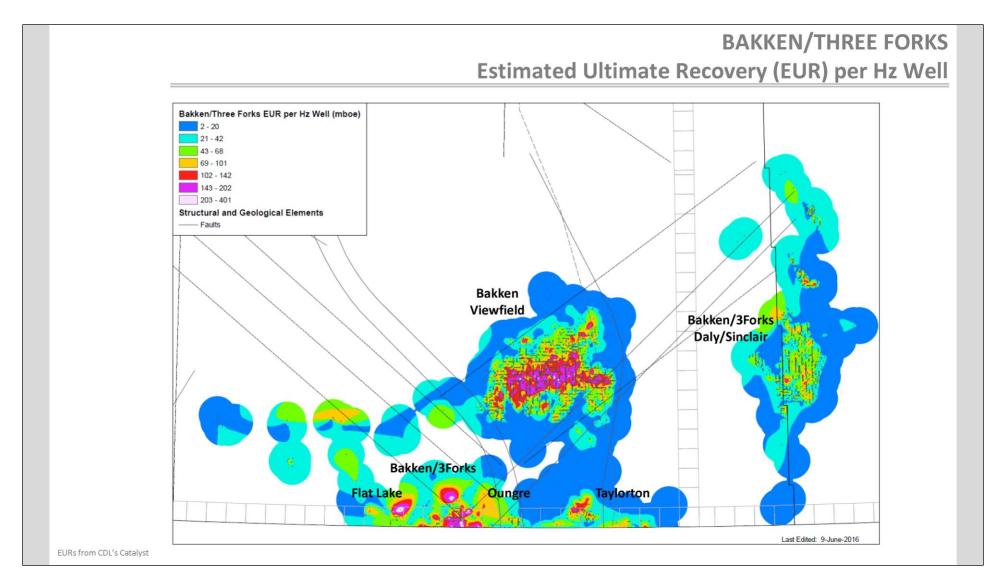
Presenter's notes: Moving to the Williston Basin where the oil-prone Mississippian Bakken/Three Forks play helped kick off the resource play boom in Canada. Most of the production is from the Middle Bakken Siltstone unit and interbedded sands in the underlying Three Forks/Torquay. The stick shows that the wells are much shallower than the Spirit River and Montney wells and the horizontals are shorter.



Presenter's notes: Recent activity has come back to the centre of the play at Viewfield, and there has been a fair bit of activity along the US border. Crescent Point now operates most of the wells in this play and some areas are being waterflooded.

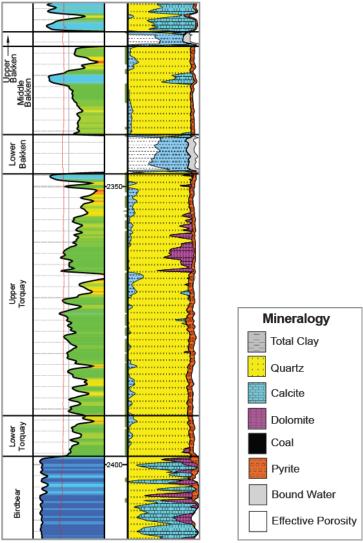


Presenter's notes: The Bakken completions graphs really reflect that this is largely a one operator play. Crescent Point has been completing wells with coiled tubing and deploying about 24 or 25 stages. Costs are trending sharply downwards and an average well is just over \$1MM to drill and complete.



Presenter's notes: At Viewfield, the Bakken solely contributes to the EURs while at Sinclair/Daly and along the border, both the Bakken and Three Forks contribute.

## 21/5-17-1-15W2



# **Pros**

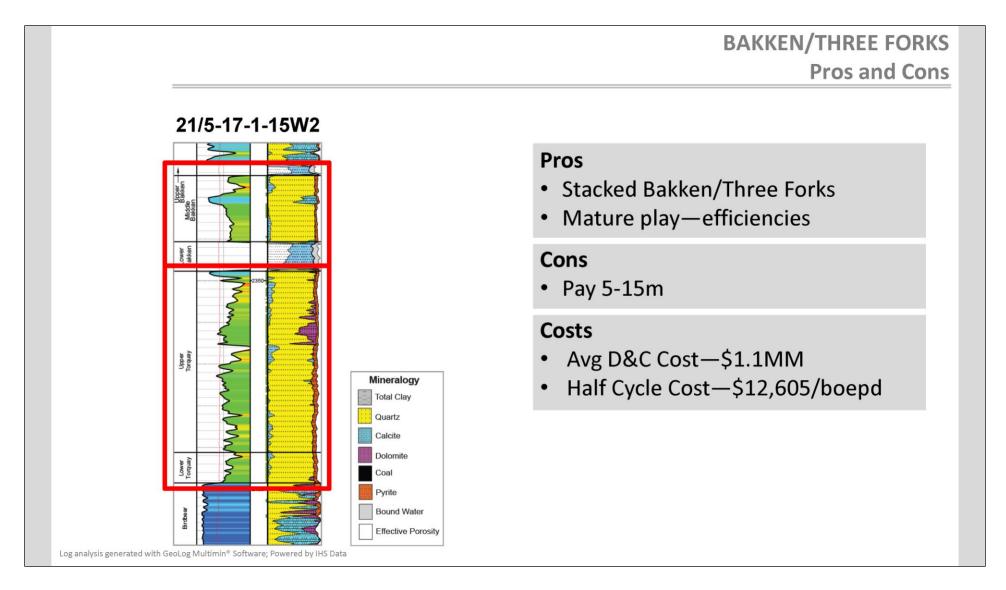
- Stacked Bakken/Three Forks
- Mature play—efficiencies

