

Oil And Gas Summary of Shale Gas Activity in Northeast British Columbia 2012

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Geoscience and Strategic Initiatives Branch



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SUMMARY OF SHALE GAS ACTIVITY IN NORTHEAST BRITISH COLUMBIA 2012

Christopher Adams¹

ABSTRACT

Attention to shale gas prospects in Northeast British Columbia continued in 2012 with most land sale and drilling activity occurring in the Montney play trend. Bonuses garnered from the sale of Crown petroleum and natural gas rights reached a total of \$139.3 million in 2012; this followed a 13-year run of record annual land sale bonuses, which peaked at \$2.7 billion in 2008. Almost 87% of the 2012 bonus total was directed toward the exploration and development of British Columbia's shale gas regions, a slight drop from the 90% share in 2011. Operators are now focusing on the evaluation and extraction of these world-class shale gas resources, which have the potential to hold more than 1200 trillion cubic feet of natural gas. Recoverable resource numbers for these regions continue to improve with advances associated with horizontal drilling techniques and hydraulic fracturing procedures. The four major shale gas regions in Northeast British Columbia—the Horn River Basin, the Liard Basin, the Cordova Embayment and the Montney play regions—continue to add substantially to Western Canada's natural gas supply base. Operators in these regions are showing extensive flexibility in being able to respond quickly to a strengthening of natural gas prices and the development of natural gas export capacity. British Columbia's shale gas resources are the apparatus for success of British Columbia's Natural Gas Strategy and Liquefied Natural Gas Strategy. In terms of industry drilling activities, Northeast British Columbia's Montney play region has a significant advantage over other shale gas regions in the province because of its liquids-rich gas content. It continues to be one of the most active and productive natural gas plays in North America with production now more than 1.6 billion cubic feet per day.

This report highlights shale gas activity in the key shale gas regions of Northeast British Columbia with most of the statistics presented focusing on 2012 and early 2013.

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¹Geoscience and Strategic Initiatives Branch, Oil and Gas Division, British Columbia Ministry of Natural Gas Development, Victoria, British Columbia, Christopher.Adams@gov.bc.ca

Key Words: : shale gas, exploration and development, industry activity, Northeast British Columbia, 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

INTRODUCTION

Shale gas prospects and the technology used to extract natural gas from shale continue to redistribute exploration and development activities in Northeast British Columbia (BC). Growing shale gas production in North America has generated new opportunities for natural gas exports to overseas markets and BC's world-class shale gas plays, such as the Horn River Basin, the Cordova Embayment, the Liard Basin and the Montney play trend, will have a major impact in strategically supplying these markets. During the last few years, shale gas regions in Northeast BC have presented oil and gas operators the opportunity to further develop technical advances in natural gas extraction with the use of horizontal drilling and multistage hydraulic fracturing

techniques. As producing companies achieve success in these regions, they continue to make noteworthy purchases of Crown petroleum and natural gas (PNG) rights. In 2010, Northeast BC's shale gas regions garnered 94% of the province's land sale bonus total of \$844 million. Although total land sale bonuses dropped to \$223 million in 2011, PNG rights purchases directed toward shale gas development amassed a 90% share of the bonus total. In 2012, provincial land sale bonus totals dropped further to \$139 million, but purchases directed toward shale gas exploration and development remained strong, capturing almost 87% of the bonus total. The Montney play trend, which generates considerable natural gas liquids and condensate volumes, accounted for almost the entire 2012 bonus total, whereas the Horn River Basin saw a small allocation. There were no

PNG rights sold within the Cordova Embayment and the Liard Basin in 2012.

