

# Summary of Shale Gas Activity in Northeast British Columbia 2014

Upstream Development Division  
Tenure and Geoscience Branch

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Natural Gas  
Development

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# Summary of Shale Gas Activity in Northeast British Columbia 2014

British Columbia Ministry of Natural Gas Development  
Tenure and Geoscience Branch  
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## ABSTRACT

*Drilling activity in British Columbia picked up moderately in 2014 with a total of 697 wells rig released, compared to 567 the year before. Raw natural gas production in the province, which has seen an increase of 44% over the last ten years, was 4.6 billion cubic feet (Bcf) per day in 2014. The BC Oil and Gas Commission reported that exploration and development activities by industry in 2014 added 8.7 Tcf of remaining raw gas reserves. The established remaining raw gas reserves estimate of 51 trillion cubic feet (Tcf) to year-end 2014 represents a 20.6% increase over 203 year-end remaining gas reserves. British Columbia's crude oil production in 2014 was 20,281 barrels per day with contribution from the Heritage Montney 'A' oil pool becoming more significant. Bonuses collected from the sale of British Columbia's Crown petroleum and natural gas rights in 2014 totalled \$382.8 million compared to \$224.7 million in 2013. The average price per hectare of \$2,574 in 2014 was the highest since 2008. Almost 99% of the 2014 bonus total (\$377.2 million) was directed toward the purchase of parcels in British Columbia's unconventional Montney play trend.*

*Exploration activity highlights are covered for the four major unconventional gas regions in Northeast British Columbia, which encompass the Horn River Basin, the Liard Basin, the Cordova Embayment and the Montney play region. Other regions highlighted are the Greater Sierra region, which is focused on Upper Devonian Jean Marie tight gas development, and the Hay River area, which has seen continued development of the Cretaceous Bluesky heavy oil pools. Operators in the productive Montney play region were kept busy developing gas potential from the sandstone, siltstone and shale sequences of the Triassic Montney as well as tight gas targets in the Lower Cretaceous Cadomin. There was also increased activity in the north western edge of the Fort St. John region with the expansion of the areally-extensive Triassic Halfway tight gas play and horizontal development of the Charlie Lake light oil play.*

Adams, C., Janicki, E., and Balogun, A. (2015): British Columbia Oil & Gas Industry Activity Report 2014; BC Ministry of Natural Gas Development, xx pages.

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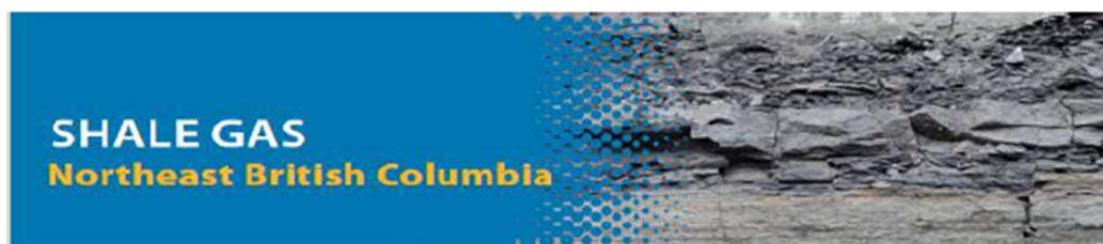
**Keywords:** shale gas, exploration and development, industry activity, Northeast BC, petroleum and natural gas rights, resource region, drilling, rig releases, operators, producers, special projects, horizontal drilling, hydraulic fracturing, natural gas, natural gas liquids, liquefied natural gas, Horn River Basin, Cordova Embayment, Montney play region, Liard Basin, production, reserves

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## INTRODUCTION

Exploration and production companies appear to have three clear business objectives in the near term: lowering their break-even points, solidifying their capital structure and focusing on the operating assets that hold less economic risk. Approximately 86.6% of wells drilled in British Columbia are now targeting world-class regionally extensive unconventional gas plays, such as the Horn River Basin, the Cordova Embayment, the Liard Basin and the Montney play trend. These unconventional gas regions continue to have a major impact on the growth of natural gas supply in British Columbia. Oil and gas operators are continually improving natural gas extraction techniques from a variety of low permeability horizons (Table 1) with optimal multistage hydraulic fracturing systems, better well and completion design methods used with horizontal drilling, and improved water use management strategies. In 2014, producing companies continued

to see remarkable success in their unconventional development programs, particularly in many regions of the Montney play trend. Bonuses paid for the purchase of petroleum and natural gas rights in the province in 2014 were up 70% compared to 2013. Producers particularly focused on purchasing rights within the liquids-rich gas portions of the Montney play trend where significant natural gas liquids (NGL's) and condensate production exists. In 2014, Northeast BC's unconventional gas regions garnered almost 99% of the provincial land sale bonus total of \$382.8 million. This was British Columbia's highest annual bonus total since 2010 and a 46% increase from 2013, when provincial land sale auctions tallied over \$224.7 million in successful bonus bids with unconventional gas-directed activity accounting for 97.5%. The Montney play trend accounted for almost the entire 2014 bonus total while the Bivouac area, where the Devonian Muskwa Formation is being developed for its shale gas potential (130 km southeast of Fort Nelson), saw a very small allocation of the bonus total.



**PROSPECTIVE HORIZONS**

	Formations	Description	Depth	Average thickness	Total organic carbon	Gas in place
<b>LOWER CRETACEOUS</b>	Wilrich and Buckingham shales	Potential interbedded sand and siltstone	800–1200 m	100 m	2.3%	60 Bcf per section
<b>JURASSIC</b>	Nordegg and Fernie shales	Recognized source rocks	1200–2500 m	Up to 30 m organic-rich section	up to 14%	>20 Bcf per section
<b>TRIASSIC</b>	Doig, Doig Phosphate and Montney	Montney turbidites may increase permeability. Phosphate units have high TOC and are excellent source rocks.	1200–3000 m	300–500 m	0.5 to >10%	10–110 Bcf per section
<b>DEVONIAN</b>	Exshaw, Besa River, Fort Simpson, Horn River and Muskwa	Exshaw and Muskwa are widely distributed organic shales. Fort Simpson and Besa River are thick basin-filling shales.	1800–3500 m	Huge thicknesses are common with some high TOC intervals.	0.5 to >10%	10–100 Bcf per section

**GEOLOGICAL ANALOGUE**

<b>MISSISSIPPIAN</b>	Barnett Shale (Fort Worth Basin)	Marine-shelf deposit	2000–2500 m	100 m	4.5%	140 Bcf per section
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TABLE 1. PROSPECTIVE HORIZONS FOR SHALE GAS IN NORTHEAST BRITISH COLUMBIA

## **BACKGROUND**

The number of wells drilled in British Columbia since the early 1900's reached 24,325 by the end of 2014 (Figure 1). It wasn't until the 1950's that petroleum exploration and development in British Columbia began in earnest. The northeast portion of British Columbia, which is part of the Western Canada Sedimentary Basin, is the only area of the province currently producing commercial quantities of oil and natural gas. Historically, drilling and production activity for oil and natural gas focused on the shallower Cretaceous and Triassic reservoirs in the Fort St. John region and on the shallower depths of the larger mid-Devonian gas pools in the Northern Plains region. In the 1990's, natural gas producers began focusing on tight gas development of the regionally-extensive Devonian shelf carbonates of the Jean Marie platform and the shelf-edge play in the Fort Nelson resource region. In 2003, industry began ramping up activity on tight gas development in basin-centered resource plays such as the Cretaceous Cadomin in the Deep Basin region. With advances in horizontal drilling and hydraulic fracturing techniques, producers are now unlocking vast tracts of gas-bearing shales in the Horn River Basin, Cordova Embayment, Liard Basin and in the over-pressured siltstones of the Montney play trend (Figure 2).

BC's unconventional gas resources are recognized as having large-scale potential with more than 400 trillion cubic feet (Tcf) of ultimate marketable gas. In 2011, an energy market assessment by the BC Ministry of Energy and Mines and the National Energy Board estimated a medium case, ultimate gas-in-place of 448 Tcf in the Horn River Basin and an expected marketable resource estimate of 78 Tcf. The assessment centered on the Upper and Middle Devonian basinal shales of the Evie (Klua), Otter Park and Muskwa members of the Horn River Formation and accounted for drilling to year-end 2010 (Ministry of Energy and Mines and National Energy Board, 2011). On November 6th, 2013, the National Energy Board, the BC Oil and Gas Commission, the Alberta Energy Regulator, and the BC Ministry of Natural Gas Development (National Energy Board, 2013) jointly released the first study ever to estimate the marketable unconventional petroleum resource in the Montney Formation, which is considered one of the largest gas resources in the world. That study estimated that the British Columbia portion of the Montney petroleum resource is expected to contain 271 Tcf of marketable natural gas. Further assessments are ongoing to determine the technically recoverable and marketable resource potential of the Liard Basin and Cordova Embayment in British Columbia. Numerous stratigraphic horizons and play areas in Northeast BC have exceptional potential for containing unconventional resources and only a relatively small portion has been commercially produced to date.

## **DATA SOURCES**

Data for this report have been collected from available public sources. No confidential data or information has been used in its preparation and all results are based on information available at the time of the review. Shale gas activity within the vast region of the Liard Basin is currently taking place within the central and northern areas of the outline shown in Figure 3. The Horn River Basin, north of the town of Fort Nelson, and the Cordova Embayment to the east, are bordered by a Middle Devonian carbonate platform succession.

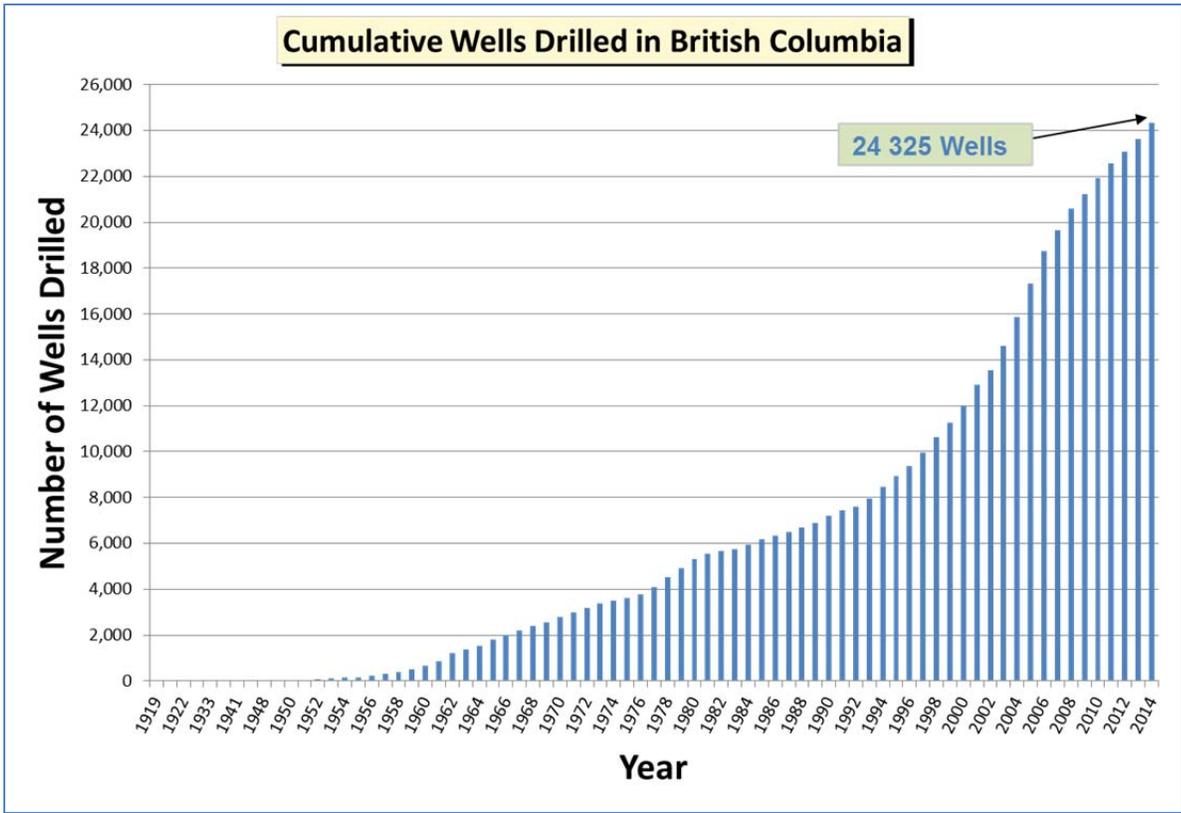


Figure 1. The cumulative number of wells drilled in British Columbia surpassed 24,000 in 2014. Most wells drilled prior to 1920 were located in more accessible regions of the province such as the Fraser Delta in the southwest. It was 1921 when the first five or six exploration wells were drilled in the Peace River area of northeast BC. The wells were part of a test-hole program operated by the provincial government (Janicki, 2008).

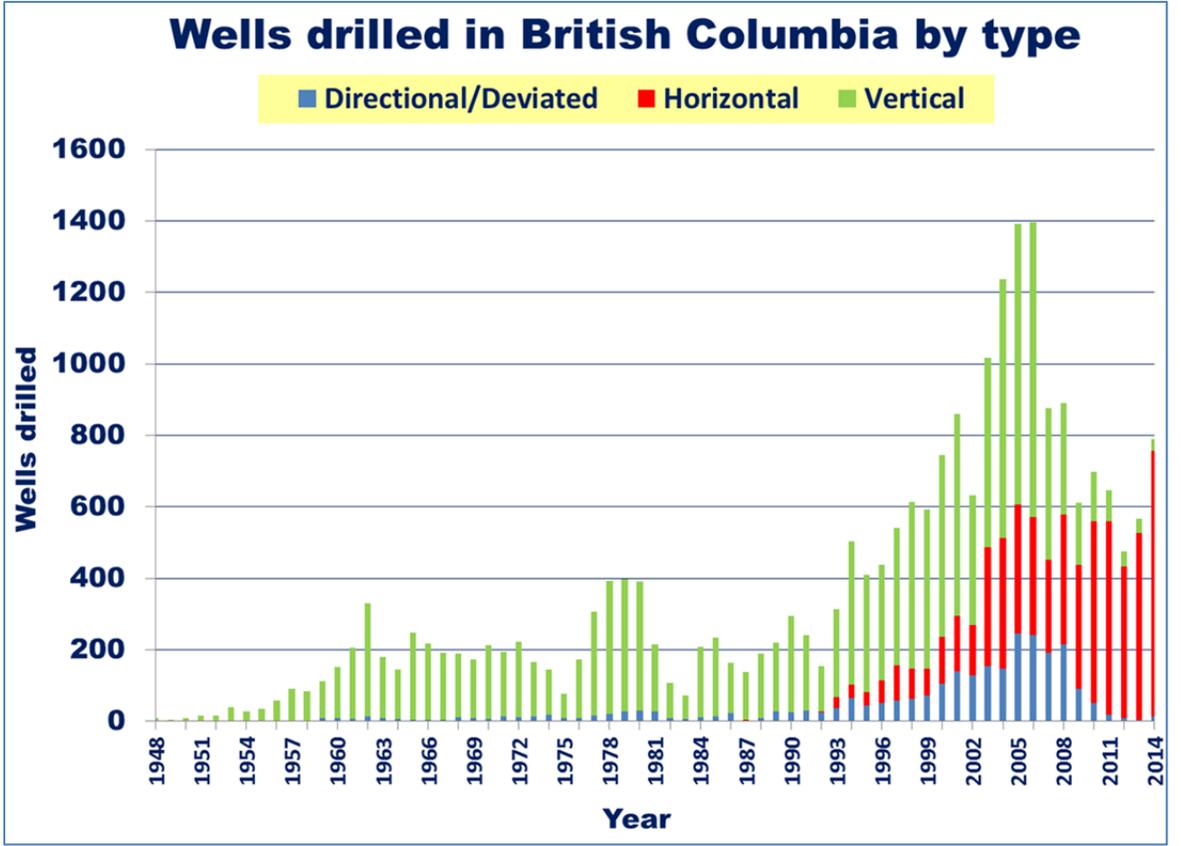


Figure 2. The annual number of horizontal wells drilled in BC began reaching double digits in 1993 and accounted for approximately 10% of all wells drilled. Today, almost 95% of all wells drilled are horizontal.

Further south, the Montney play trend now encompasses approximately 2.9 million hectares from the south Peace region near the city of Dawson Creek extending up to the Tommy Lakes and Trutch areas in NTS map area094G/10.