# Cons

• Pay 5-15m

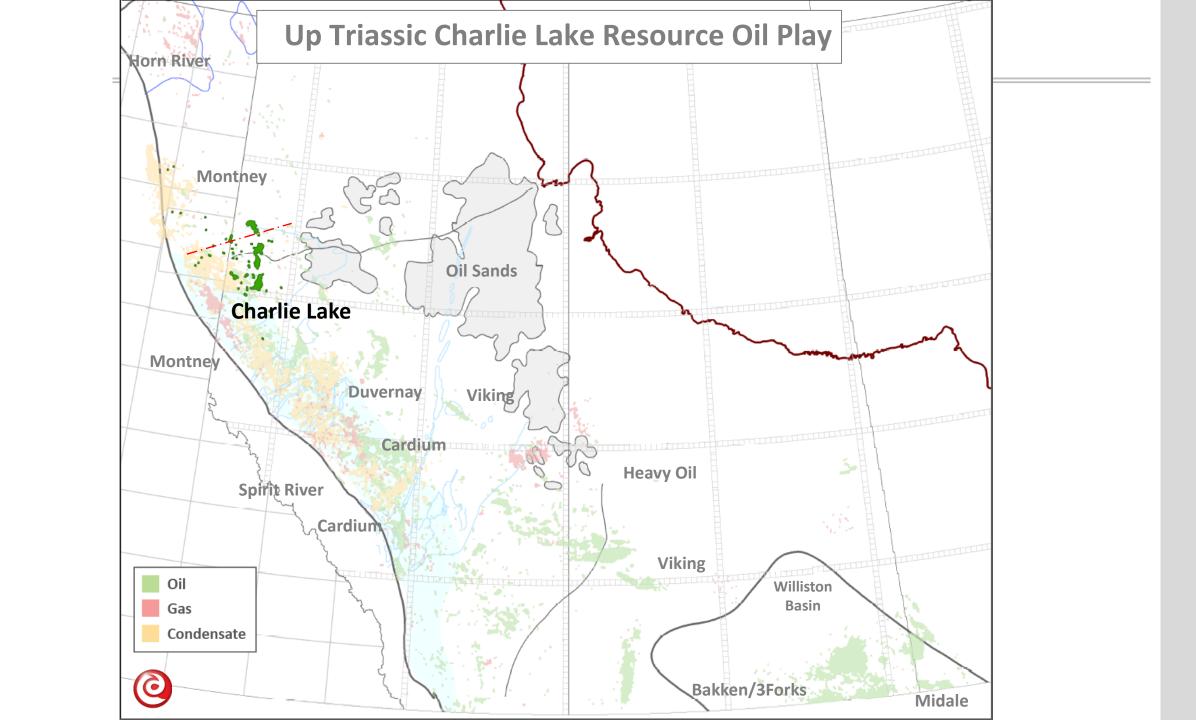
# Costs

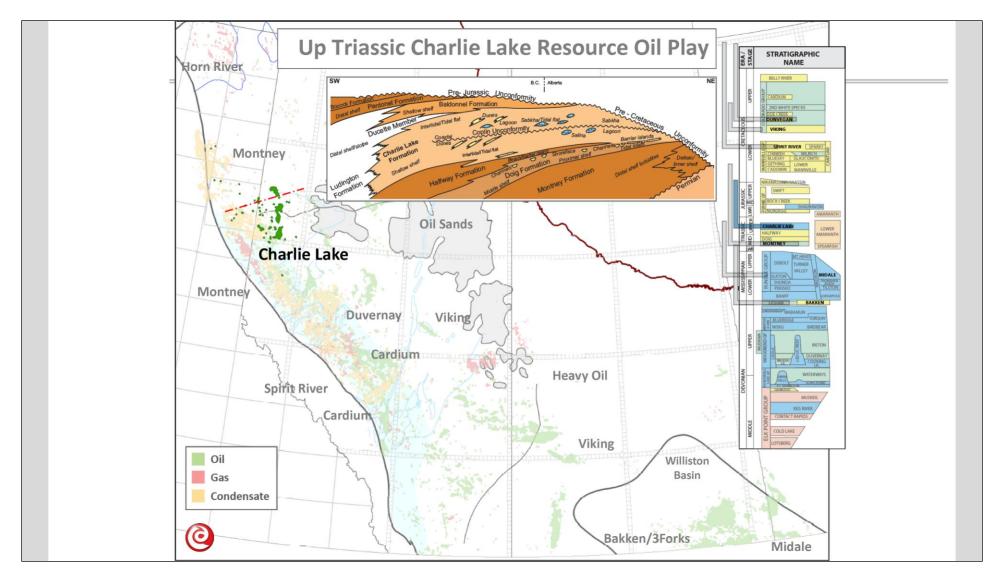
- Avg D&C Cost—\$1.1MM
- Half Cycle Cost—\$12,605/boepd



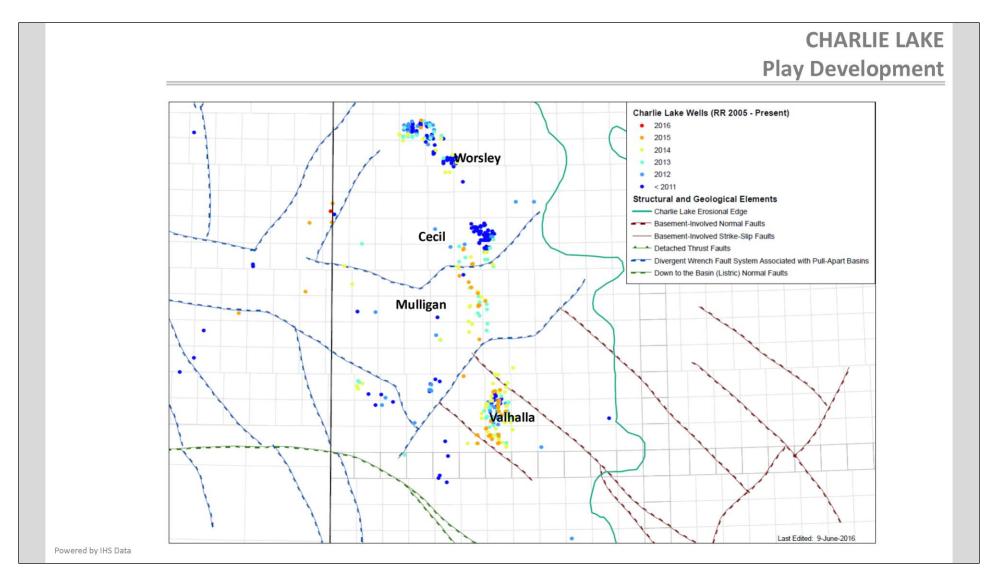
Presenter's notes: Pros: The Bakken/Three Forks is a stacked oil play. The logs show the thee-part Bakken formation with the productive siltstone in the middle, and the underlying sands or benches in the Three Forks. The play is very mature and the operators have achieved efficiencies. Cons: Pay is thin compared to the deep gas plays