During the last decade, the BC Oil and Gas Commission (OGC) approved more than 30 Innovative Technology (formerly known as Experimental) projects for evaluating the shale gas potential in Northeast BC. Innovative Technology applications, analyzed by the OGC, may be approved as a Special Project Order under section 75 of the *Oil and Gas Activities Act*. Orders are subject to specific detailed conditions, which include the submission of an annual progress report to the OGC. Innovative Technology projects are designated as such if there is an application of innovative technology or if there is an innovative method of carrying out oil and gas and related activities. To date, most Innovative Technology projects approved for shale gas potential in Northeast BC have been in relatively low-density drilling areas such as the Horn River Basin; however, some schemes have been approved for fields in the northwest extension of the Montney play trend such as Altares, Farrell Creek, Pocketknife and Town. In the Horn River Basin, Innovative Technology project requests are being denied more often because proposed development technology is no longer considered unique to many areas of the basin.

BACKGROUND

Formations prospective for shale gas in the BC portion of the Western Canada Sedimentary Basin potentially contain large volumes of hydrocarbons (Table 1). Organic-rich shales may generate and store methane due to biogenic gas generation during the early diagenesis stage and subsequent catagenic generation at higher levels of maturity. Most shales have low matrix permeabilities and require extensive and widespread natural or induced fracture systems to sustain commercial flow rates. While there has been much publicity regarding the success of several shale gas plays in the United States, BC's shales are recognized as having large-scale potential with more than 1200 trillion cubic feet (Tcf) of original gas-in-place. Assessments are ongoing to determine the technically recoverable and marketable resource potential. Numerous stratigraphic horizons and play areas in Northeast BC have exceptional potential for containing this resource and only a relatively small portion has been commercially produced thus far.

Shale is abundant throughout Northeast BC and more information about its geology and its vast resource potential has recently been documented. In 2006, a Petroleum

TABLE 1. PROSPECTIVE HORIZONS FOR SHALE GAS IN NORTHEAST BRITISH COLUMBIA.



PROSPECTIVE HORIZONS

	Formations	Description	Depth	Average Thickness	Total Organic Carbon	Gas in Place
LOWER CRETACEOUS	Wilrich and Buckinghorse shales	Potential interbedded sand and siltstone	800–1200 m	100 m	2.3%	60 Bcf per section
JURASSIC	Nordeg and Fernie shales	Recognized source rocks	1200–2500 m	Up to 30 m organic-rich section	up to 14%	> 20 Bcf per section
TRIASSIC	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
DEVONIAN	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

MISSISSIPPIAN	Barnett Shale (Fort Worth Basin)	Marine-shelf deposit	2000–2500 m	100 m	4.5%	140 Bcf per section
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Geology Open File by the Resource Development and Geoscience Branch of the BC Ministry of Energy, Mines and Petroleum Resources (now the Geoscience and Strategic Initiatives Branch of the Ministry of Natural Gas Development) evaluated the regional shale gas potential of the Triassic Doig and Montney formations of Northeast BC (Walsh et al., 2006). That study quantified the potential original gas-in-place via spatial analysis. Earlier Triassic shale gas plays included the Doig Phosphate in the Groundbirch area (Middle Triassic) and the Upper Montney (Lower Triassic) in the Swan Lake, Bissette and Dawson Creek areas. The Upper Montney play area is limited by depth, shallowing to the northeast and deepening to the southwest. Walsh et al. (2006) provided original gas-in-place estimates of 30–200 Tcf for the Upper Montney, 50–500 Tcf for the Lower Montney, 40–200 Tcf for the Doig Formation and approximately 70 Tcf for the organic-rich Doig Phosphate unit. The study noted that original gas-in-place estimates would have to be taken in context and not be compared directly with estimates for conventional plays because critical reservoir characteristics remain poorly understood. The Montney is considered by many to be a ‘hybrid’ play (shale and tight gas), so it is included in this description of shale gas activity. A further report on resource assessment of the Montney Formation in BC is forthcoming in 2013 as a result of the BC Oil and Gas Commission, the National Energy Board, the BC Ministry of Natural Gas Development and the Alberta Energy Resources Conservation Board (ERCB) working jointly to understand the impact and distribution of this high-profile natural gas and petroleum resource base.