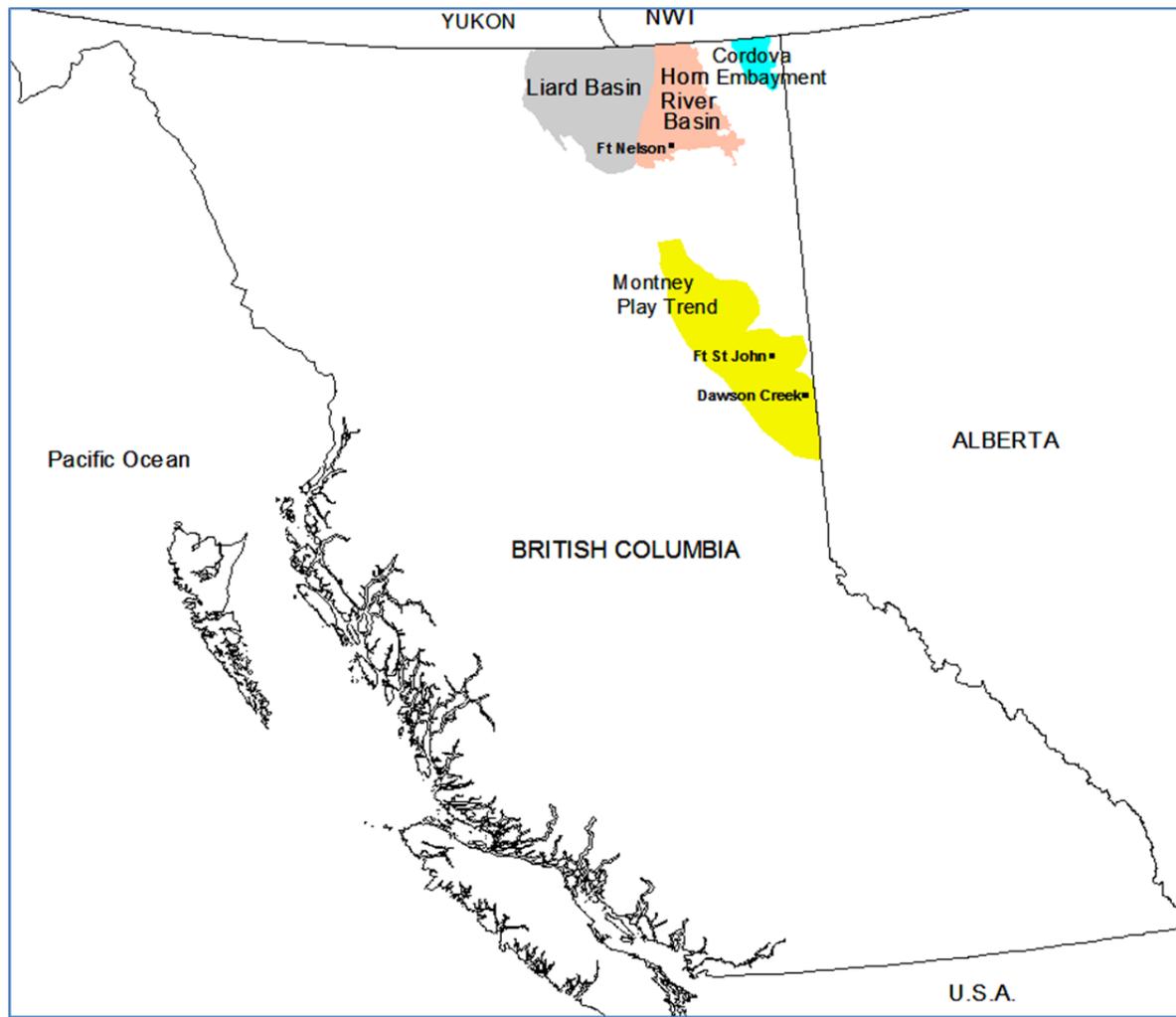


Figure 3. Shale gas play regions of northeastern British Columbia

## 2014 OIL AND GAS EXPLORATION AND DEVELOPMENT ACTIVITY

A total of 697 wells were drilled in Northeast BC in 2014 (Figure 4). Of those, 531 have been given gas well status. Most wells being drilled are in the province’s unconventional gas regions. The main geological target was the Triassic Montney Formation in the Montney Play trend, followed by the Lower Cretaceous Bluesky Formation at Hay River and the Upper Devonian Jean Marie Member in the Gunnell, Sierra and Elleh areas.

Bonuses (Figure 5) collected from the sale of BC’s Crown PNG rights in 2014 totaled \$382.8 million. Of that total, \$377.3 million or 99% was directly attributed to interest in Northeast BC’s unconventional gas plays. Essentially, the entire percentage was directly related to unconventional gas development of Lower Triassic play targets of the Montney play trend with a small portion accredited to the Muskwa unconventional shale play in the Bivouac area.

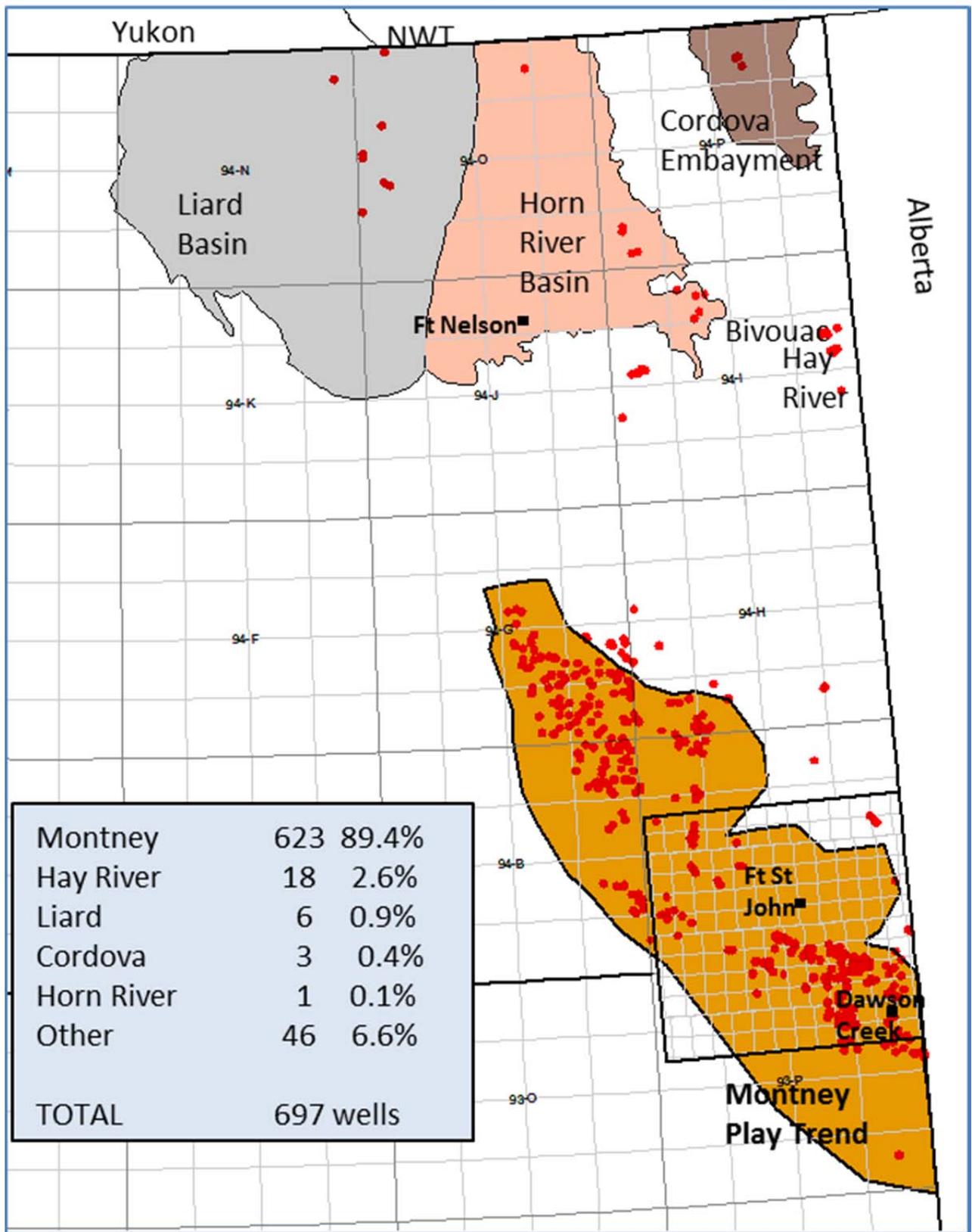


Figure 4. A total of 697 wells were rig released (red dots) in Northeast BC in 2014. Of those, 531 have been given a gas well status. Most wells are now being drilled in the province’s unconventional gas regions. The main geological target for 2014 was the Triassic Montney Formation in the Montney Play trend, followed by the Lower Cretaceous Bluesky Formation at Hay River and the Upper Devonian Jean Marie Member in the Gunnell, Sierra and Elleh areas.

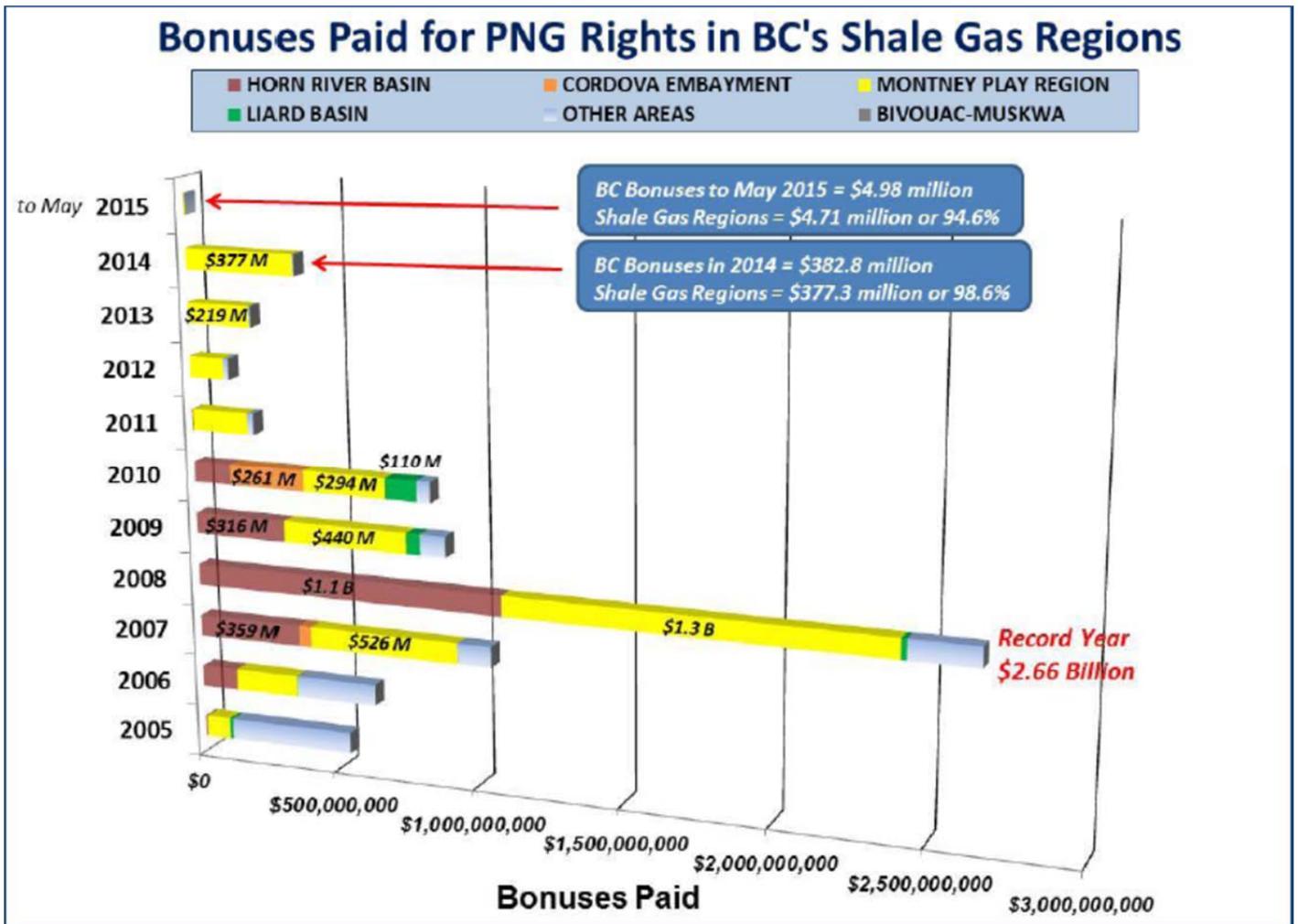


Figure 5. Bonuses collected over the last decade from the sale of crown petroleum and natural gas (PNG) rights in British Columbia’s shale gas regions. Over the last several years, land brokers and producers have focused on purchasing PNG rights in the unconventional Montney play region. There have been no major PNG rights sales in the Horn River Basin, Cordova Embayment and Liard Basin since 2010.

### Horn River Basin

The Horn River Basin covers an area of approximately 1.15 million hectares within the Fort Nelson/Northern Plains region. It lies east of the Bovie Lake–Maxhamish fault system and extends east and south to the Devonian Slave Point Barrier Reef Complex (Figure 6). Prior to a more dedicated interest in Middle Devonian shale sequences in 2005, most wells drilled in the Horn River Basin were targeting carbonate plays of the Mississippian Debolt Formation to the Middle Devonian Keg River/Pine Point formations. Over the last ten years, major and intermediate producers have been testing potential reservoirs from the Upper Devonian to Lower Mississippian Exshaw shale and the Muskwa–Otter Park members of the Middle Devonian Horn River Basin. These producers have been extremely successful in unlocking the potential of these organic-rich shales.

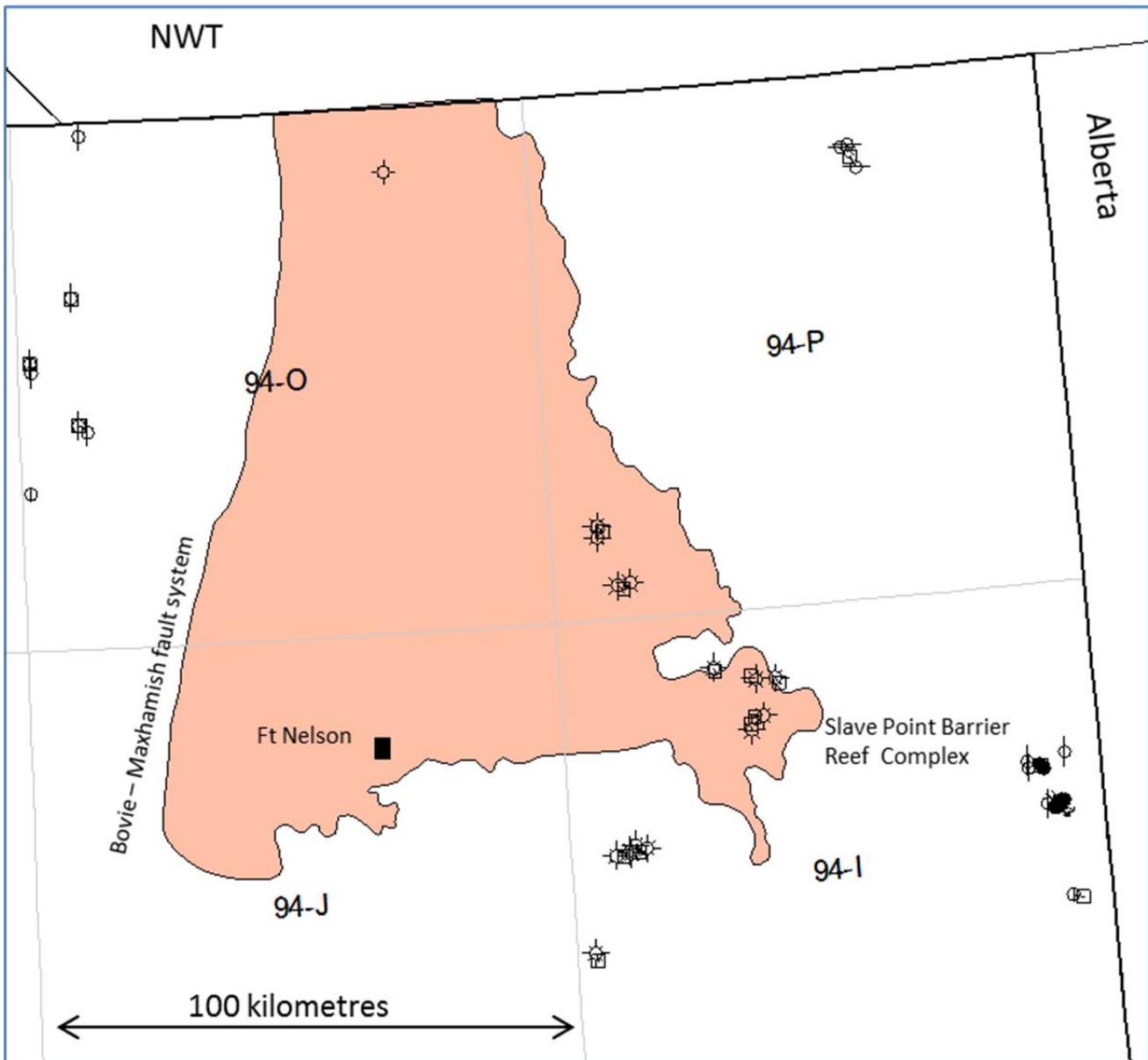


Figure 6. Slower overall drilling activity levels for shale gas development in the Horn River Basin in 2014 are the result of low natural gas prices and the lack of natural gas liquids (NGLs) throughout the entire basin. Wells shown on the southeastern portions of the Horn River Basin were not drilled for shale gas targets but rather for tight gas development of the Upper Devonian Jean Marie Reef Play. The Shelf Edge Play contains sweet gas trapped in a barrier reef complex along the Jean Marie Formation’s western edge.