## **Developing Resource Plays**

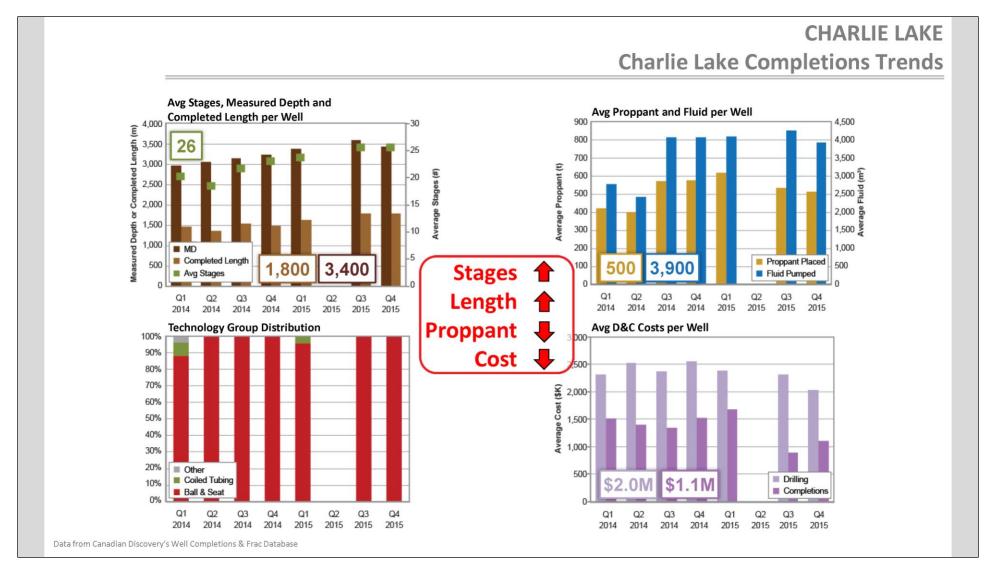




Presenter's notes: The Upper Triassic Charlie Lake in NW Alberta was deposited during what one of our young engineers called "a very hectic time in the Earth's history". The cross-section shows unconformities galore as sea level was fluctuating rapidly, and there may have been some tectonism going on. Environments of deposition ranged from shallow shelf in the west to intertidal and tidal flats near the BC/AB border to barrier islands to the east. As a result, the geology is a complex mixture of siliciclastics and evaporites. The play is oil-prone and the stick shows the wells to be of moderate depth with long horizontals

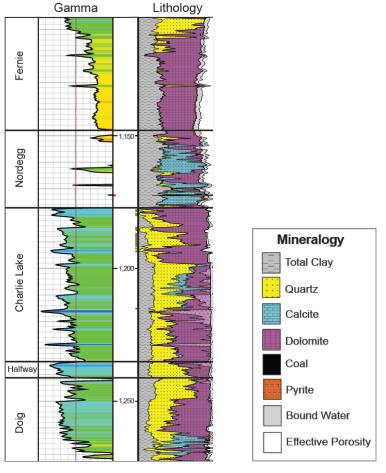


Presenter's notes: The play is concentrated in a N-S band from Worsley to Valhalla with most of the recent activity at Mulligan and Valhalla.



Presenter's notes: Completions trends are stabilizing and costs are declining. An average well comes in at 3.1MM to drill and complete.