An energy market assessment by the BC Ministry of Energy, Mines and Natural Gas and the National Energy Board (2011) 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 the year end of 2010 (BC Ministry of Energy, Mines and Natural Gas and National Energy Board, 2011).

The energy market assessment and the Petroleum Geology Open File are available for download or on CD, respectively, from the Geoscience and Strategic Initiatives Branch of the BC Ministry of Natural Gas Development. Also available on CD is the Petroleum Geology Open File entitled *Shale Gas Potential: Core and Cuttings Analysis, Northeast British Columbia* (Walsh et al., 2007).

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. For ease of analyses and description, the key shale gas regions in Northeast BC are displayed in Figure 1. Shale gas activity within the vast region of the Liard Basin (upper left on map figure) is currently taking place within the central and northern areas of the outline shown. 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. Further south, the Montney play trend now encompasses approximately 2.6 million hectares from the south Peace region near the city of Dawson Creek extending up to the Trutch area in NTS map area 094G/10.

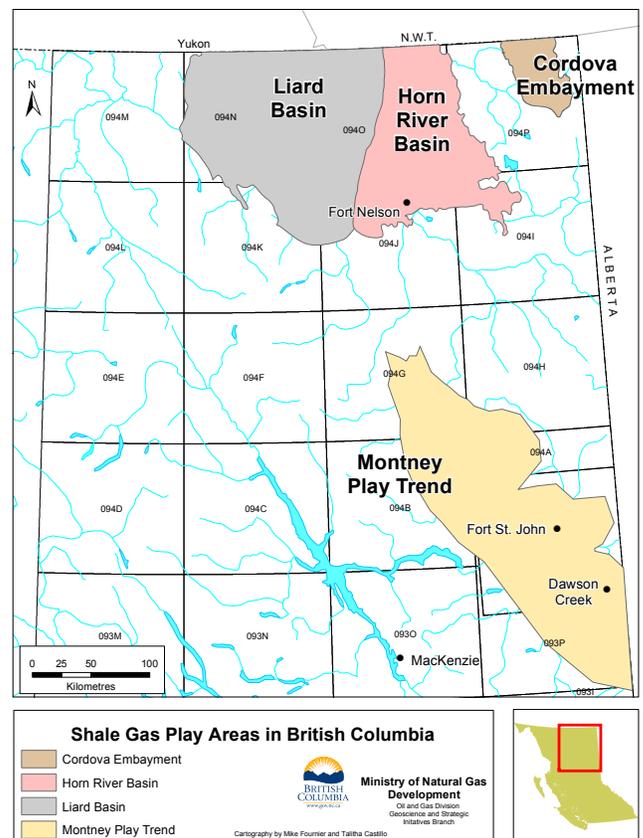


Figure 1. Key shale gas regions of Northeast British Columbia.

SHALE GAS EXPLORATION ACTIVITY

Bonuses collected from the sale of BC's Crown PNG rights in 2012 totalled \$139.3 million, down by 37% from the previous year. Of that total, \$120.6 million or 87% was directly attributed to interest in shale gas plays (Figure 2). Almost all of that percentage was directly related to shale gas development in the Montney play region and only a fraction was accredited to the Horn River Basin.

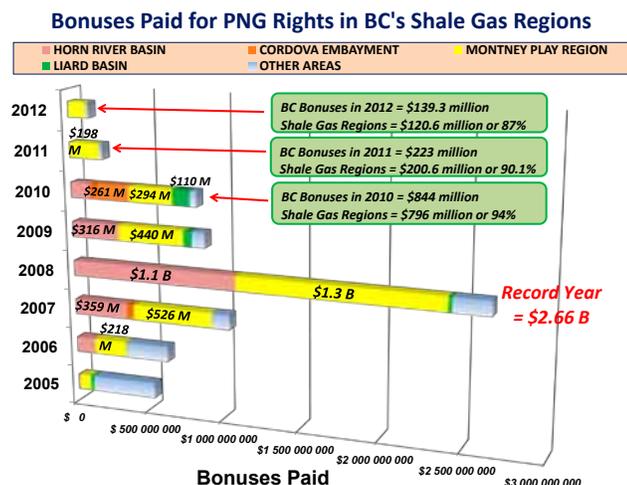


Figure 2. Bonuses collected during the last eight years from the sale of Crown petroleum and natural gas (PNG) rights in British Columbia's shale gas regions. In 2012, land brokers and producers focused on purchasing PNG rights in the Montney play region. For the second year in a row, no PNG rights purchases were made in the Cordova Embayment or the Liard Basin.