### ***Land sale activity***

There were no PNG rights sold within the Horn River Basin in 2014. This marks the second consecutive year in which no annual bonuses were collected. Land sale activity in the basin has slowed in the seven years after a record bonus total of \$1.1 billion was achieved in 2008. Producers are deferring new capital expenditures in unconventional dry gas regions and continue to focus their drilling programs on the liquids-rich gas portions of Northeast BC region.

### *Industry activity*

**Chevron Canada Limited** has assumed the role of operator of the Horn River Basin resource assets previously held by **Apache Canada Ltd.** Apache, which owned a 50% interest with **Chevron Canada Ltd.** in the proposed \$4.5 billion Kitimat liquefied natural gas (LNG) export terminal, sold its half of the project to **Woodside Petroleum Limited** of Australia in late 2014 (Nickle's Daily Oil Bulletin, 2015a). Since 2005, Apache has been one of the most active shale gas operators in the Horn River Basin with activity primarily centered in the areas of **Komie, Two Island Lake** and **Ootla** (NTS map areas 094O/7, 8, 9 and 10).

**Woodside Petroleum Limited** remains focused on advancing its Kitimat LNG project to monetize significant unconventional resources in both the Liard Basin and the Horn River Basin. Woodside's upstream resource in both basins cover approximately 259 000 hectares (Woodside's share is 129 500 net hectares). Appraisal data suggest recoveries of approximately 20 Bcf per well in the Horn River Basin and 40 Bcf per well in the Liard Basin. With both of these regions offering significant upside potential, the emphasis over 2015 and 2016 is on drilling, particularly in the Liard Basin, to underpin LNG development, while maintaining a strong upstream position (Woodside Petroleum Limited, 2015).

**Quicksilver Resources Inc.** continues to manage its assets in the Horn River Basin's **Fortune** area. The company's horizontal well program in the area has been targeting shale gas in the Devonian-aged Muskwa and Klua formations since 2009. Quicksilver's acreage totals approximately 130,000 net acres (52 609 hectares) with proved reserves of 70 Bcf and an un-booked resource potential of 14 Tcf. Although new drilling activity hasn't occurred in the Fortune area since 2012, the producer did complete operations on one groundwater source well in the area in early 2014. Water source wells are drilled to reduce the reliance on surface water for hydraulic fracturing operations and to supplement water requirements with various sources of non-potable groundwater. These shallow wells are drilled into Quaternary-aged sediments and are usually completed within a sandstone bedrock aquifer of less than 200 metres. In the third quarter of 2014, Quicksilver's average net production from the Fortune area was 34.8 MMcf/day from 12 producing wells. This was down from 55.7 MMcf/day in the third quarter of 2013, primarily attributable to natural gas declines and a maintenance outage at a third-party facility, which serves Quicksilver's Horn River Basin assets (Nickle's Daily Oil Bulletin, 2014f). Quicksilver's remaining capital spending of \$120 million in the Horn River Basin has been deferred until the earlier of June 2016 or 12 months following the completion of a strategic transaction for an integrated Horn River Basin project (Quicksilver Resources Inc., 2014). In late July 2014, Quicksilver filed an application with the National Energy Board to export 20 million tonnes per year of LNG from its proposed Discovery LNG project north of Campbell River, British Columbia. The NEB approved this application in late June 2015 for a 25-year natural gas export licence.

## Production

Between April 2005 and December 2014 over 800 Bcf has been produced from the Muskwa-Otter Park and Evie formations within the Horn River Basin. Daily natural gas production from these formations accounted for approximately 11% of BC's total daily gas production of 4.6 Bcf/d in 2014 (Figure 7).

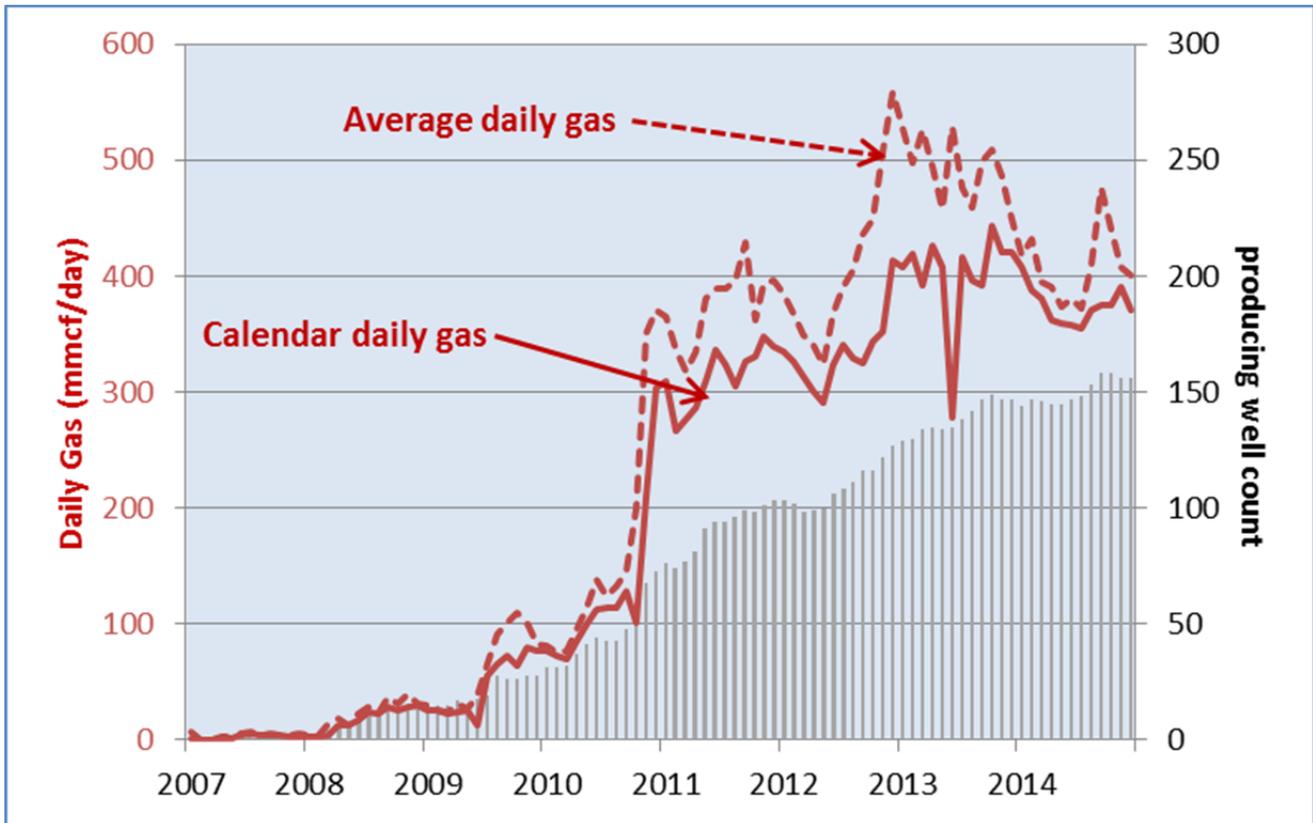


Figure 7. Approximately 772 Bcf of natural gas has been produced from the Muskwa-Otter Park and Evie formations within the Horn River Basin from 2007 to end of 2014. In December 2014 the average daily calendar rate was 533 MMcf/day and the average daily rate was ~500 MMcf/day from 224 producing wells.

## Liard Basin

Straddling the borders of the Northwest and Yukon territories with BC, the Liard Basin and Fold Belt region remains a relatively unexplored area situated on the eastern margin of the Cordilleran Fold and Thrust Belt (Adams, 2011). In Northeast BC, the region covers a prospective area of approximately one million hectares and contains more than 5 km of Cambrian to Upper Cretaceous sedimentary strata. The Middle Devonian to Middle Mississippian Besa River Formation within the Liard Basin is an emerging shale gas play that has the potential to contain a resource larger than that found within the Horn River Basin and Cordova Embayment. This formation represents a thick shale sequence resulting from the western shale-out of carbonates spanning the Kakisa to Debolt formations. In addition, this unit contains the western equivalents to shale successions further east, such as the

Horn River, Fort Simpson and Exshaw formations (Ferri et al., 2013). In the Horn River Basin, this equivalent stratigraphy is over 2000 m in thickness whereas the outcrop belt of the Besa River Formation is slightly over 300 m thick.

**Land sale activity**

Producer interest in the Liard Basin has occurred in and around the La Jolie and Patry areas, located approximately 110 km northwest of the city of Fort Nelson in the central region of the Liard Basin. The most significant land sales to date in the Liard Basin occurred at the July 15, 2009 Crown reserve PNG rights disposition, where land brokers purchased seven drilling licences for \$31.3 million on 46 258 hectares. The purchased parcels were located just north of Patry in NTS 094O/12 and 094O/13. The following year, at the June 23, 2010 PNG rights disposition, 14 licences were purchased to the northwest and southwest of the same area totaling \$110.4 million on 66,645 hectares (Figure 8). Well activity in the area at the time indicated that Apache Canada Ltd. drilled two experimental vertical wells, one of which was rig released in late December 2010 at d-34-K/94-O-5. The d-34-K well lists the Upper Devonian Fort Simpson as the projected formation.

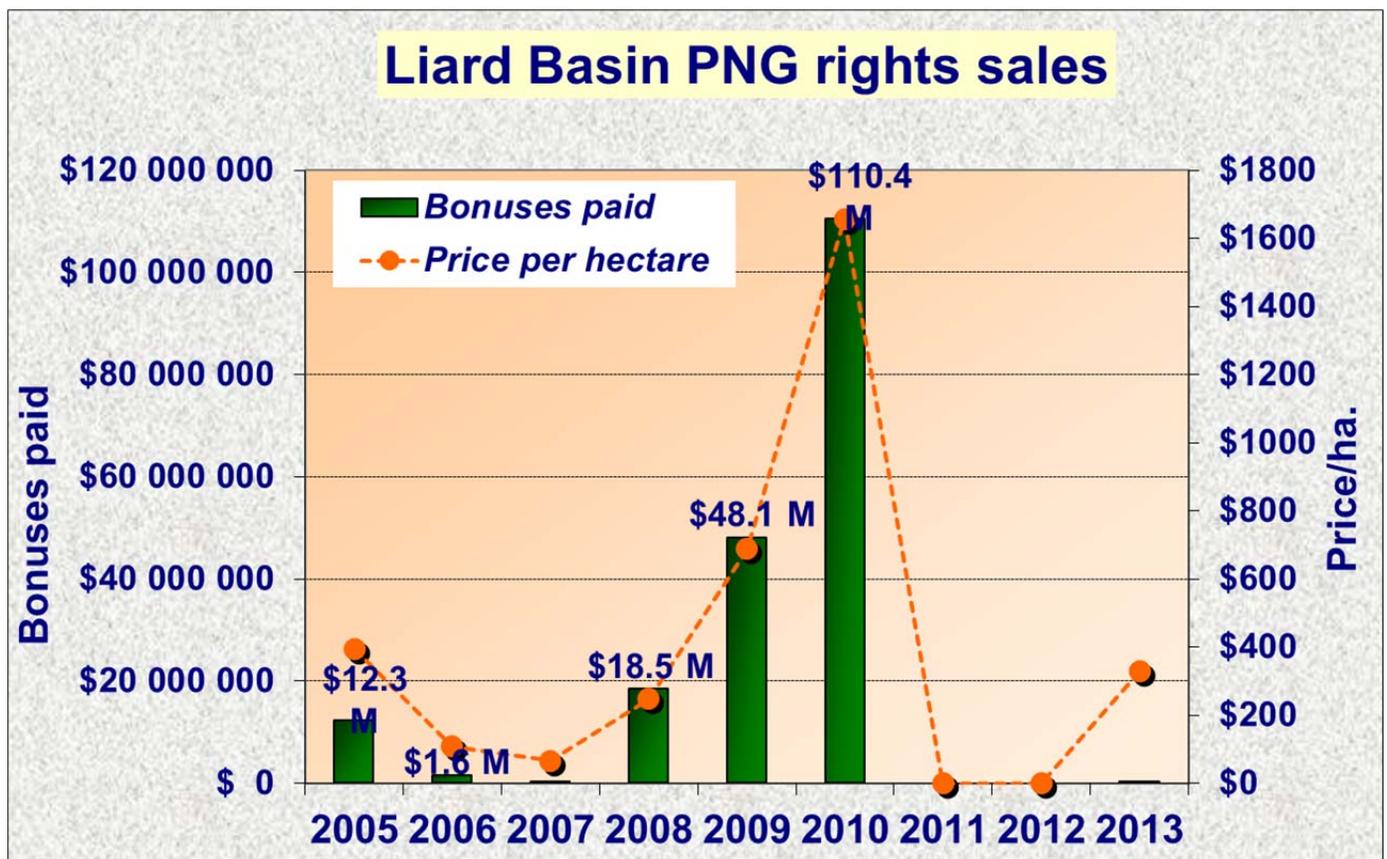


Figure 8. The highest annual bonus total in the Liard Basin so far was in 2010 when \$110.4 million was garnered at the June 23 Crown petroleum and natural gas rights sale. Fourteen licences covering 66 645 hectares were sold in the La Jolie–Beaver River areas (NTS 094N/09 and 094N/16) and to the southwest of the Patry area (NTS 094O/05 and 094N/08). Two parcels were sold in 2013 in the eastern section of the Liard Basin (NTS 094O/11)

There were no PNG rights sales in the Liard Basin in 2011 and 2012, but in 2013, two PNG rights parcels were sold but both were unrelated to shale gas-directed activity. The sold parcels were located in the Maxhamish area (NTS 0940/11) and were purchased by Britt Resources Ltd. Seoul-based STX Energy announced in 2010 that it acquired the Maxhamish gas field from Encana Corporation for C\$152 million. The gas field is 616 square kilometers in size and is estimated to hold 120 Bcf of gas. STX Energy plans to increase the daily production of the gas field from its current 20.5 MMcf to 27 MMcf/day (Asia Pacific Foundation of Canada, 2010).

No parcels were purchased by land brokers or producers in the Liard Basin as a result of PNG rights dispositions held in 2014.

### *Industry activity*

Six wells were rig released in the Liard Basin throughout 2014 (Figure 9). Four wells were drilled by **Woodside Petroleum Limited** in the **Patry** area (central Liard Basin) as well as in the **La Jolie** and **Sandy** areas (north Liard Basin). The projected target for these wells was the Besa River and Kotcho formations. Two wells were rig released by **Nexen Energy ULC**; one of those wells targeted the Horn River Formation in the **Patry** area and the other targeted the Evie Member in the **Beaver River** area. The Beaver River area is the northernmost field in Northeast BC located near the Yukon Territory border. The remaining well was drilled by **Paramount Resources Ltd.**, which holds approximately 133 net sections (34 500 net hectares) in the Liard Basin that are prospective for shale gas in the Middle Devonian Besa River.

**Woodside Petroleum Limited**, which acquired Apache Corporation's 50% interest in the Kitimat LNG project, including 129 500 net hectares in the Liard basin and Horn River basin, has stated that upstream development, particularly the Liard Basin, will be the focus for 2015. Woodside announced the acquisition of Apache Corporation's 50% share in the Liard project in late 2014 (Nickle's Daily Oil Bulletin, 2015f). **Chevron Canada Corporation** was scheduled to take over as operator in June 2015 to refocus its efforts on the upstream delineation of the resource in the Liard Basin. Work activity in 2015/2016 will be dedicated to ensuring that the quality and quantity of the resource in the Liard Basin is understood. Woodside has outlined plans for seven appraisal wells to begin in the second quarter of 2015. Most wells will operate in the **La Jolie** and **Patry** areas and will reach total depths of 6500 m or greater. Appraisal well data suggest recoveries of roughly 40 Bcf per well in the Liard Basin (Woodside Petroleum Limited, 2015).