## **Pros**

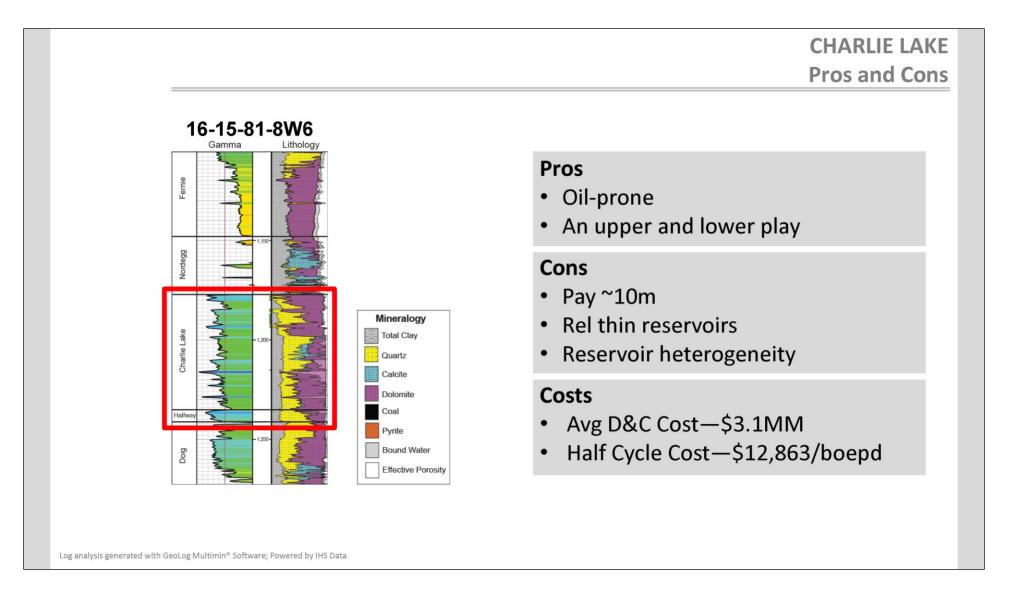
- Oil-prone
- An upper and lower play

#### Cons

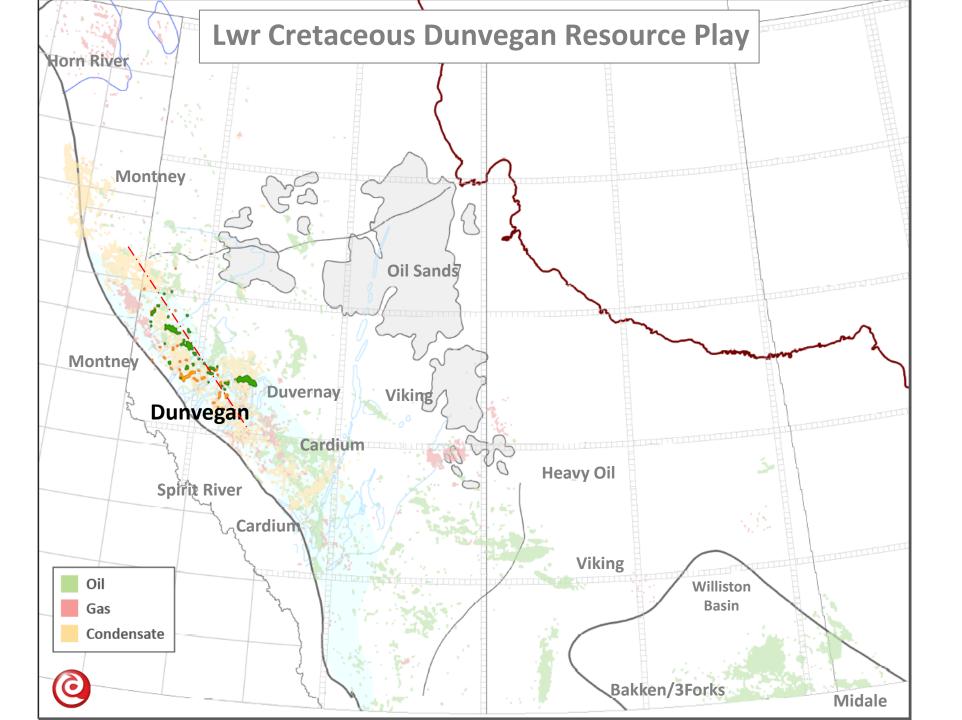
- Pay ~10m
- Rel thin reservoirs
- Reservoir heterogeneity

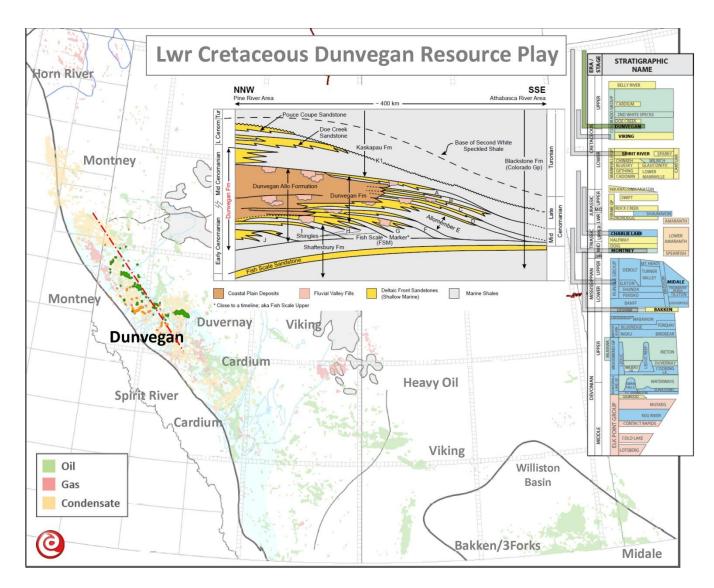
#### **Costs**

- Avg D&C Cost—\$3.1MM
- Half Cycle Cost—\$12,863/boepd

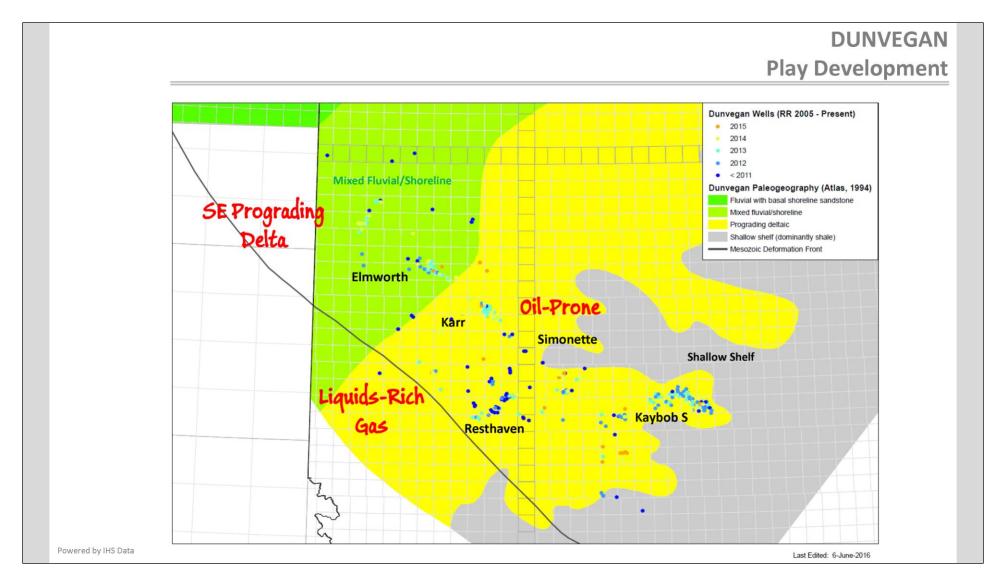


Presenter's notes: There are two plays, an upper and a lower. Cons: This log from Mulligan shows the complex lithologies in the Charlie Lake and the thinness of the pay intervals, so detailed mapping is required.

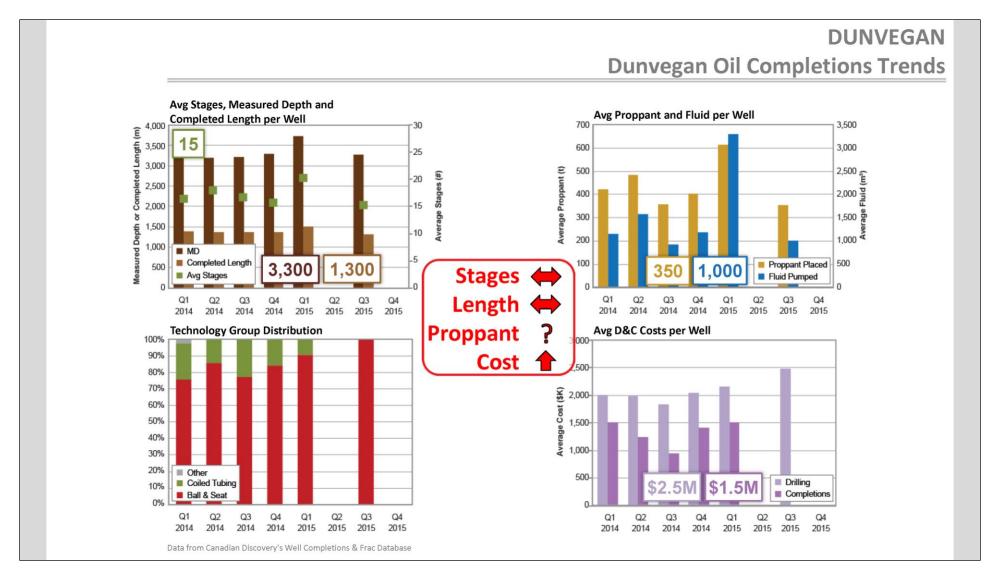




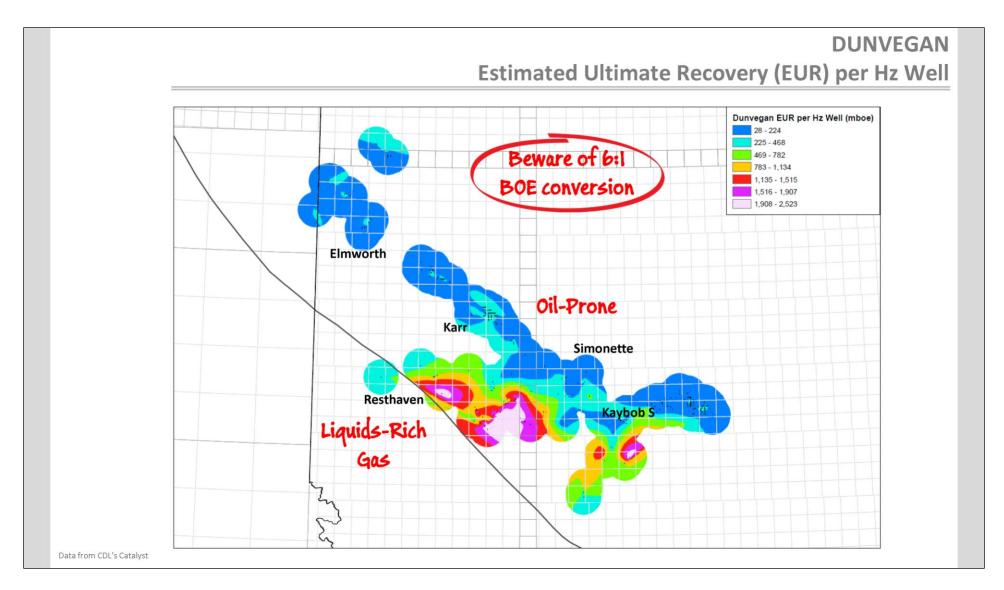
Presenter's notes: The Lower Cretaceous Dunvegan in northwestern Alberta was deposited as a southeasterly prograding delta and has produced conventionally for many years. Operators are now using multi-stage horizontals in the unconventional fringe reservoirs, and also in the conventional channels. Both oil and liquids-rich gas are produced. The wells, especially the gas ones, are moderately deep and have long laterals



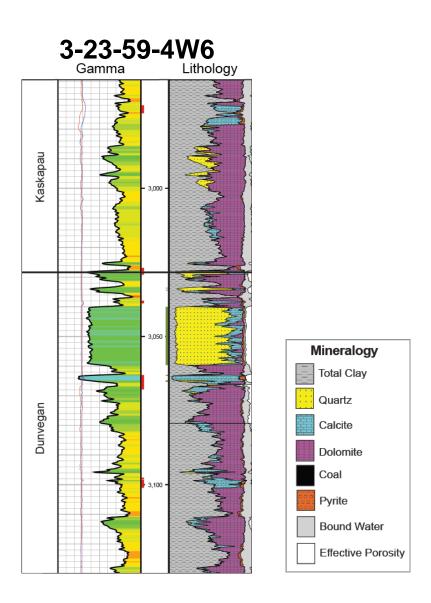
Presenter's notes: Resource play activity is focused along the axis of one of the lobes of the delta and is down a lot in 2015/16 compared to 2014. Liquids-rich gas is produced at Resthaven where it is deeper and hotter, while oil is produced updip



Presenter's notes: These graphs are for the oil play. The low well count in 2015 makes it hard to discern if trends are real. An average well costs in the range of \$4.0MM. Operators appear to be moving to ball and seat isolation technologies, while the number of stages and measured depth is fairly stable. Costs appear to be on the rise, but data are scarce.



Presenter's notes: The highest EURs are coming from the gas play at Resthaven, which has high rates and good liquids production, but beware of that 6:1 conversion! The oil areas are more active



#### **Pros**

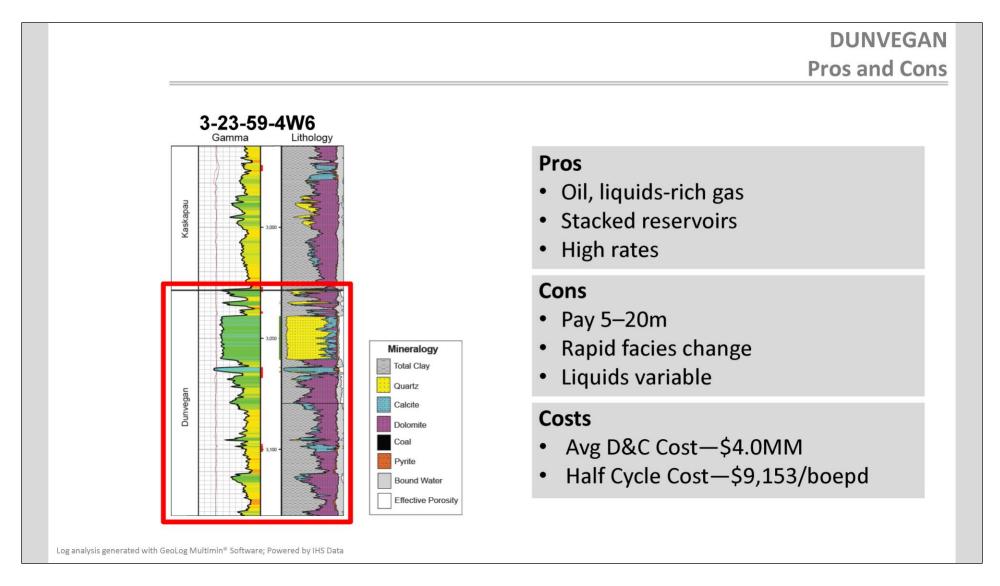
- Oil, liquids-rich gas
- Stacked reservoirs
- High rates