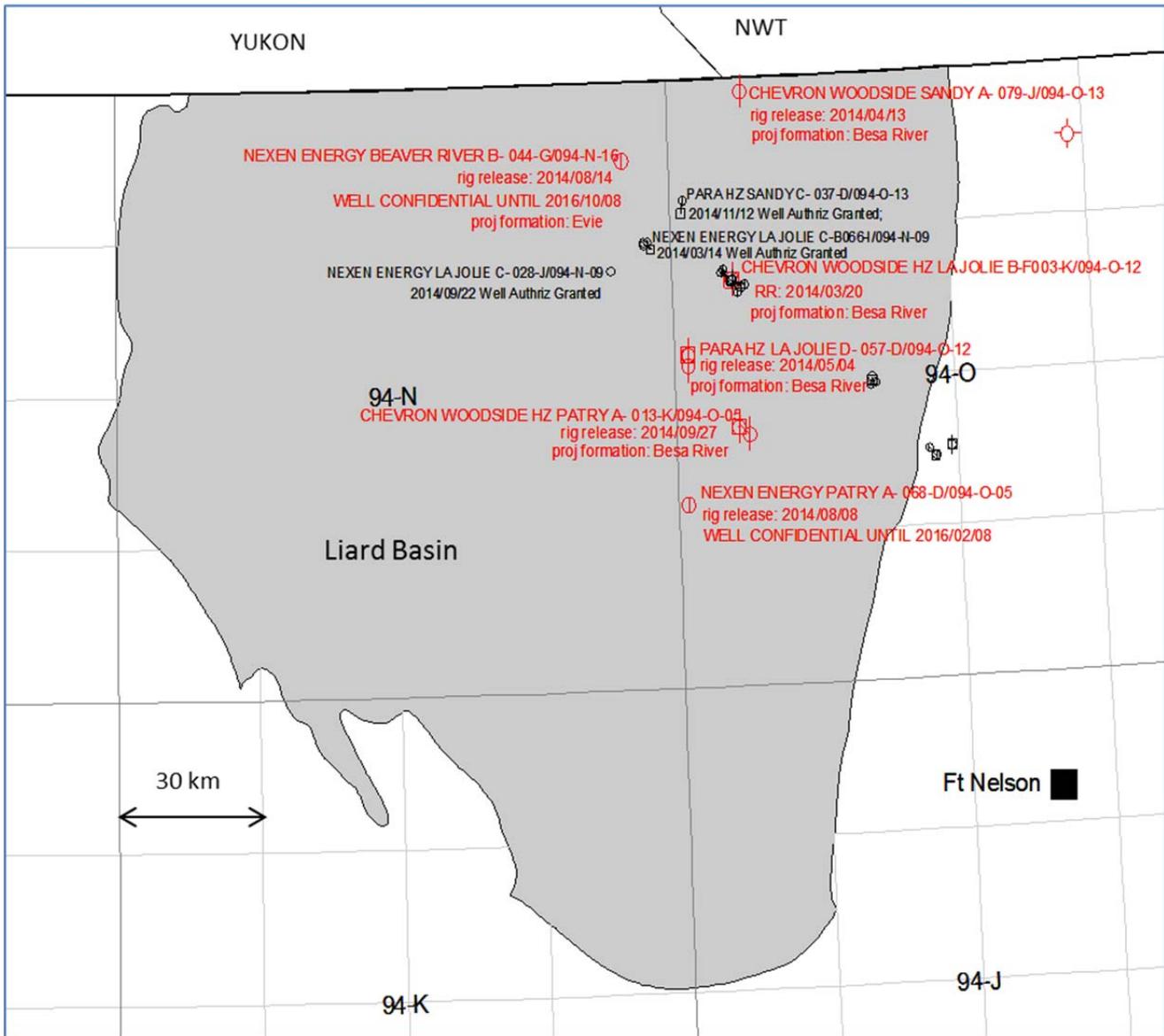


Figure 9. 2014 rig releases (in red) and well licensing activity (in black) in the Liard Basin. As Chevron significantly paces its spending on the Kitimat LNG project due to current market conditions, there is a refocus of efforts on the upstream delineation of the resource.

### ***Production***

As of April 2105, two wells in the Liard Basin were producing gas from the Besa River ‘A’ pool at a calendar rate of 4.1 MMcf/d. Cumulative production from September 2009 to April 2015 reached 12.2 Bcf from four wells drilled; three by Woodside Petroleum Limited (Apache Canada Ltd.) and one by Paramount Resources Limited.

### **Cordova Embayment**

The Cordova Embayment covers an area of 270 000 hectares and sits approximately 130 km northeast of Fort Nelson in the far northeastern corner of the province. The area lies east of the well-established Devonian Jean Marie gas production and deeper exploration targets such as the Slave Point and Pine Point (Keg River)

carbonates. More than 340 wells have been drilled in the basin since the early 1960s; most of those are in the Helmet, Helmet North and Midwinter West areas. Since 2008, approximately 40 of those wells have targeted shale gas.

**Land sale activity**

The Cordova Embayment has not seen land sale activity since 2010 when bonuses reached \$261 million for the year (Figure 10). Producing companies in the Cordova Embayment have attained their competitive land positions and continue to focus on drilling and resource appraisal.

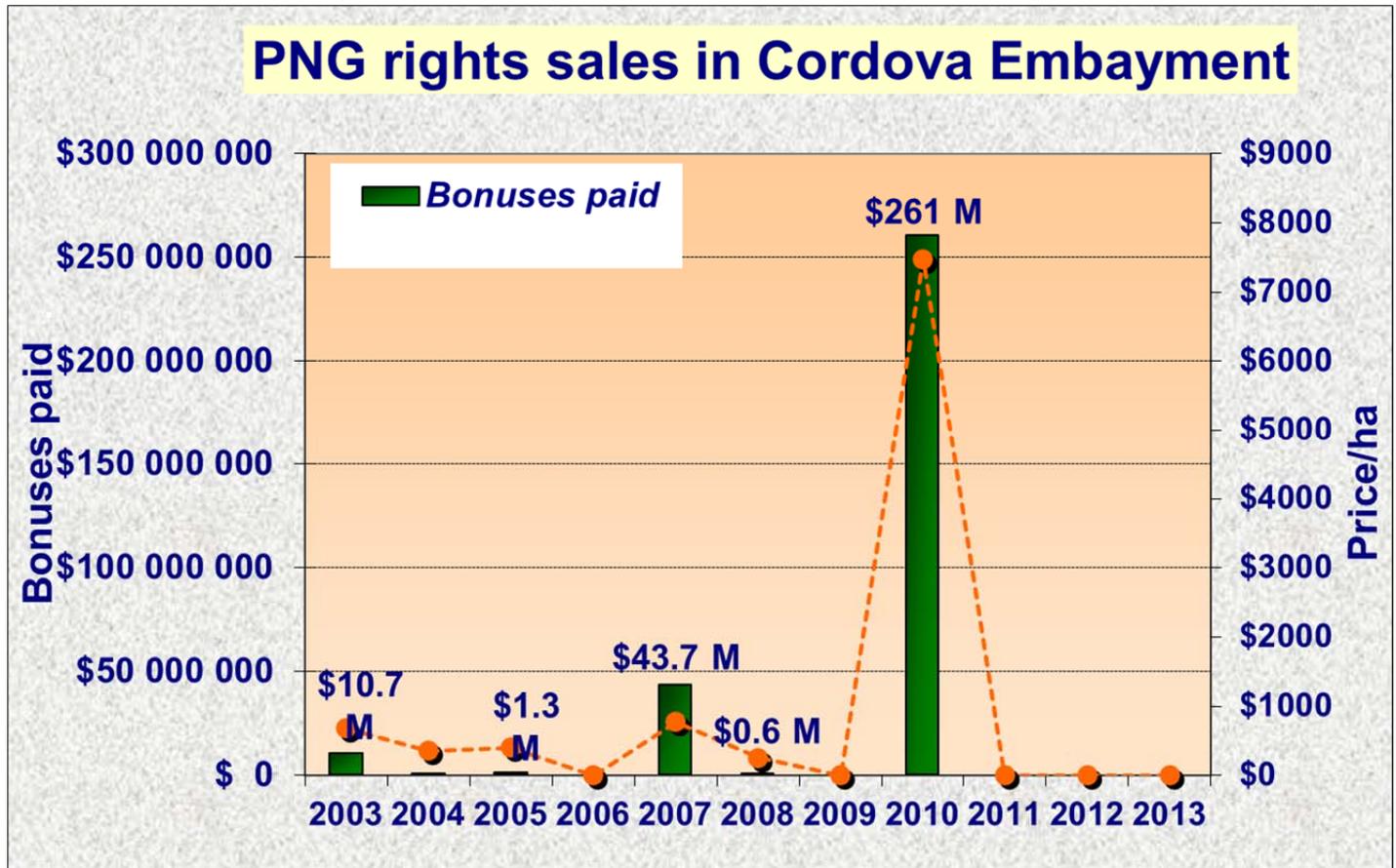


Figure 10. The Cordova Embayment saw a sizable increase in the level of land sale activity in 2010, with bonuses reaching a high of \$261 million. That total was achieved at the June 23 Crown petroleum and natural gas rights sale, where 18 licences and 4 leases covering 34, 877 hectares were sold in NTS 094P/10 and 094P/15. No PNG rights have been sold in the Cordova Embayment since 2011, but drilling continued with 43 wells rig released over the last four years.

**Industry activity**

Because of its geological similarity with the Horn River Basin, the Cordova Embayment is a logical place to conduct exploration for shale gas plays. The presence of free gas in natural fractures was evident in a well drilled in 1976 by Chevron Standard Ltd. in the North Helmet area. A core description from a Devonian shale section

noted that the entire core had “bleeding gas from hairline fracture planes” (Dobek, 1976). With increasing depth of coverage in the Cordova Embayment, appropriate testing and completion strategies can be determined and the evaluation of the relative success of recompletion versus new drills.

**Nexen Energy ULC** and **INPEX Gas British Columbia Limited** (IGBC) continue in the early stages of development in the Cordova Embayment. The joint interest partners will conduct a series of drilling, well completion and production testing programs in the **Helmet North** area. Nexen has acquired more than 3300 hectares in the region and holds a 60% operated interest in its joint venture lands with INPEX holding the remaining 40%. Nexen drilled three wells in the Cordova Embayment in 2014 (Figure 11); two wells list the projected target as the Upper Devonian Muskwa while the other is targeting the Evie member (Middle Devonian). All three wells have been listed as suspended since the spring of 2014.

Nexen Energy and IGBC will meanwhile proceed with shale gas development and production operations in all of Northeast BC’s northernmost shale gas regions. In fact, **Japan Oil, Gas and Metals National Corporation** (JOGMEC) and **INPEX CORPORATION** recently began a joint study on technology relating to shale gas development in the Horn River Basin, Liard Basin and Cordova Embayment with IGBC and Nexen ULC. The study entails the evaluation of geological characteristics from these regions by analyzing the properties of rock samples extracted from shale gas reservoirs, which have already been allocated for development. The integrated interpretation resulting from the study should help optimize and streamline the development of shale gas reservoirs in all three regions. The joint study is expected to continue for one year (Nickle’s Daily Oil Bulletin, 2015g).

**Penn West Exploration Ltd.** announced in 2014 that it had engaged the services of **CIBC World Markets Inc.** to assist with the sales process of certain interests it holds in the Cordova Embayment (Nickle’s Daily Oil Bulletin, 2014e). Plans to sell its shale gas assets in the Cordova Embayment were part of a second phase of a massive divestiture program by Penn West in 2013. So far, its Cordova assets remain on the auction block. Penn West has been evaluating the Devonian shale sequence in the **Helmet North** area within the Cordova Embayment since 2008. The producer has acquired more than 95 000 hectares in the region and, until late 2013, continued to direct capital towards its Cordova Gas project. Penn West continued with assessment and appraisal work in 2013 on its Cordova Joint Venture, where Mitsubishi Corporation has been a joint venture partner since 2010. Only well completion operations were to be conducted on various Penn West wells in the area in 2014 (Nickle’s Daily Oil Bulletin, 2013a).

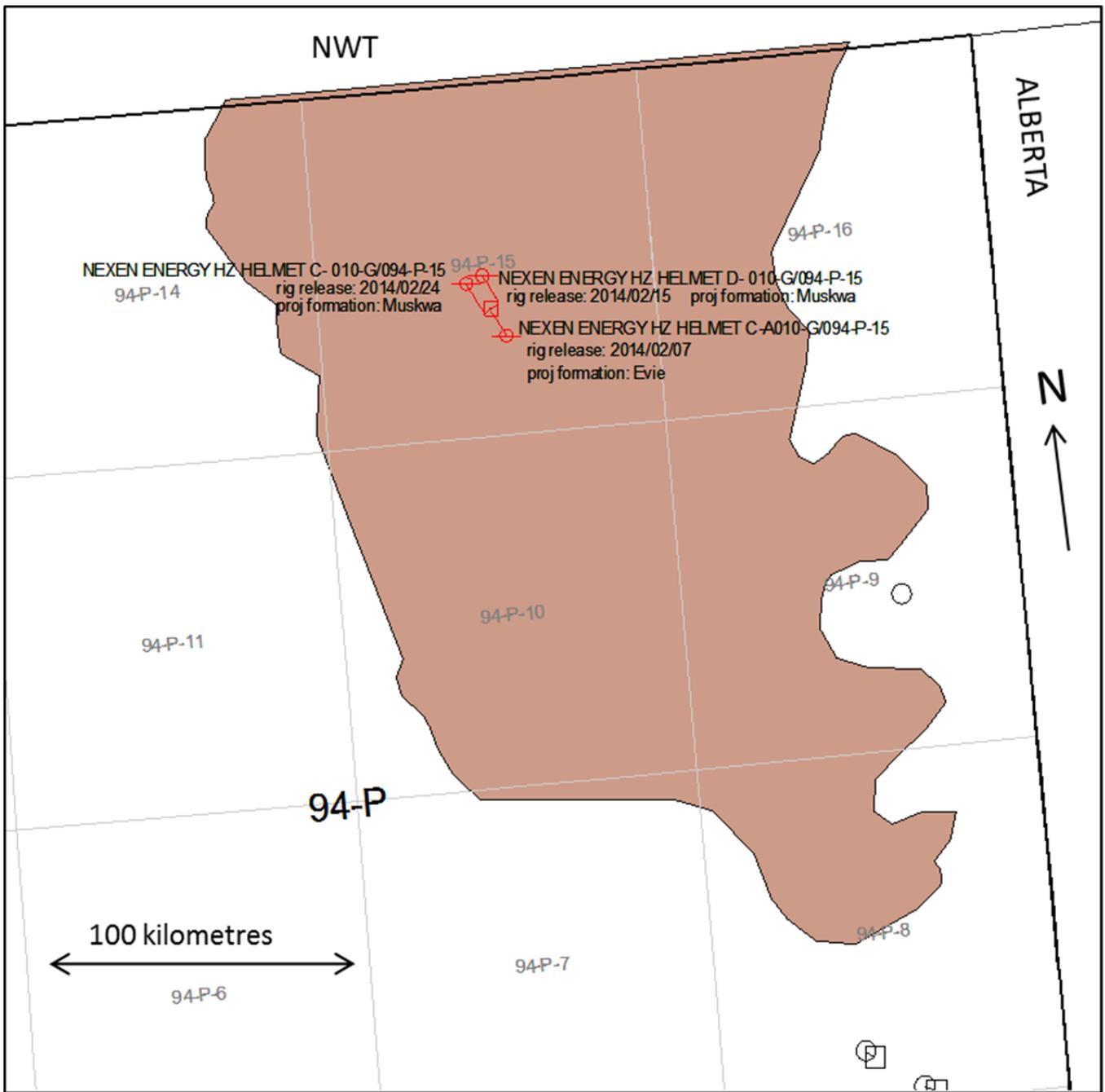


Figure 11. Virtually all well activity in the Cordova embayment from 2010 to 2014 was directed towards shale gas targets. Nexen Energy ULC completed drilling operations on three wells from one pad in early 2014. All three remain suspended at time of writing

### ***Production***

As of March 2015, 17 wells in the Cordova Embayment were producing gas from Devonian shale sequences in the Muskwa, Otter Park and Evie (Figure 12). Cumulative production from January 2008 to December 2014 reached 32.3 Bcf from 20 wells drilled mostly by Penn West Exploration Ltd. and one by Canadian Natural Resources Limited. Prior to shale gas exploration, the Cordova Embayment saw gas production primarily from the Upper Devonian Jean Marie and the Middle Devonian Slave Point and Keg River in the Helmet North and Midwinter areas.

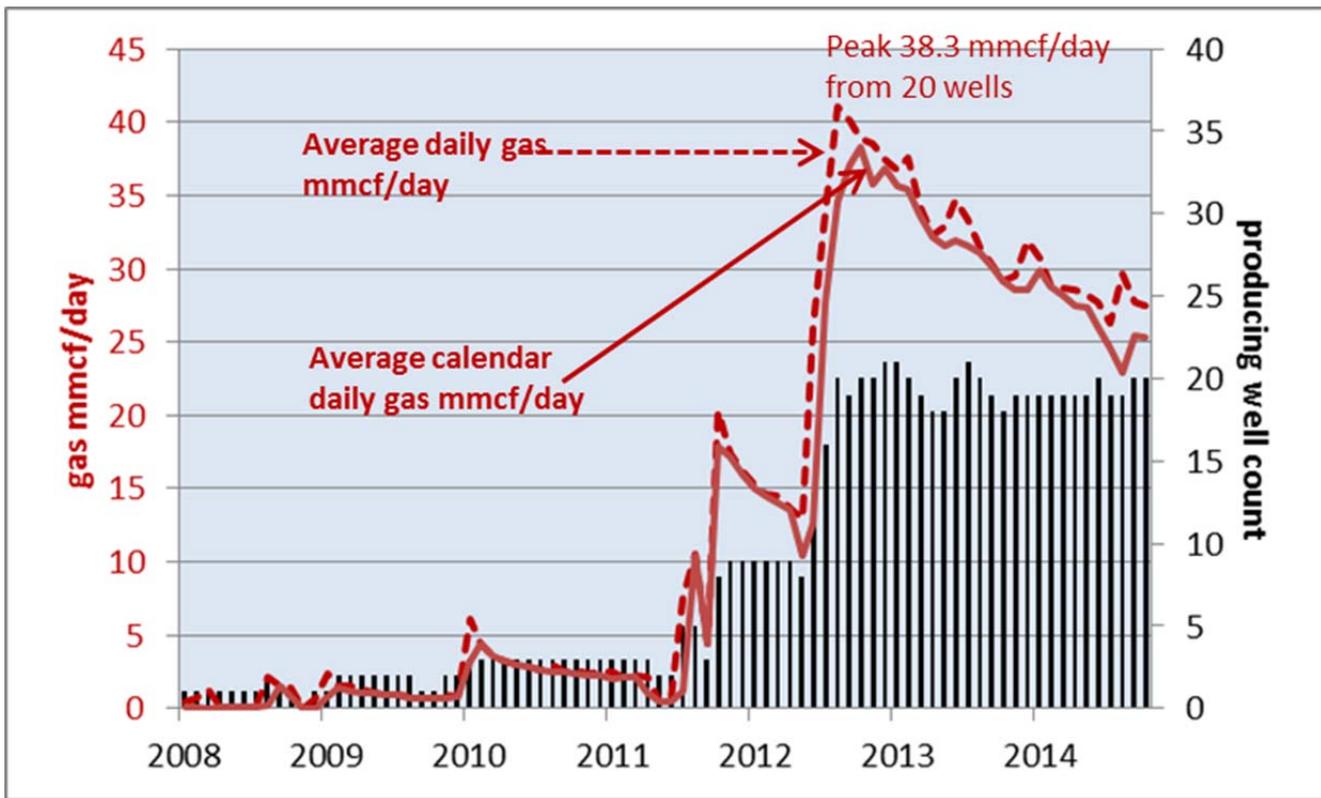


Figure 12. The first well to produce from Devonian shale gas sequences in the Cordova Embayment was in March 2008 by Canadian Natural Resources Limited. Peak production volumes occurred in December 2012 when 20 wells were producing at combined calendar day rate of 38.3 MMcf/day. At the end of 2014, 20 wells were on production at a calendar day rate of 25.3 MMcf/day. Cumulative production to the end of 2014 was 32.3 Bcf.

### **Bivouac-Muskwa**

The Devonian Muskwa Formation is being extensively developed for its shale gas potential in the Horn River Basin and Cordova Embayment, where gas production is predominantly dry. Further to the southeast, on the northern edge of the Peace River Arch (PRA), there has been some industry activity focusing on the Muskwa shales, specifically in the Bivouac area (NTS 094I/08 block). The Devonian Muskwa in this area of Northeast BC sits on the Beaverhill Lake Formation and is thought to have localized faulting, which has trapped the Muskwa shales and allowed condensate to migrate through the thick Fort Simpson shales (Ferri et al, 2014). The Bivouac field covers an area of over 30,000 hectares and sits approximately 130 km southeast of Fort Nelson along the British Columbia/Alberta border. It has well-established gas production from the Mississippian Debolt and from deeper targets in the Upper Devonian Jean Marie carbonates.

#### ***Land sale activity***

So far, only two of British Columbia's PNG rights sales have resulted in parcels being purchased in the Muskwa play area at Bivouac. At the December 2013 PNG rights disposition, land broker Standard Land Company Inc.

paid a bonus of \$64,319 for a 1085-hectare lease (average of \$59 per hectare). A month later, at the January 2014 land sale, Basm Land & Resources Ltd. paid \$89,845 for a 2716-hectare licence at an average of \$33 per hectare. Although the parcels sold are not indicative of a robust regional resource play, it could designate a narrow zone of condensate potential in this district of Northeast BC.

### ***Industry activity***

**Husky Energy Inc.** is pursuing a number of initiatives to advance its oil and liquids-rich gas resource plays in western Canada. In 2014, Husky drilled one well in the Bivouac area targeting the Muskwa shales (Figure 13). The first horizontal well (Husky HZ Bivouac a-55-B/094-I-08), drilled in January of 2013 to a true vertical depth of 1827.8 m and a measured depth of 3620 m, began production from the Muskwa ‘A’ pool in September 2013. It continues producing at a calendar daily rate of 279 MMcf/day with cumulative condensate production of 2943 barrels (as of May 2015). The Muskwa Formation at this well is approximately 27 m thick and occurs at a depth of 1819 m. An 18-stage nitrified slick water fracture treatment using plug and perf technology was performed along a 1600 m horizontal leg.

### ***Production***

As of May 2015, one well in the Bivouac area (UWI b-33-B/094-I-08, Surface a-55-B/094-I-08) was producing gas from Devonian Muskwa Formation. Over the first three months of production (September to December 2013) the daily average gas rate was 1.1 MMcf/day and 22.3 barrels/day of condensate. Cumulative gas production from September 2013 to May 2015 was almost 269 MMcf.

### **Greater Sierra – Jean Marie Project**

There has been renewed interest of tight gas development of the Upper Devonian Jean Marie Reef Play in the Greater Sierra region (east of Fort Nelson). The Shelf Edge Play contains sweet gas trapped in a barrier reef complex along the Jean Marie Formation’s western edge. The play was a major contributor to the development of horizontal well technology in the province beginning in the mid-1990’s. At that time, Encana Corporation was the key operator along the Shelf Edge Play and held approximately 810,000 net hectares of development potential in the area.

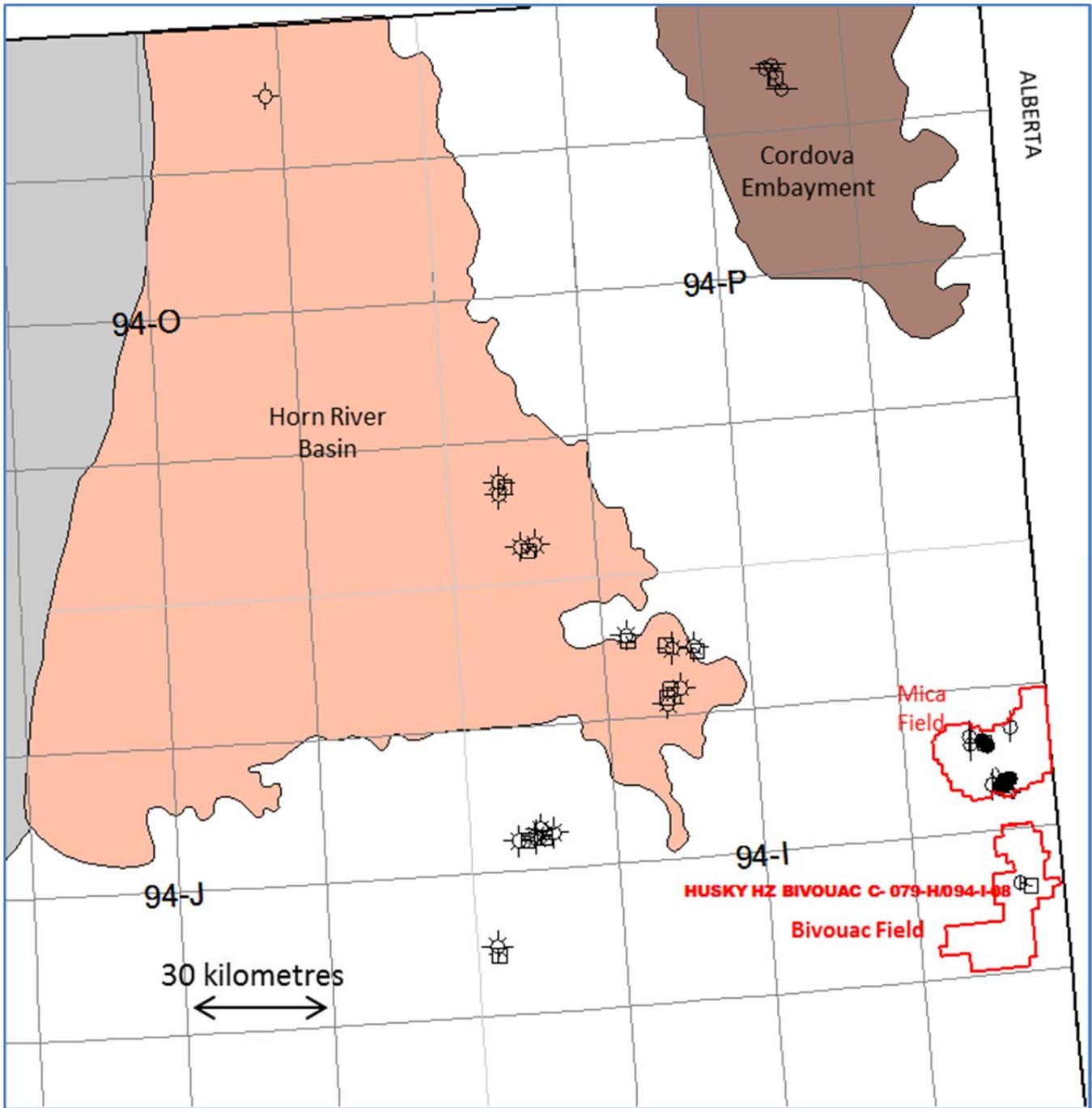


Figure 13. The Muskwa Formation represents a widespread, organic-rich unit in the Western Canada Sedimentary Basin and is identified as one of the principle source-bed horizons (Ferri et al, 2014). Husky Energy Inc. is pursuing a number of initiatives to advance its oil and liquids-rich gas resource plays in western Canada, including the exploration of Muskwa shales in the Bivouac area. Wells indicated here were rig released in 2014. In 2014 one well was rig-released at Bivouac targeting the Muskwa Formation (HUSKY HZ BIVOUAC C- 079-H/094-I-08). It is confidential until January 27, 2016.

In April 2013, Encana Corporation struck a deal with Endurance Energy Ltd. to sell this mature natural gas asset. Endurance Energy Ltd. is controlled by New York's Warburg Pincus LLC, one of the world's largest private equity firms. Prior to this divestiture, the Jean Marie property produced slightly more than 120 million cubic feet of natural gas a day with a mix of conventional and unconventional gas. All of Encana's operational staff in Fort Nelson will continue to be employed by Endurance Energy Ltd. (operating as Endurance B.C. Gas Ltd. in Northeast BC) and there is every indication that Endurance is looking for a long-term focus on the play (Fort Nelson News, 2013).

### ***Land sale activity***

Since 2013, only one of British Columbia's Crown PNG rights sales may have been related to the development of the Jean Marie Reef Play. In July 2015, a 264-hectare parcel was purchased by Scott Land & Lease for \$17,688 or \$67 per hectare. The parcel was purchased to include rights covering the surface to below the base of the Jean Marie. The lease is surrounded by wells that were drilled targeting the Jean Marie Formation. These wells were previously drilled by Encana Corporation and Endurance B.C. Gas Ltd. is now listed as the owner.

### ***Industry activity***

Recent tight gas development of the Upper Devonian Jean Marie Reef Play by **Endurance B.C. Gas Ltd.** occurs in the **Gunnell Creek, Yoyo, Sierra, Elleh** and **Eskai** areas. These areas are located within the southeast corner of the Horn River Basin and further south of the Basin. In 2014 and early 2015, twenty-two wells were rig released in by Endurance in these areas with all wells targeting the Jean Marie Formation. All but one of those wells is producing with the highest producing well located in the Elleh area. That well was drilled in early 2015 and produced an average of 2.5 MMcf/day over April and May of 2015. Condensate production totaled 366 barrels over those two months.

### ***Production***

As of May 2015, there were 617 wells producing gas from the Jean Marie Shelf Edge Reef at a calendar day rate of ~200 MMcf/day. Peak daily production of 255 MMcf/day occurred in June 2004. Cumulative gas production from the area since 1995 has reached 663 Bcf. From April 2014 to May 2015, Endurance B.C. Gas Ltd. reached cumulative gas production of 3.8 Bcf. The producer's calendar day gas rate in May 2015 was 15.5 MMcf/day from 21 producing wells.

## **Montney play trend**

Since 2007, the development of gas from the sandstone, siltstone and shale sequences has surpassed the expectations of many producers working along the Montney play trend. At year-end 2012, the play trend accounted for 33% of British Columbia's remaining raw gas reserves of 40.2 Tcf and is now one of the most active natural gas plays in North America (BC Oil and Gas Commission, 2013). Before that period, development of gas in the Montney unconventional play trend area was restricted to vertical drilling for poor-quality, conventional fine-grained sandstone reservoirs (BC Oil and Gas Commission, 2012). The Triassic Montney Formation is a thick, regionally charged formation of unconventional tight gas and shale gas distributed over an area extending from north-central Alberta to the northwest of the city of Fort St. John in Northeast BC (Figure 14). The fairway covers approximately 2.9 million hectares in the South Peace region and includes major facies of fine-grained shoreface, shelf siltstone to shale, fine-grained sandstone turbidites, and an organic-rich phosphatic shale. In recent years, producers have pushed land sale and drilling activity northward in the fairway, which offers the advantage of producing natural gas liquids and condensate, as opposed to the drier shale gas areas in the extreme northern regions of the province.

### ***Land sale activity***

Annual bonuses garnered from PNG rights sold within the greater Montney exploration and development fairway reached a peak of \$1.32 billion in 2008 (Figure 15). Record land sale bonuses collected that year can be directly correlated with an industry shift to incorporate unconventional gas reservoirs, which include Triassic targets such as the Upper, Middle and Lower Montney as well as the Doig and Doig Phosphate. Land sale bonuses dropped steadily in the following years with 2012 bringing in total bonuses of only \$121 million. In 2013, bonuses from PNG rights sold increased to \$219 million, and in 2014, jumped further to \$377 million. Land sale activity in the Montney play trend in 2014 accounted for 98.5% of all land sale bonuses collected in the province. The highest monthly bonus total was collected at the November 2014 PNG rights disposition. It represented the 11<sup>th</sup> highest single sale in British Columbia's history with a total 28 836 hectares purchased for \$209.6 million at an average price of \$7267 per hectare. Charter Land Services paid the highest bonus total at the sale spending \$123.6 million for an 8 350-hectare licence covering six tracts and several sections offsetting the Kobes and Blueberry areas in the structured outer Foothills region at 87-25W6, 88-25W6 and 094A/12. The tracts include a mix of PNG rights mostly from surface to basement, but in all cases include the Triassic Montney. The second most expensive parcel was purchased by Windfall Resources Ltd. The land broker paid \$66.81 million for a 3,710-hectare licence, which included four tracts at 94A/12 and 94B/09 just east of the Kobes area. Both parcels are located on a trend just southwest of the some of the more liquids-rich areas within the Regional Northern Montney Field such as Inga and Blueberry.

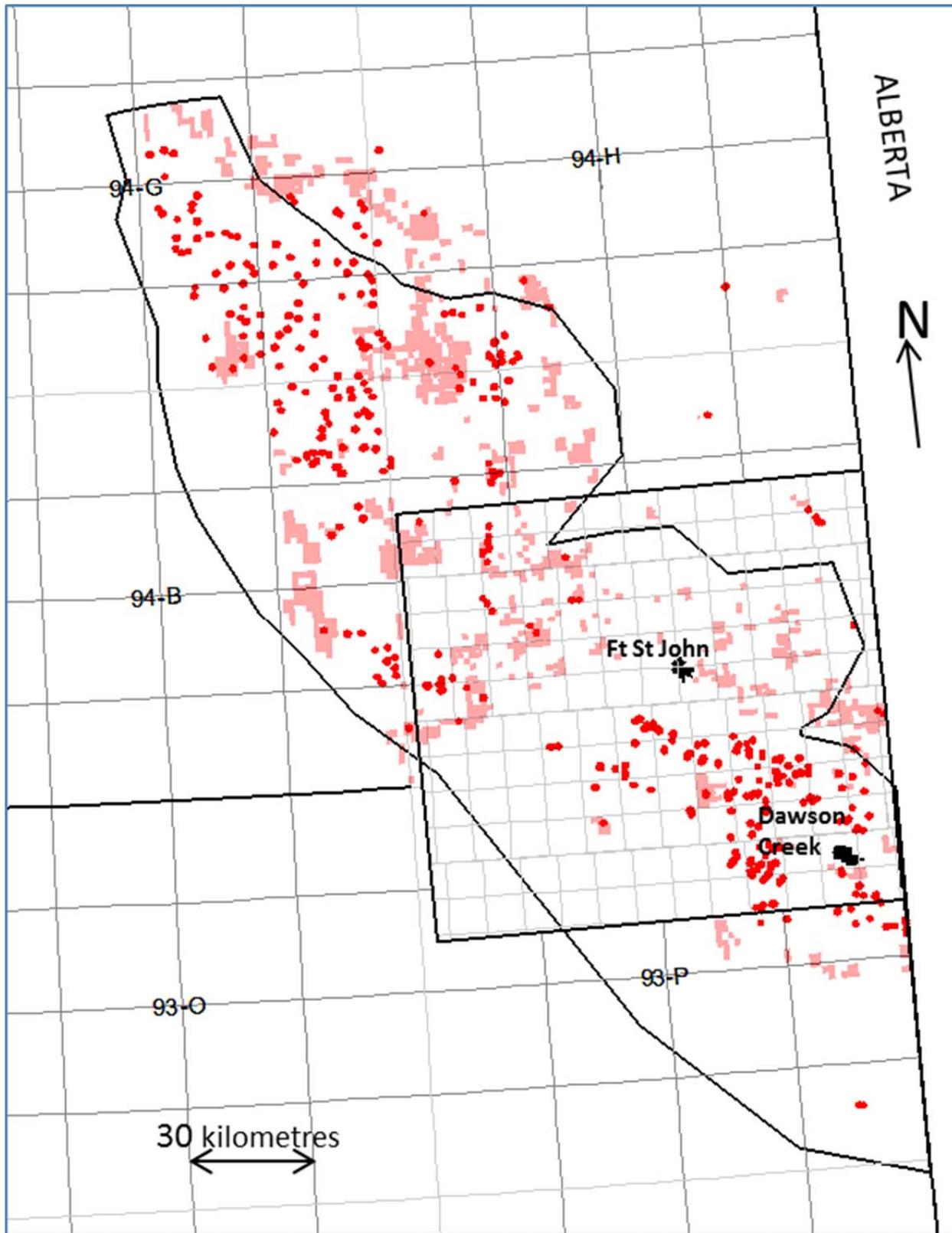


Figure 14. Petroleum and natural gas (PNG) rights sold (pink polygons) and wells drilled (red dots) within Montney play region in 2014. The main play area of the Montney trend covers approximately 2.9 million hectares (7.2 million acres) in the Fort St. John–Dawson Creek region of Northeast BC and extends geographically up to the Trutch area.