## Cons

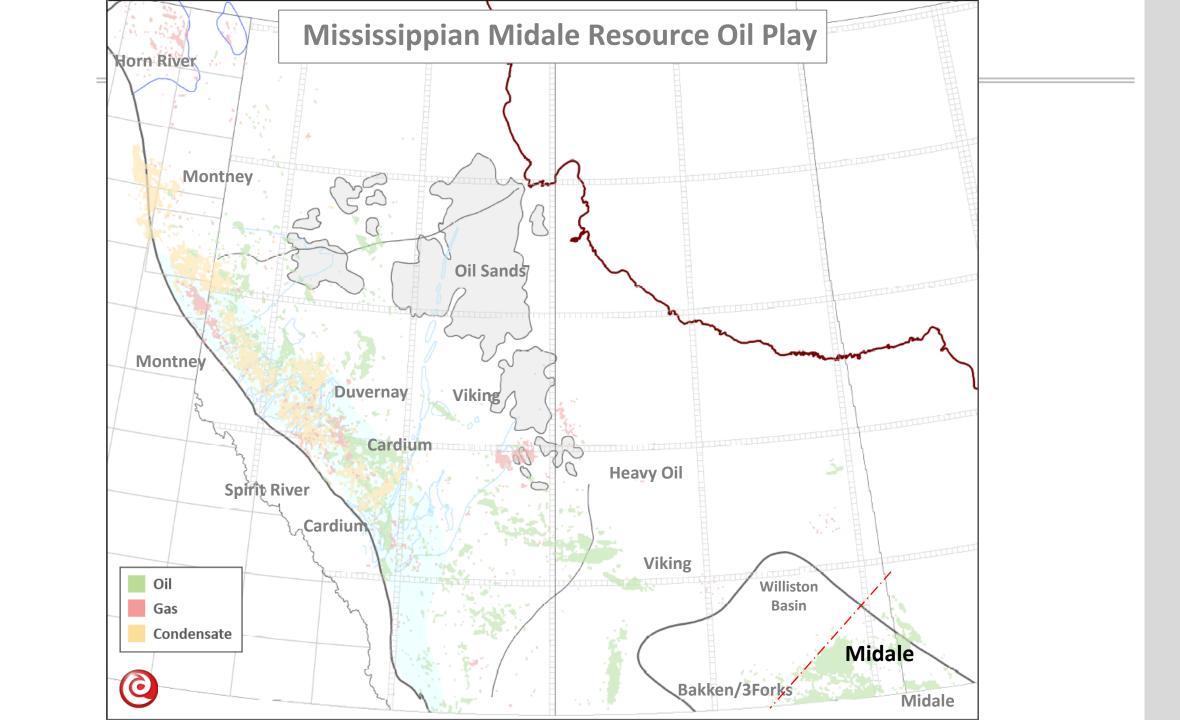
- Pay 5–20m
- Rapid facies change
- Liquids variable