## PNG rights sold in Montney play region

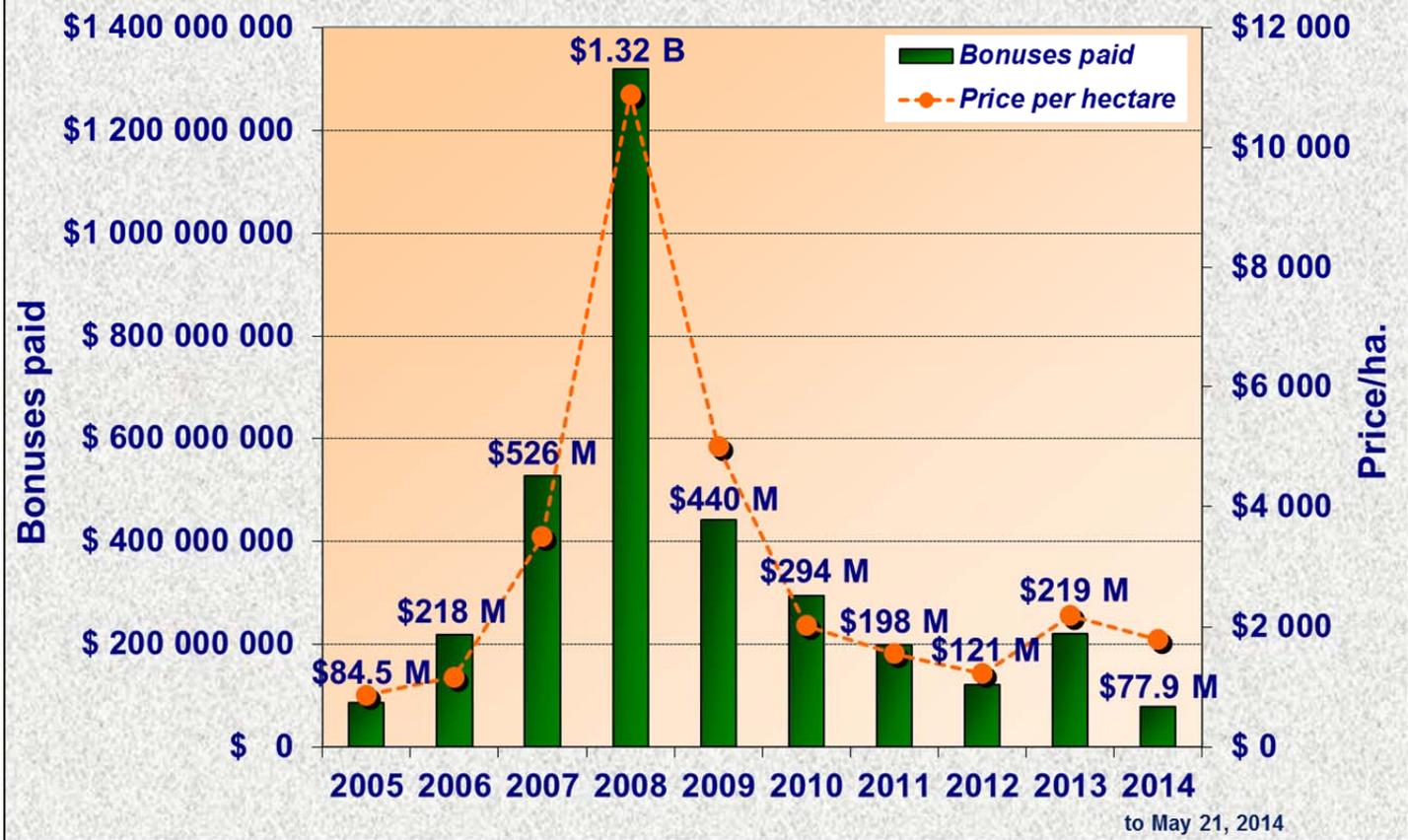


Figure 15. Bonuses garnered from petroleum and natural gas (PNG) rights sales in the Montney play trend since 2005.

### Industry activity

The Triassic Upper Montney zone continues to offer exceptional growth in production, particularly from such fields as **Monias, Dawson Creek, Swan Lake** and **Tupper Creek**. The Upper Montney is limited by depth within the Montney play region; it is shallow in the northeast and deepens to the southwest. Technological advances and the application of new horizontal well techniques are a major component to unlocking the potential of the Montney resource. These techniques are giving producers such as Progress Energy Canada Ltd. and Talisman Energy Inc. the opportunity to target the Upper, Middle and Lower Montney, and Doig in areas of the northern Montney play region, which is bounded by the **Caribou, Lily Lake, Altares, Town** and **Gundy Creek** fields. This widespread expansion of the productive north Montney fairway has been experiencing a surge of interest during the last two years and is located in a relatively undrilled region of Northeast BC. In addition to unconventional Montney gas, conventional Debolt gas thrust traps are targeted in this region. A total of 616 wells were rig released within the Montney play region in 2014 (Figure 16). Over 97% listed the Triassic Doig, Doig Phosphate and Montney formations as the projected target (Table 3).

Operator	2014 rig releases
Progress Enrg Cda Ltd	203
ARC Rsrcs Ltd	58
Shell Cda Ltd	57
Encana Corp	55
Tourmaline Oil Corp	48
Cdn Nat Rsrcs Ltd	33
Murphy Oil Co Ltd	32
Crew Enrg Inc	31
Painted Pony Petr Ltd	17
Storm Rsrcs Ltd	17
Kelt Expl (Lng) Ltd	14
Canbriam Enrg Inc	13
Black Swan Enrg Ltd	10
UGR Blair Creek Ltd	8
Todd Enrg Cda Ltd	5
Pengrowth Enrg Corp	3
Bonavista Enrg Corp	2
Cdn Spirit Rsrcs Inc	2
Leucrotta Expl Inc	2
Suncor Enrg Inc	2
Tervita Corp	2
Northpoint Rsrcs Ltd	1
Spyglass Rsrcs Corp	1
TOTAL	616

Montney 2014 rig releases by formation	
Target zones	Rig releases
Montney	544
Doig Phosphate	43
Doig	11
Paddy/Cadotte	5
Baldonnel	4
Cadomin	3
Bluesky/Gething	2
Belloy	1
Golata	1
Debolt	1
Dunvegan	1
TOTAL	616

TABLE 3. Montney Play Region Operators and Target Zones

**Progress Energy Canada Ltd.**, a subsidiary of global LNG player **Petroleum Nasional Berhad (PETRONAS)** of Malaysia, invested over \$2 billion in drilling and infrastructure projects in Northeast BC in 2014 (Progress Energy Canada Ltd., 2015). Most of this investment was directed towards its North Montney Joint Venture, which contains a combination of liquids-rich and dry gas assets in the northern Montney fairway. Progress continues with its target of expanding the areal extent of productive Montney in the fairway with full-scale commercial developments and a goal of delivering 2.0 Bcf/day to **Pacific NorthWest LNG** by 2019. Progress Energy, one of the busiest drillers in Canada and certainly the most active in British Columbia, drilled a total of 203 wells in the north Montney region in 2014. Progress has drilled to establish 19 Tcf of proved plus probable reserves at year-end 2014, which will support 2.0 Bcf/day of LNG natural gas feedstock for 25 years. PETRONAS has yet to decide whether it will proceed with its Northwest LNG export facility on Lelu Island (near Prince Rupert). A final investment decision (FID) will depend on critical components supporting economic viability of the project and competition from other LNG producing countries. Progress Energy was one of the first movers in the north

Montney region and has now identified a potential drilling inventory of 2500–7500 locations, encompassing both the Upper and Lower Montney targets of the Lower Triassic. The producer uses development pods in its drilling process; each pod lays out 80 drilling locations in a concentrated area with a centralized facility capable of processing 50 MMcf/day.

In 2014, **Royal Dutch Shell plc.** carried out a strategic review of its North American tight-gas and liquids-rich shale portfolio. Certain assets were identified where it was necessary to consider whether carrying amounts were recoverable with regard to short- and long-term commodity price assumptions. One of these assets assessed for the potential effects on the carrying amount was the **Sunset Prairie-Groudbirch** complex within Northeast BC's Montney play region. The company determined that the carrying amount of exploration and production at Groudbirch remained supportable in a lower long-term price scenario (Royal Dutch Shell plc, 2015). **Shell Canada Limited** drilled 49 new wells in the Sunset Prairie-Groudbirch complex in 2014, down slightly from the 53 drilled the year before. The producer holds PNG rights totaling more than 300 sections (80 000 hectares) in the complex, which now include several natural gas processing plants and more than 900 km of pipeline. The latest production figures from Shell show that 330 MMcf/day is being produced from over 300 wells (Shell Canada Limited, 2015). Wells at Groudbirch are drilled with a mix of single and multiwell pads at moderate target depths of 2200–3000 m. The Triassic Montney target lies in a sequence of siltstone, sandstones and shales more than 150 m thick. Horizontal wells drilled with long reach laterals may set a new standard for field development in the Groudbirch complex and could ultimately reduce the number of wells needed to successfully produce from Montney targets. A Sunset area well drilled in 2013 at UWI 100/12-18-79-18W6 completed drilling in only 25 days to a total measured depth of 6250 m. The lateral portion of 3897 m was drilled using only one drill bit. It was one of five long lateral wells drilled on a pad. The well became an active gas producer in January 2014 at an impressive rate of 11.2 MMcf/day over four days and has seen cumulative gas reach almost 2.9 Bcf to the end of January 2016. Shell's remaining wells drilled in 2014 were in the Regional Northern Montney Field in the areas of **Beg**, **Gundy Creek** and **Inga** where Shell continues to focus on future development of the Triassic Montney. Shell Canada is one of four companies that have formalized a joint venture partnership with LNG Canada to develop a proposed LNG export project in Kitimat, British Columbia. The other joint venture partners are **PetroChina Corporation**, **Korea Gas Corporation (KOGAS)** and **Mitsubishi Corporation**. Shell's Groudbirch area assets are a good supply link to an LNG liquefaction plant off the BC coast.

**ARC Resources Ltd.** (ARC) continues to use its significant operational expertise in developing tight, low-permeability formations to be a leading operator and producer in the Montney play trend. The company was one of the first operators to establish successful horizontal completion methods along the trend with its early work in developing Upper Montney shale gas in Northeast BC's Dawson area (79-15W6).

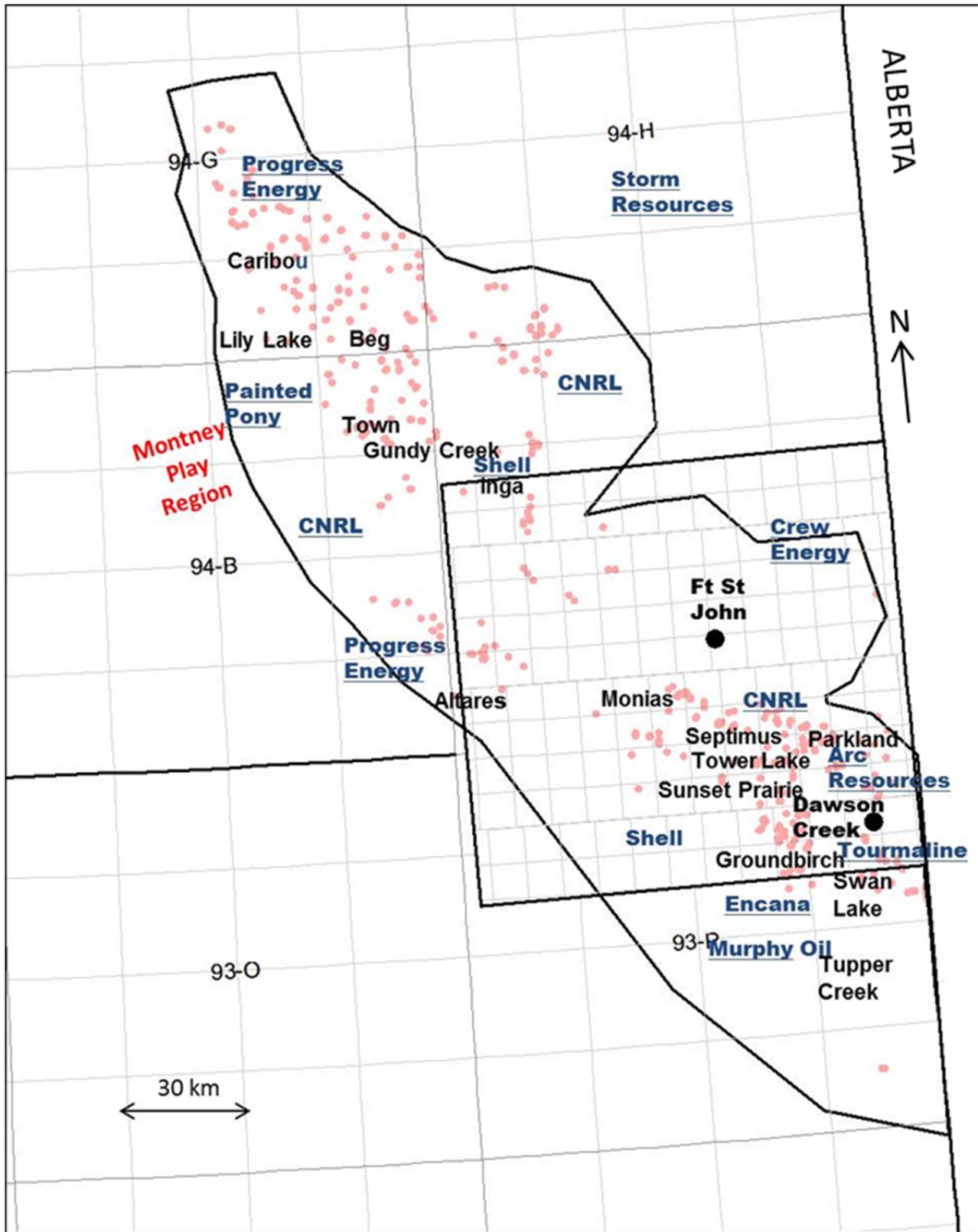


Figure 16. The key active producers operating in the Montney play trend in 2014 are shown in blue text approximately where they operate. Major areas of activity are shown in approximate position in black text. The 623 wells drilled in the Montney region accounted for 89.4% of the 697 wells drilled in the province in 2014. The Triassic Doig and Montney formations encompassed most of the projected zones targeted by producers.

ARC has now expanded its land holdings in the Northeast BC portion of the Montney fairway to 615 net sections (159 000 hectares), which include its key areas of **Dawson, Sundown, Sunrise, Sunset Prairie, Septimus, Parkland** and **Tower Lake** and further north in the **Attachie** and **Blueberry** areas. Over the first three months of 2015, daily production from these Northeast BC assets was 353 MMcf/day of natural gas, 3155 barrels/day of oil and 1947 barrels/day of natural gas liquids (ARC Resources Ltd, 2015). According to an independent resource evaluation conducted by **GLJ Petroleum Consultants Ltd.** in 2014, the discovered resource potential of ARC's Northeast BC Montney areas is significant at 35.4 Tcf of discovered gas initially in place (DGIIP), up from 30.4 Tcf in 2013 (ARC Resources Ltd., 2015a). ARC's most productive area is the Dawson field, where core development has focused on the Upper Montney 'A' pool. Development potential also exists in the Lower Montney as improved completion techniques continue to show promising results. Volume rates at Dawson reached 169 MMcf/day of natural gas and 900 barrels/day of liquids in the final quarter of 2014. Thirteen natural gas wells were drilled in the area in 2014; ARC plans to bring two Lower Montney wells on stream in 2015. The new Dawson Phase III Gas Plant is scheduled to be commissioned in 2017. The facility will be capable of processing 90 MMcf/day and 7500 barrels/day, which would bring total gas processing capacity at Dawson to 255 MMcf/day and over 8500 barrels/day of liquids handling. In the Parkland/Tower Lake areas, ARC produces predominantly light oil and free condensate with additional liquids in the gas stream. In 2014, eighteen liquids-rich natural gas wells completed drilling in the Parkland area and 11 oil wells were drilled at Tower. ARC was producing a combined total (Parkland and Tower Lake) of approximately 104 MMcf/day of gas and 8390 barrels/day of liquids in the fourth quarter of 2014. The areas support two layers of Upper Montney development with current piloting of Lower Montney potential. ARC expects to execute \$170 million in capital spending in the Parkland/Tower areas in 2015 and is planning to drill two natural gas wells at Parkland and 22 oil wells at Tower Lake to partially fill a 60 MMcf/day gas processing and liquids handling facility. In the Sunrise area, natural gas production reached 46.6 MMcf/day in the fourth quarter of 2014 with production coming from four layers of the Montney Formation. ARC drilled 15 horizontal wells in the area in 2014, which has progressed from pilot drilling to full-scale development. Further north in the Attachie area, ARC continues to monitor pilot production from two wells on its interest lands in the eastern and western portion of the area. ARC will continue assessing options for commercial development and infrastructure requirements on its properties at Attachie.