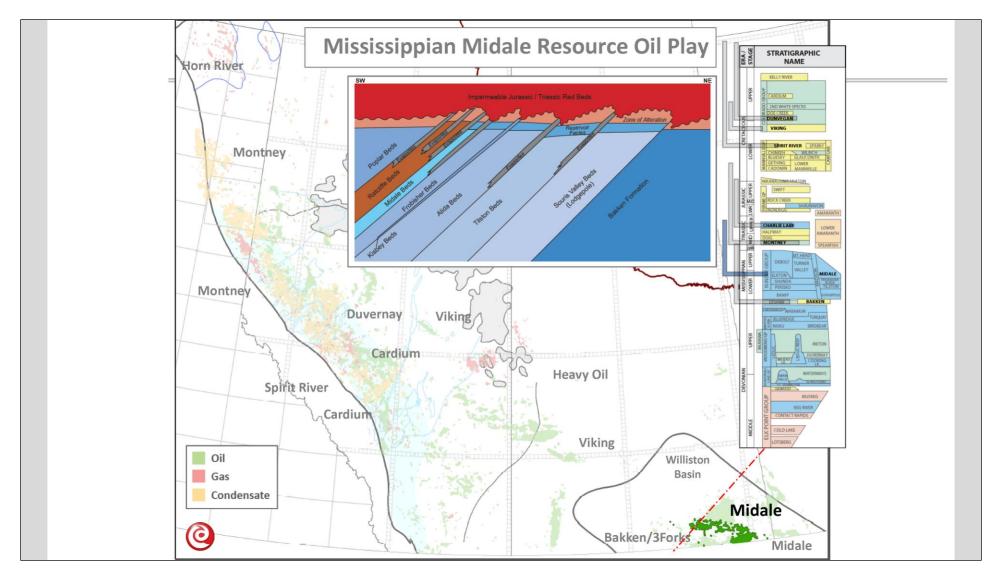
#### **Costs**

- Avg D&C Cost—\$4.0MM
- Half Cycle Cost—\$9,153/boepd

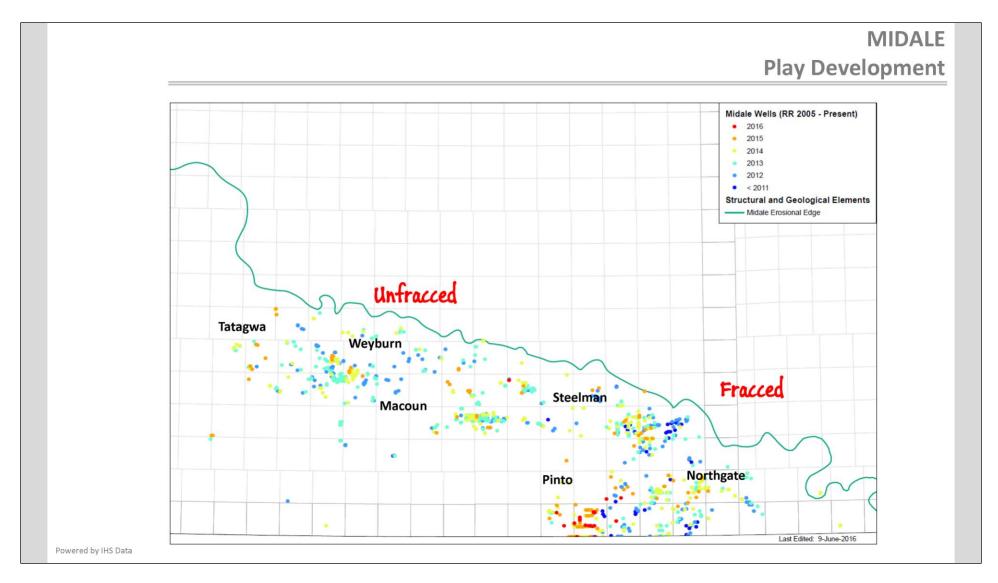


Presenter's notes: Pros: the Dunvegan has stacked reservoir potential as you can see in this log from Resthaven. This lovely channel sand has 20m of pay with 8% porosity. As well, initial rates can be high. Cons: the reservoir is relatively thin and facies change rapidly.

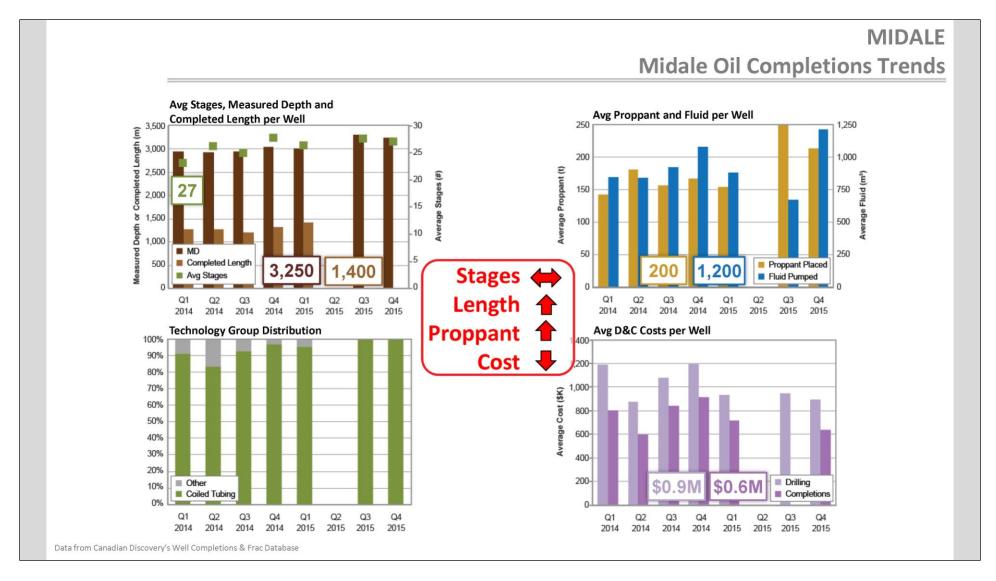




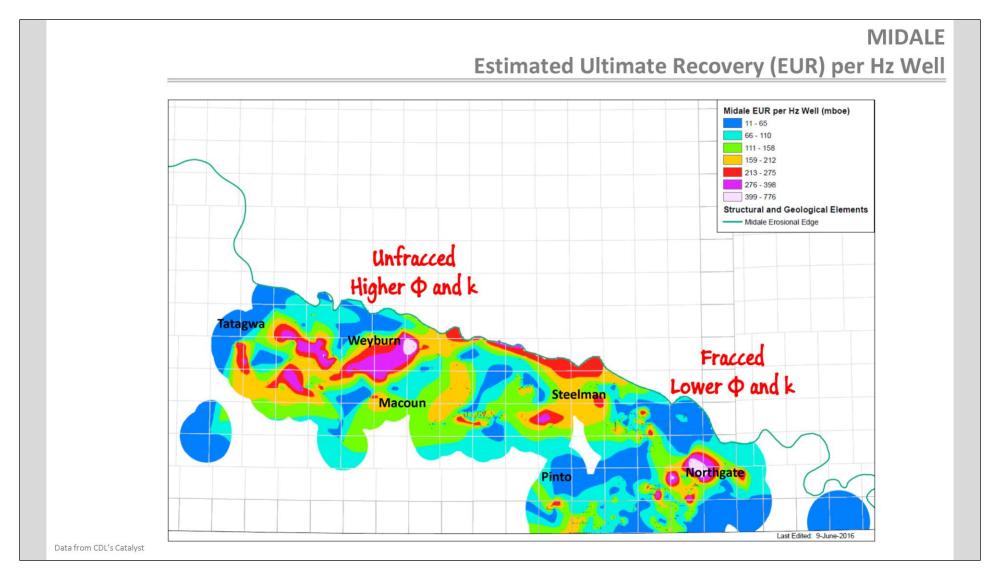
Presenter's notes: Moving to the Williston Basin. The oil-prone Midale play is one of several Mississippian subcrop plays that have been developed conventionally, but with horizontal wells, for many years. Around 2012, some operators began to frac the Midale in selected areas. Wells are relatively shallow with moderate laterals. The cross-section shows the Mississippian subcrop plays that are being pursued at the moment, which from the top include the Ratcliffe, Midale, Frobisher, Alida, Tilston and Souris Valley Beds.



Presenter's notes: The Midale fracked play is concentrated at Pinto and Steelman, while the unfracked play is centred around Weyburn. The cross-section shows the complex lithologies in the Midale, ranging from dolomites to evaporites.

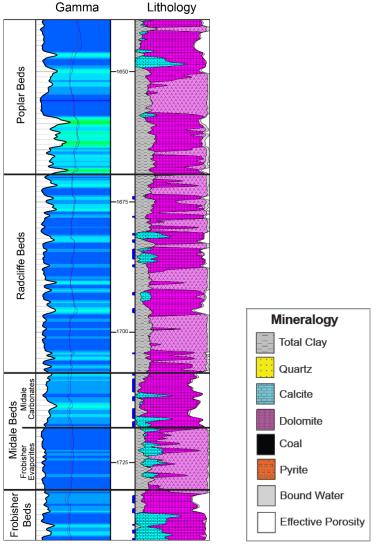


Presenter's notes: In the fracked play operators are using coiled tubing to deploy about 27 stages per well. It looks like experimentation is ongoing with the amounts of fluid and proppant being placed per well. Costs are trending down and an average well comes in at \$1.5MM.



Presenter's notes: The EURs reflect the underlying quality of the reservoir in this play. Core data suggests that the porosity and permeability are higher at Weyburn where the wells are generally not fracked and lower at Pinto and Steelman where fracking occurs.

#### 5-28-1-6W2



### **Pros**

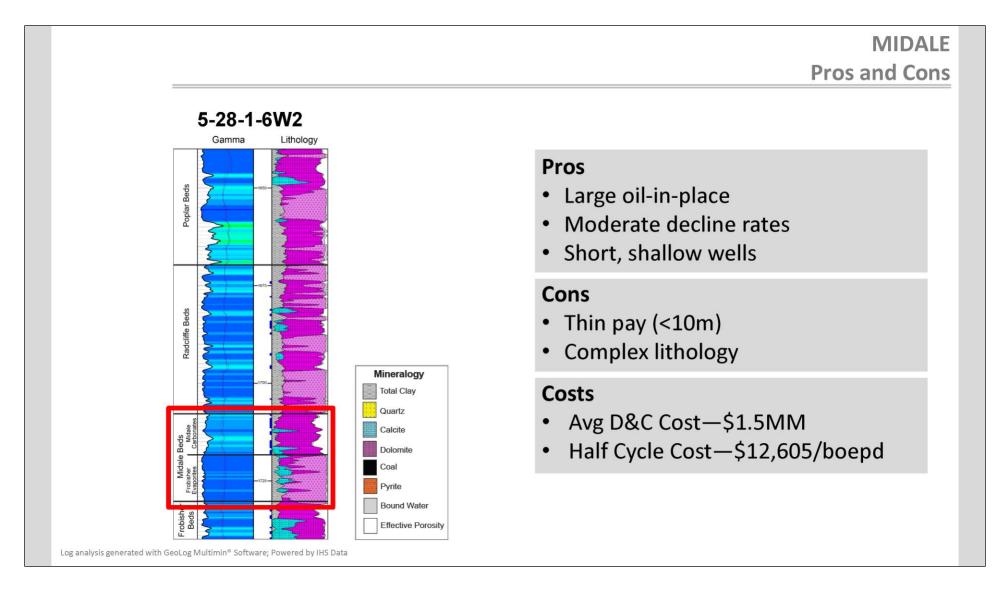
- Large oil-in-place
- Moderate decline rates
- Short, shallow wells

## Cons

- Thin pay (<10m)
- Complex lithology

## **Costs**

- Avg D&C Cost—\$1.5MM
- Half Cycle Cost—\$12,605/boepd



Presenter's notes: The log shows the complex lithologies in the Midale and that there is pay in the overlying Ratcliffe and Frobisher below. The Midale has favourable economics for several reasons: large OIP, low decline rate and the wells are relatively inexpensive to drill and complete.

# Wrap Up

W Play Com							
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rs	Mature Pla	Play	Maturing F		Emerging Plays		
Viking	Bakken	Montney	Spirit River	Midale	Charlie Lake	Dunvegan	
MD 1,535m Lateral 600m Pay 10m	MD 3,000m Lateral 1,350m Pay 15m (Oil)	MD 4,000m Lateral 1,700m Pay 300m	MD 4,400m Lateral 1,400m Pay 120m	MD 3,250m Lateral 1,400m Pay 10m	MD 3,500m Lateral 1,800m Pay 10m	MD 3,300m Lateral 1,300m Pay 20m	
Wells Drilled	Wells Drilled	(Liquids Rich Gas/Oil)  Wells Drilled (2015)	(Liquids Rich Gas)  Wells Drilled (2015)	Wells Drilled (2015)	Wells Drilled	(Liquids Rich Gas/Oil)  Wells Drilled (2015)	
				-	-	iin	
965	451	850	395	113	77	54	
D&C Costs	D&C Costs (\$MM)	D&C Costs (\$MM)	D&C Costs (\$MM)	D&C Costs	D&C Costs (\$MM)	D&C Costs (\$MM)	
0.6	1.1	6.4	4.3	1.5	3.1	4.0	
IP90 (boepd)							
63	102	680	837	119	241	437	
Half Cycle Cost (D&C Costs/IP90) (\$/boepd)							
0 0 0 0	9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	0 0 0 0 0	8 8 8 8 8 B 4 9 7		0 0 0 0 0 0 0 0 0 0 0 0 0		
9,524 Rank	10,784 Rank	9,412 Rank	5,137 Rank	12,605 Rank	12,863 Rank	9,153 Rank	

Presenter's notes: This infographic compares the seven plays you've just seen with the developing or emerging plays to the left and the more mature plays to the right. The stick shows the TVD and horizontal length with the Spirit River being the deepest, the Montney and Charlie Lake having the longest horizontals, in contrast to the shallow and short Viking. Net pay is also shown to pay on the top of the sticks. The Montney at 300m and the Spirit River with 120m dwarf the other plays. In 2015, the most wells were drilled in the Viking, followed by the Montney, Bakken and Spirit River. Drilling and completion costs are represented by the bar...Montney wells were the most expensive, Viking the least Barrels represent the IP90 rate, with the Spirit River coming in at number one, followed by the Montney and Dunvegan. The Viking has the lowest IP rates. The half cycle cost at the bottom is CDL's way of putting some sort of normalized ranking on these plays. It is the drilling and completion costs divided by the IP90 rate with the units being \$/boepd. Low numbers are good...the lower the better! With that in mind, the Spirit River takes the 2015 prize!