**Encana Corporation** continues its strategy of focusing on its highest quality assets in North America. One those assets is the Montney region in northeast BC where the producer has seen success with its high intensity completions design and where wells have continued to produce at much higher rates than prior type curve expectations, specifically in the Dawson area (Encana Corporation, 2015). Encana's assets in the **Cutbank Ridge** resource play, which basically covers five development areas within the southern portion of the Montney play trend in British Columbia, consist of gas production from the Montney, Cadomin and Doig geological formations. The Montney resource region is a good fit with Encana's objective to accelerate liquids growth and optimize base gas production. Encana's net land position in the Montney region, which encompasses areas of northwestern

Alberta and northeastern British Columbia, is over 237,000 hectares. In 2014, the company rig released 53 wells within the British Columbia portion of the Montney resource play and another 26 wells on the Alberta side of the play. In the fourth quarter of 2015, output from the Montney averaged 24,600 barrels a day of liquids and 570 MMcf/day of gas. Encana plans to continue with the development of oil and liquids-rich areas of the Montney play and estimates drilling 25 net wells in the region in 2015. In late December 2014, **Veresen Midstream Limited Partnership** agreed to undertake up to \$5 billion of new midstream expansion for Encana and the **Cutbank Ridge Partnership** in the Montney region. Under a 30-year fee-for-service arrangement, the transaction includes existing infrastructure comprised of gas gathering and compression facilities in the Dawson Creek area, consisting of approximately 500 km of pipeline and 675 MMcf/day of compression (Encana Corporation, 2015a).

**Tourmaline Oil Corporation** has been a significant participant in recent British Columbia Crown land sales and, as a result, has built a drilling inventory of over 1100 future horizontal well locations. Tourmaline's Northeast BC Montney activities are focused in the **Sunrise/Dawson/Sundown** play area where it believes the Triassic Montney is the thickest, most over-pressured and liquids rich. Tourmaline's Sunrise-Dawson-Sundown play has three distinct over-pressured Montney horizons to exploit. These vertically stacked turbidite lobes all exhibit high deliverability from horizontal drilling (average rates from 3.8 to 4.9 MMcf/day) with a reasonably strong liquids content of 35–50 barrels/MMcf. In April 2015, production from the area was 225 MMcf/day of natural gas and 4000 barrels/day of condensate and NGLs (Tourmaline Oil Corporation, 2015). As of April 2015, Tourmaline has drilled a total of 148 multi-stage fracture-stimulated wells in the Sunrise-Dawson-Sundown play and tested 140 of those. Over the last two and a half years of drilling, the average initial production test rate was 12 MMcf/day with an average liquids rate of 325 barrels per day. Tourmaline drilled 46 wells (43 horizontal) in the Sunrise-Dawson-Sundown complex in 2014; approximately 50 wells are slated to be drilled in 2015. The company has also stated that complementing its growing Montney inventory is a series of high-deliverability/low operating cost sweet Mississippian Kiskatinaw and Upper Devonian Wabamun natural gas pools. Tourmaline believes that these deeper pools, referred to as a Paleozoic gas play, may have considerable exploration and production potential (Tourmaline Oil Corporation, 2015a).

As part of its reduction in capital spending, **Murphy Oil Corporation** (Murphy) announced in early 2015 that it would suspend drilling operations in the **Tupper Creek** area (Tupper West, Tupper Main) after February 2015. Murphy was an early participant in the development of Triassic shale gas potential from the Montney turbidites in the **Tupper Creek** area with activity beginning back in 2007. Recently, Murphy implemented a new completion strategy and a downhole choke management plan at Tupper West and Tupper Main. These techniques are based on similar practices used in the Eagle Ford Shale where estimated ultimate recoveries (EUR's) have shown improvement in offset wells. Murphy has had excellent results in optimizing completions on new wells, which, in the early stages, have resulted in higher cumulative production and well pressures and, ultimately leading to higher EUR's (Murphy Oil Corporation, 2015). Murphy rig released 35 wells in 2014 with all wells drilled in the **Groundbirch, Sundown** and **Swan Lake** areas. Natural gas production from Murphy's Montney operations in

the first quarter of 2015 was 187 MMcf/day, similar to the fourth quarter of 2014. Production rates are expected to fall by approximately nine per cent in 2015 to 170 MMcf/day.

**Canadian Natural Resources Ltd.** (CNRL) holds a significant unconventional land asset base of approximately 422 000 net hectares (over one million net acres) along the Montney fairway. One of CNRL's main project areas in Northeast BC's Montney play trend is the **Septimus** field, where it continues with its concentrated liquids-rich drilling program. CNRL's total North American natural gas volumes in 2014 increased by 38% to 1.53 Bcf/day compared to 1.13 Bcf/day in 2013. The increase was largely due to the acquisition of Canadian natural gas properties in 2014, the completion of CNRL's drilling program at Septimus and the expansion of a Septimus area plant in late 2013 (Canadian Natural Resources Ltd., 2015). CNRL drilled 33 wells in Northeast BC in 2014; twenty-five of those wells were rig released in the Septimus area, while the remaining finished drilling further north in the Birch, Nig Creek, West Jedney, West Peejay, Beg and Daiber areas.

**Crew Energy Inc.** increased its land interests in the Montney region to 487 net sections (126,000 hectares) in 2014, further improving its competitive land position in the over-pressured regional Montney complex. The producer's Montney resource has significant upside with TPIIP (total petroleum initially in place) of 109 Tcf (Crew Energy Inc., 2015). Crew's most active drilling and development program occurs in the highly prospective **Septimus** area. The area is the most developed, representing 73% of its overall corporate proved developed producing reserves, yet the developed land base in the area represents only 2% of the company's total Montney acreage. Wells in the area are testing at initial rates as high as 15 MMcf/day with an EUR per well of 5 Bcf. Total activity at Septimus in 2014 resulted in 23 wells being drilled; all were targeting liquids-rich gas. Crew also continued to evaluate Montney potential at its **Attachie**, **Groundbirch** and **Tower Lake** area properties. Crew's activity in the over-pressured, liquids-rich natural gas area of Attachie area is in the proof of concept stage while further south at Groundbirch, two wells were drilled and tested that confirmed the over-pressured nature of the reservoir in the area and the high liquids content of the production (Nickle's Daily Oil Bulletin, 2015). Crew's emerging light oil play in the Tower Lake area is realizing good growth potential from optimizing efficiencies such as tighter spacing used in pad drilling. The company drilled and completed five horizontal wells from pad locations in 2014; this resulted in bringing on new production in the 4th quarter of 2014 of approximately 2400 BOE/day (Crew's fourth quarter overall production output was 20,869 BOE/day).

**Painted Pony Petroleum Ltd.** is one of the most active producers in the northwest section of the Montney play trend and is ideally situated to be a key supplier to BC's proposed west coast LNG export terminals. However, its five-year plan is based entirely on sales to North American markets, with no reliance on LNG projects (Painted Pony Petroleum Ltd., 2015). Seventy-three operated wells have been drilled since 2005 in Painted Pony's Montney Project, which targets three productive Triassic Montney Formation intervals (Upper, Lower and Middle). Painted Pony refers to these intervals as "three stacked resource plays in one" with the Montney

exploitable gas column being more than 300 m thick, gas charged and highly over-pressured. In the first quarter of 2015, daily production volumes from the Montney Project reached approximately 91 MMcf/day and 1068 barrels/day of natural gas liquids. Painted Pony's development program activities in 2015 are estimated to generate an average production rate of 16 000 BOE/day; this is expected to grow to an average of 48,000 BOE/day by 2017. The producer continues to delineate and develop its large-scale and conveniently located natural gas assets in the Regional Northern Montney Field. Painted Pony's Montney rights now exceed 56,000 hectares (217 net sections) with a 75% average working interest on all of its key properties. These interest areas include the **Cypress, Blair Creek, Daiber** and **Town** areas (NTS 094B/15 and 094B/16) and the more recently-purchased assets in the **Townsend** area (NTS 094B/09). Painted Pony's estimated expenditures for 2015 are \$104 million, which will be subject to review on a quarterly basis. Activity in the Blair Creek–Daiber areas in 2014 entailed drilling 11.5 net wells; another four net wells are expected to be drilled in 2015. In early 2015, construction of a 25 MMcf/day compression and dehydration facility in the Blair Creek area was completed and a Daiber area lean gas processing facility was expanded from 25 to 50 MMcf/day. In the Townsend area, four 100% working interest wells were drilled in 2014. Gas and condensate production began on three horizontal wells on the company's a-11-J/94-B-09 pad. Construction of the **AltaGas Ltd.** 198 MMcf/day, shallow-cut gas processing facility in the Townsend area is set to begin in the late summer of 2015. Painted Pony expects to begin ramping up production at Townsend to its initial firm capacity of 150 MMcf/day in September 2016 with firm capacity escalations to the full 198 MMcf/day 12 months after facility start-up (Painted Pony Petroleum Ltd., 2015a). Painted Pony is now using the recently adopted open-hole ball-drop packer-style system rather than perf-and-plug completion technology in many of its active areas. In fact, all wells completed by Painted Pony in 2014 used the open-hole multi-stage (OHMS) system (Nickle's Daily Oil Bulletin, 2015a). The ball-drop packer-style technology offers an increase in the number of completion stages per well (typically 17–19 stages, as opposed to 8–10 stages using the perf-and-plug style). More recently, Painted Pony has achieved considerable early production gains from the implementation of a parallel-pair well drilling and completion pattern. This advancement combines operational experience using open-hole fracture stimulations with new sequencing and refined placement of Montney horizontal well trajectories.

**Storm Resources Ltd.** has acquired approximately 141 sections (100 000 net acres) of undeveloped land in the **Umbach** area in the northwest region of the Montney play trend (NTS 094H/03). Crown land acquisitions in 2014 totaled \$88 million on 29 sections with 100% working interest lands at Umbach, which is prospective for liquids-rich natural gas. Storm reported first-quarter 2015 average production of 8580 BOE, representing 141% growth from the first quarter of 2014. Natural gas liquids recovery was 33 barrels/MMcf of natural gas sales, which included approximately 60% condensate plus pentanes (Storm Resources Ltd., 2015). Activity at Umbach in 2014 consisted of drilling 16 Montney-directed horizontal wells and one Montney vertical delineation well. So far, Storm has drilled 37 horizontal wells into the Montney at Umbach with 27 wells producing. Wells in the area are generally drilled in 11 to 14 days at a vertical depth of 1550 m and a horizontal length of 1100 to 1500 m. Storm continues to modify its horizontal drilling techniques to improve 90-day, 180-day and first-year production rates

as displayed by a comparison of calendar day rates for all producing Montney horizontal wells shown in Table 2. The company estimates that the most recent horizontal wells (20 to 24 frac stages) will average 3.6 MMcf per day in the first year with an ultimate recovery of 6.3 Bcf of raw gas.

	Frac stages	IP 30 Calendar Day Gross Raw Gas mmcf/d	IP 90 Calendar Day Gross Raw Gas mmcf/d	IP 365 Calendar Day Gross Raw Gas mmcf/d
2011–2012 hz's (7 wells)	7 to 14	1.9 mmcf/d, 345 BOE/d sales, 7 hz's	1.4 mmcf/d, 255 BOE/d sales, 7 hz's	1.3 mmcf/d, 235 BOE/d sales, 7 hz's
2013 hz's (6 wells)	16 to 18	4.0 mmcf/d, 725 BOE/d sales, 6 hz's	2.9 mmcf/d, 525 BOE/d sales, 6 hz's	2.2 mmcf/d, 400 BOE/d sales, 6 hz's
2014 hz's (10 wells)	16 to 20	4.7 mmcf/d, 850 BOE/d sales, 10 hz's	4.9 mmcf/d, 885 BOE/d sales, 7 hz's	4.3 mmcf/d, 780 BOE/d sales, 1 hz
2015 hz's (3 wells)	18 to 22	5.6 mmcf/d, 1015 BOE/d sales, 1 hz	not available	not available

TABLE 2. STORM RESOURCES' COMPARISON OF HORIZONTAL WELL DAY RATES IN THE UMBACH AREA OF NORTHEAST BC

If natural gas prices improve from current levels, Storm's activity in 2015 will include placing nine standing horizontal wells on production, which would top up the approximately 16 MMcf/day of unused raw compression capacity at Umbach. The producer currently operates two compressor facilities at Umbach that have a total capacity of 72 MMcf/day; first quarter 2015 throughput was averaging 42 MMcf/day. A third compressor station with throughput capacity of 35 MMcf/day of raw gas is expected to be operational by mid-2016.

**Kelt Exploration Ltd.**, which acquired all of the issued and common shares of **Artek Exploration Ltd.** in mid-April of 2015, has elected to direct its most of its capital spending going forward to its core area in Northeast BC. The core area includes the Triassic Doig high-yield, condensate-rich areas of **Inga** and **Fireweed**, located in the north-central region of Montney play trend. Kelt's land holdings include approximately 167 net sections with Doig rights and approximately 157 net sections with Montney rights in its Inga-Fireweed-Stoddart core area, which gives the producer an extensive inventory to pursue drilling operations (Kelt Exploration Ltd., 2015). Operations in 2014 included the drilling of six wells in the Fireweed area and eight in the Inga area (pre-Artek acquisition). Seven of those wells were placed on production and are producing from either the condensate-rich Doig or Montney formations. Kelt Exploration has reported that that recent well performance in the Triassic Doig and Montney formations, where wells have been completed using slick-water fractures, have revealed promising results with production notably outperforming wells that have used other fracture techniques. In fact, two recent Doig wells that were completed using slick-water fractures have shown increases of almost 100% in productivity compared to the average Doig type well using propane-based hydraulic fracturing (Kelt Exploration Ltd., 2015a). Kelt's 2014/15 drilling plans for the Inga-Fireweed-Stoddart core area will involve the drilling of 12 gross wells (5.8 net wells).

As of December 2014, **UGR Blair Creek Ltd.** (UGR) held over 28 000 net hectares of land interest in the unconventional Montney play trend in BC. UGR has a net resource of 27 Tcf of gas-in-place with a recovery potential of 10 Tcf from an inventory of 1,500 locations in its northern Montney assets (Unconventional Gas Resources, 2014). The producer's goal is to grow its gas production in its Montney properties to 100 MMcf/day by early 2016; production in February 2015 was approximately 60 MMcf/day. UGR drilled eight Montney wells in 2014 in the areas of **Jedney, Town, Daiber** and **Kobes** (all in the Northern Regional Montney Field). In late 2014, it was announced that **Kanata Energy Group Ltd.** entered into an agreement with UGR to build significant natural gas infrastructure and processing facilities in the Daiber area (NTS 094B/16). Facilities would include processes for compression, dehydration, refrigeration and condensate stabilization. A gas refrigeration plant is scheduled to be operational in early 2015. In terms of gas marketing, UGR's asset location bodes well for activity in the LNG sector, but the producer insists that its business plan does not rely on LNG exports. It foresees selling into the North American market.

**Saguaro Resources Ltd.** was formed in 2012 to pursue exploration, acquisition and development opportunities in unconventional light oil and liquids-rich natural gas plays in the Western Canadian Sedimentary Basin (Saguaro Resources Ltd., 2015). Its core area in Northeast BC is located along the northeastern edge of the **Laprise Creek** area on a trend to the northwest (NTS 094H/05 & 094G/08). In 2014, thirteen wells were drilled in Saguaro's Northern Montney gas project at Laprise Creek. All wells targeted the Montney Formation with eight wells listed as producing by the end of the year. The best producing well was drilled in early 2014 at UWI 200/c-013-H/94-G-08. March 2015 lists a calendar day rate of 2.2 MMcf/day at almost a full month of production hours; cumulative production over 11 months was 828.5 MMcf.

**Canbriam Energy Inc.** continues to see promising results from its Montney project in the **Altares** area. The producer operates approximately 95 sections (25,000 hectares) in this west-central region of the Montney fairway. Drilling in 2014 consisted of 13 wells rig released and another 13 rig releases from January to May 2015; all wells were drilled in the Altares area (NTS 094B/08). Within the company's significantly over-pressured "Main Fault Block" in the Altares area, well results have met or exceeded nine Bcf raw gas type curves for Upper Montney wells and eight Bcf for Lower Montney wells (Nickle's Daily Oil Bulletin, 2015c). Canbriam has approximately 34 years of upside drilling inventory on its lands with the potential for 1622 net locations (Canbriam Energy Inc., 2015). Production in 2014 averaged approximately 9,628 BOE/day (81% gas, 11% condensate, 8% butane and propane). At year-end 2014, proved plus probable reserves from the project area were 1.36 Tcf of gas and 54.6 million barrels of natural gas liquids. Canbriam will continue to focus on these area lands due to their prospectivity for natural gas liquids, which yield approximately 50 barrels/MMcf on nearly 50% of Canbriam's land. The producer's drilling activity in 2015 will be exclusively centered in the Altares area. In mid-February 2015, Canbriam commissioned Phase 1 of its 100 per cent owned and operated gas processing facility, which supports another 80 MMcf/day on top of the 50 MMcf/day capacity that's currently in place. Also, a source water pipeline

extension and water hub facility is scheduled for start-up in the second quarter of 2015. This is expected to reduce water handling costs by up to \$30 million per year.

**Black Swan Energy Ltd.**, a private-equity backed exploration and production company formed in 2010, continues with its delineation program in the **Beg and Aitken Creek** areas of the northern Montney play trend. Black Swan's land position in the region consists of approximately 58 500 hectares (144 460 acres), which offer a reasonably low-cost opportunity in a 250-metre thick, gas-charged resource within the over-pressured region of the North Montney (Black Swan Energy Ltd., 2014). Black Swan rig released its first Montney well in the Beg area in March of 2012 at (UWI b-058-G/94-G-01) with cumulative production reaching 912 MMcf as of December 2014. Activity in 2014 included the drilling of seven horizontal development wells drilled mostly in the beg area. Six of those wells are producing at a combined calendar gas rate of 12.2 MMcf/day. One of Black Swan's most productive wells drilled in 2014 was rig released in mid-August (UWI a-096-A/94-G-01). Since being on stream in January of 2015, it has recorded production from the Triassic Montney of 267 MMcf at a calendar day rate of 3.5 MMcf/day and cumulative condensate production of 3757 barrels. As a result of Black Swan's recent acquisition of **Carmel Bay Exploration Ltd.**, more activity will be forthcoming in the **Nig Creek** area, which is contiguous to Black Swan's land position in the North Montney.

**Chinook Energy Inc.** owns 65 sections of Montney rights in the **Birley Creek/Umbach** areas of Northeast BC. The producer has stated that it will continue to expand and delineate its large Montney resource in 2015 at a pace that does not weaken value creation or restrict growth potential (Nickle's Daily Oil Bulletin, 2015d). Like many other producers, Chinook will use its capital flexibility and balance sheet strength to provide optionality throughout a lower commodity price cycle. Chinook's 2014 drilling program involved the drilling of three (2.25 net) horizontal wells in the Birley Creek/Umbach areas; all were targeting liquids-rich natural gas in the Upper Montney zone. The first well, UWI a-060-K/94-H-03, was drilled and completed in the first quarter and commenced production in April 2014 at restricted rates of 3.9 MMcf/d and 134 barrels of free condensate per day. The well has been on production for 248 days as of March 2015 during which it has averaged 3.0 MMcf/day and 56 barrels of free condensate per day. The second horizontal well, UWI a-072-F/94-H-03, was drilled and completed in the third quarter of 2014 and has been on production for 122 days at restricted rates during which it has averaged 4.6 MMcf/d and 27 barrels of free condensate per day. A third horizontal well at UWI a-073-L/94-H-03 was drilled in early 2015; it has been completed with production beginning in March of 2015. Current throughput capacity at Chinook's Birley Creek area compressor site is approximately nine MMcf/day. During the first quarter of 2015, Chinook was expected to spend \$25 million on the installation of a 1.6 kilometre, 12-inch gathering line along with the acquisition of long lead equipment and fabrication components to complete its Phase 1 expansion of the Birley Creek facility to 35 MMcf/day. It also has plans to upgrade an access road for all season access to its core area (Chinook Energy Inc., 2015).

**Leucrotta Exploration Inc.** (Leucrotta) is a Montney-focused producer with 172 net sections of interest land holdings in the **Dawson–Sunrise** areas of Northeast BC. During the year, Leucrotta devoted the majority of its capital spending on acquiring a large land base targeting liquids-rich Montney gas and oil for future development (Nickle’s Daily Oil Bulletin, 2015e). Leucrotta drilled four wells in Northeast BC in 2014; two were in the **Doe** area while the other two were in the **Mica** and **Sunrise** areas. In late 2014, a horizontal well was drilled in the Mica area where, over a 29-day test period, the well flowed approximately 195 barrels of light oil per day, 35 barrels per day of NGL’s, and 1.5 MMcf/day of natural gas (472 BOE/day). Based on data collected to date, this light oil discovery location has an estimated 26 million barrels of original oil-in-place (OOIP) and 36 Bcf of original gas-in-place (OGIP) per section (Leucrotta Exploration Inc., 2015). At Leucrotta’s Montney gas project, plans are underway to drill four Montney development wells into the Lower Montney turbidite play in the Doe area. These development wells will be drilled off of pads and will be adjacent to Leucrotta’s original discovery well at surface location B04-19-80-14W6, which is a Lower Montney horizontal that has been producing gas since November 2013 and is still producing at a calendar rate of 2.8 MMcf/day (as of March 2015). Leucrotta’s proved plus probable reserves of liquids-rich Montney are booked at 15 million BOE with 70 locations identified for liquids-rich Montney development (Leucrotta Exploration Inc., 2015). In terms of infrastructure, Leucrotta’s Doe 13-24 plant is currently capable of handling 25 MMcf/d of gas plus related liquids (approximately 5,000 BOE/day). Leucrotta currently produces into the Alliance Pipeline and has an agreement for approximately 7.0 MMcf/d of firm service with AECO-based pricing until December 2015 (Leucrotta website).

### ***Production***

Continuing improvement in horizontal drilling and completion techniques have resulted in significant production from areas within the Montney play trend. The application of these techniques and the added value of liquids-rich gas production have been the key components to unlocking the economic potential of the region. Gas production from the Northern Montney and Heritage Montney within the play trend has increased considerably since 2005 with the average calendar daily rate in 2014 reaching 2.5 Bcf/day from 1585 (?) producing wells at the end of 2014 (Figure 17). The play region has seen cumulative gas production of approximately 1.6 Tcf in 2014.

### **Cretaceous shale gas activity (Fort St. John and Northern Foothills regions)**

Shale gas activity directed towards Cretaceous horizons in Northeast BC continues to be assessed in several areas of the Fort St. John and Northern Foothills resource regions. Lower Cretaceous sequences are the exploration focus in the Beg–Jedney areas and further south in the Blair Creek and Farrell Creek areas. Each of these areas has unique characteristics in terms of shale gas potential. Companies currently operating in these areas are evaluating fracture stimulation programs and continue to optimize completion methods that could result in increased well productivity.

In Northeast BC, the Buckinghorse Formation is approximately 1000 m thick and extends in a northwesterly direction in a broad, low-lying belt along the eastern edge of the Foothills between the Halfway and Muskwa rivers (Glass, 1997).

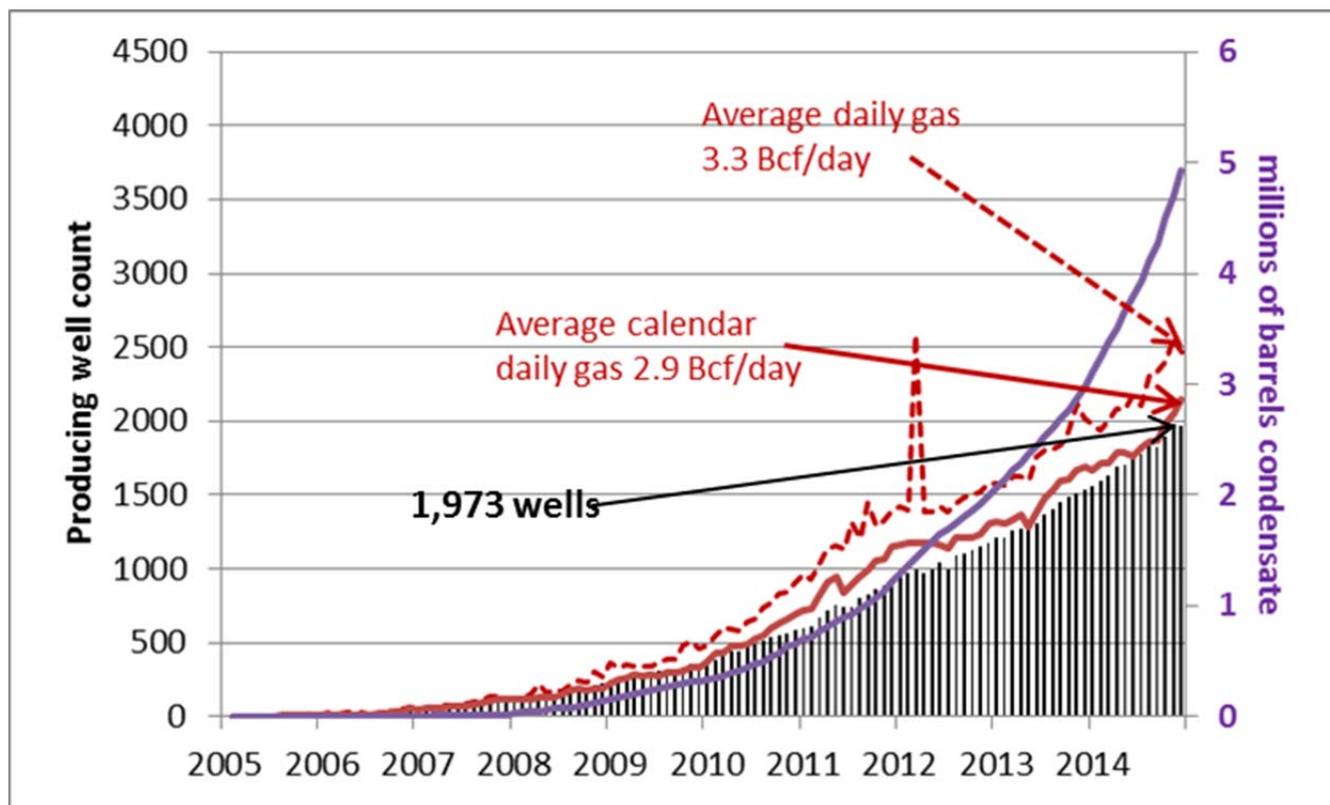


Figure 17. Montney trend annual production since 2005. Approximately 3.2 (?) Tcf of natural gas has been produced from the Lower Triassic Montney and Doig Phosphate formations from 2005 to end of 2014. The average daily calendar rate in December 2014 was 2.9 Bcf/day from 1973 wells. Cumulative condensate production was 4.93 million barrels.

### Industry activity

**Painted Pony Petroleum Ltd.** (Painted Pony) has amassed approximately 41 440 net hectares (160 net sections) of prospective Lower Cretaceous Buckinghorse rights in the greater **Blair Creek** area. The producer has been experimenting with drilling and completion techniques during the last five years and feels that there is a regionally extensive, 1200 m thick section in the area that is suitable for vertical development of 16 to 32 wells per section (Painted Pony Petroleum Ltd, 2014). The zone is shallow at approximately 400 m and the pressure regime is over pressured at an average of 0.5 psi/ft. So far, three wells have been production tested at Blair Creek. A hydraulic fracturing program is planned for two existing wells in the area; current initiatives include production test evaluations and continued regional mapping to determine the lateral extent of the gas. Painted Pony also believes the Buckinghorse shale may have potential further north of Blair Creek in the **Julienne Creek** area and to the south in the **Cameron** area.

As of December 2014, **UGR Blair Creek Ltd.** (UGR) held over 28 000 net hectares of land interest in the unconventional Montney play trend. Within that interest, UGR has additional upside potential in the untapped shales of the Lower Cretaceous Buckinghorse. In May 2009, **UGR Blair Creek Ltd.** was granted special project approval by the OGC for two experimental schemes in the **Town** area within the Montney play trend. The purpose of the schemes was to test the commercial viability of shale gas potential in the Lower Cretaceous Fort St. John Group. One of UGR's wells in the **Blair Creek** area (well authorization 13846 at b-87-G/94-B-16) began production from the Lower Cretaceous Shaftesbury Formation in December 2008 with an initial average daily rate of 283 Mcf/day. The latest production data available is from October 2011, when the well was producing at an average rate of 83 Mcf/day and cumulative production had reached 19.7 MMcf. UGR's net resource in place for the Buckinghorse shale is 25 Tcf (Unconventional Gas Resources, 2014).

## **OTHER INDUSTRY ACTIVITY**

**Harvest Operations Corp.** is now a wholly-owned subsidiary of Korea National Oil Corporation (KNOC). The producer continued to complete wells in its multi-leg horizontal oil well program in the **Hay River** area in 2014. The program at the Hay River property, which was acquired by Harvest Operations in 2005, operates under a pressure maintenance scheme supported by water injection (Harvest Operations Corp., 2015). Production from the Hay River area in northeast BC is a medium gravity crude oil (24° API) from the Cretaceous Bluesky Formation. The field, BC's single largest oil property, is along the northwestern Alberta and northeastern British Columbia border. Previously, this key area was a winter-only access site, but Harvest now has an all-season access road into the region. This provides better access for equipment and personnel and further supports the ability to both optimize operations and maximize recovery of this large resource. The Hay River property has over 200 million barrels equivalent of estimated original oil-in-place with an estimated incremental recovery potential of 5 to 15%. Harvest continues to increase its forecast recovery through development drilling and production optimization (pump upgrades, waterflood optimization, re-injection of produced natural gas and drilling down spacing). Harvest's Hay River area program in 2014 resulted in the drilling of 19 wells, including 11 producing wells (Harvest Operations Corp., 2015a). December 2014 daily calendar oil production was 4321 barrels per day.

**Canadian Natural Resources Limited** (CNRL) drilled three horizontal development wells in early 2014 in the **Birch** area. All wells list the Upper Triassic Baldonnel Formation as the total depth zone at approximately 2,700 to 3,000 metres. This activity is part of CNRL's Birch Baldonnel Project, which is investigating the possibility of a regional "resource style" oil play in the Triassic Baldonnel. CNRL is hoping to improve upon the performance of wells in the Birch Baldonnel 'C' Pool with the latest horizontal drilling and hydraulic fracturing technology. The pool, which was discovered in 1979, comprises 55 producing wells and has accumulated 4.6 million barrels of 41 degree API gravity oil, 9.87 Bcf of gas and 9,679,520 barrels of water (BC Oil and Gas Commission, 2015a). CNRL

is planning future development of 20 gross unrisks wells with a target EUR per well of 200 to 300 thousand barrels in what is now being referred to as the Baldonnel subcrop oil play.

**Venturion Oil Limited** is creating value by acquiring, developing and optimizing conventional oil fields. In British Columbia, Venturion is active in the **Boundary Lake North** area where it hopes to improve hydrocarbon production with horizontal drilling opportunities or waterflood applications. The producer drilled five wells in 2014; four horizontal wells are producing oil from the Halfway ‘D’ pool and one from the Halfway ‘I’ pool.

## **OUTLOOK**

Unconventional resource play development continues to thrive in many areas of Northeast BC. Although industry is steadily challenged with the demand and price fluctuations of world commodity markets, the increasing knowledge of BC’s unconventional gas regions through resource play development and new recovery techniques are key factors influencing the pace of industry’s activity. Capital spending on exploration and development activities in the province has been reasonably sound since 2005. The latest figures from the Canadian Association of Petroleum Producers (CAPP) in 2012 indicate capital spending of \$5.2 billion, not that far off from record spending in 2008 of \$7.9 billion. According to the Ministry of Natural Gas Development’s 2014/15–2016/17 Service Plan, annual investment in natural gas and oil exploration is forecast at 5.5 billion in 2013/14, which is approximately 10% more than the \$4.8 billion 2013/14 target provided in the 2013/14–2015/16 Ministry Service Plan. The increase is primarily the result of higher than expected activity in the Montney play region as producers continue to develop the liquids rich areas (Ministry of Natural Gas Development, 2014).

Going forward, investment in natural gas exploration and development activities is critical to an emerging LNG export industry in British Columbia. As an oil and gas jurisdiction, Northeast BC continues to offer a clear competitive advantage in terms of unconventional development and production. Raw natural gas production in British Columbia in 2014 was 1.58 Tcf (4.4 Bcf/d), which was the second highest in Canada or 26 per cent of total Canadian production. Raw gas production from BC’s shale gas regions is now contributing over 60% of the province’s total gas production, and that percentage continues to grow. Natural gas producers continue to introduce new technology to unlock the vast potential of unconventional gas resources in Northeast BC. Innovative oil and gas royalty programs and continuing geoscience research will also have a noteworthy impact on BC’s unconventional gas industry and on the export of liquefied natural gas (LNG) to overseas markets.

## **DEDICATION**

This report is dedicated to our friend, colleague, and co-author Christopher Adams, who passed away on the 30th of November, 2015. Christopher was an Oil and Gas Specialist with the BC Ministry of Natural Gas Development from

2005 until his untimely passing and was the primary author of the BC Oil and Gas Industry Activity reports. Christopher's work, including the annual industry activity reports and conference presentations, were well received by industry, earning him the respect of his peers. Christopher will be dearly missed by his colleagues within and outside of the BC public service.

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