Horn River Basin

The Horn River Basin covers an area of approximately 1.31 million hectares within the Fort Nelson/Northern Plains region. It lies east of the Kledo–Bovie Lake fault system and extends east to the Slave Point Platform (Figure 3). Prior to recent shale gas interest, approximately 300 wells had been drilled in the basin, mainly targeting carbonate plays of the Mississippian Debolt Formation to Middle Devonian Keg River/Pine Point Formation. Major and intermediate producers approved for Innovative Technology projects (experimental schemes) during the last few years have been testing potential reservoirs in 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, which has now resulted in established production from the area.

LAND SALE ACTIVITY

For the first time since 2000, bonuses garnered from land sale activity in the Horn River Basin in 2012 failed to reach the million dollar mark. Only one parcel was purchased by Standard Land Company at the February PNG rights disposition. The land broker picked up a 269 hectare lease for \$23 330 at the southern tip of the Horn River Basin in NTS 094J/09. Rights purchased were below the base of the Upper Devonian Fort Simpson zone but excluded natural gas in the Middle Devonian Slave Point zone. This is the lowest annual bonus total in the Horn River Basin in the last 13 years and comes only four years after the record bonus total of \$1.1 billion in 2008. It indicates that producers are now conducting their drilling programs on their previously purchased lands (Figure 4).

INDUSTRY ACTIVITY

Encana Corporation holds more than 116 000 net hectares in Horn River Basin and is listed as operator for more than 80 shale gas–directed wells since 2003 (Figure 5). Encana's average natural gas production from the Horn River Basin reached approximately 95 million cubic feet (mmcf) equivalent per day in 2012, including first gas production from the **Kiwigana** area (western part of the basin), where Encana extended a farm-out agreement with **Korea Gas Corporation** to invest \$185 million on approximately 8100 hectares (20 000 acres). Encana's activities in the Horn River Basin in 2012 focused mainly on completion activities, but another nine wells finished drilling operations early in the year. Encana expects to drill fewer wells in 2013 in its core area of **Two Island Lake**. Underscoring the slower activity levels in the Horn River Basin are low natural gas prices and the lack of natural gas liquids (NGLs) throughout the entire basin. In an effort to reduce its capital commitments, Encana announced the sale of its 30% stake in the proposed Kitimat LNG export terminal to **Chevron Canada Ltd.** Encana will also sell a small portion (approximately 13 200 hectares) of undeveloped land in the Horn River Basin (Encana Corporation, 2012a).

On October 22, 2012, **Encana Corporation** and its partners announced that the commissioning of the first phase of the 400 mmcf/day Cabin gas plant, which was slated to be on stream by December 2012, will be deferred. Further expansion of up to 800 mmcf/day was scheduled for the third quarter of 2014, but the construction of that phase will also be deferred (Encana Corporation, 2012c). **Enbridge Inc.** reached an agreement with **Encana Corporation** in October 2011 to acquire a 57.6% interest in the Cabin gas plant, located 60 km northeast of Fort Nelson and approximately 6.7 km from the proposed Fort Nelson North processing facility. Enbridge later acquired another 13.3% interest, bringing its total ownership in the Cabin gas plant development to 71%, marking its first venture into the Canadian midstream market.

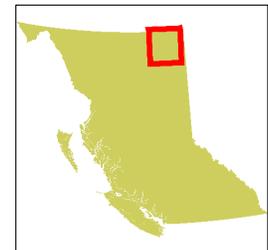
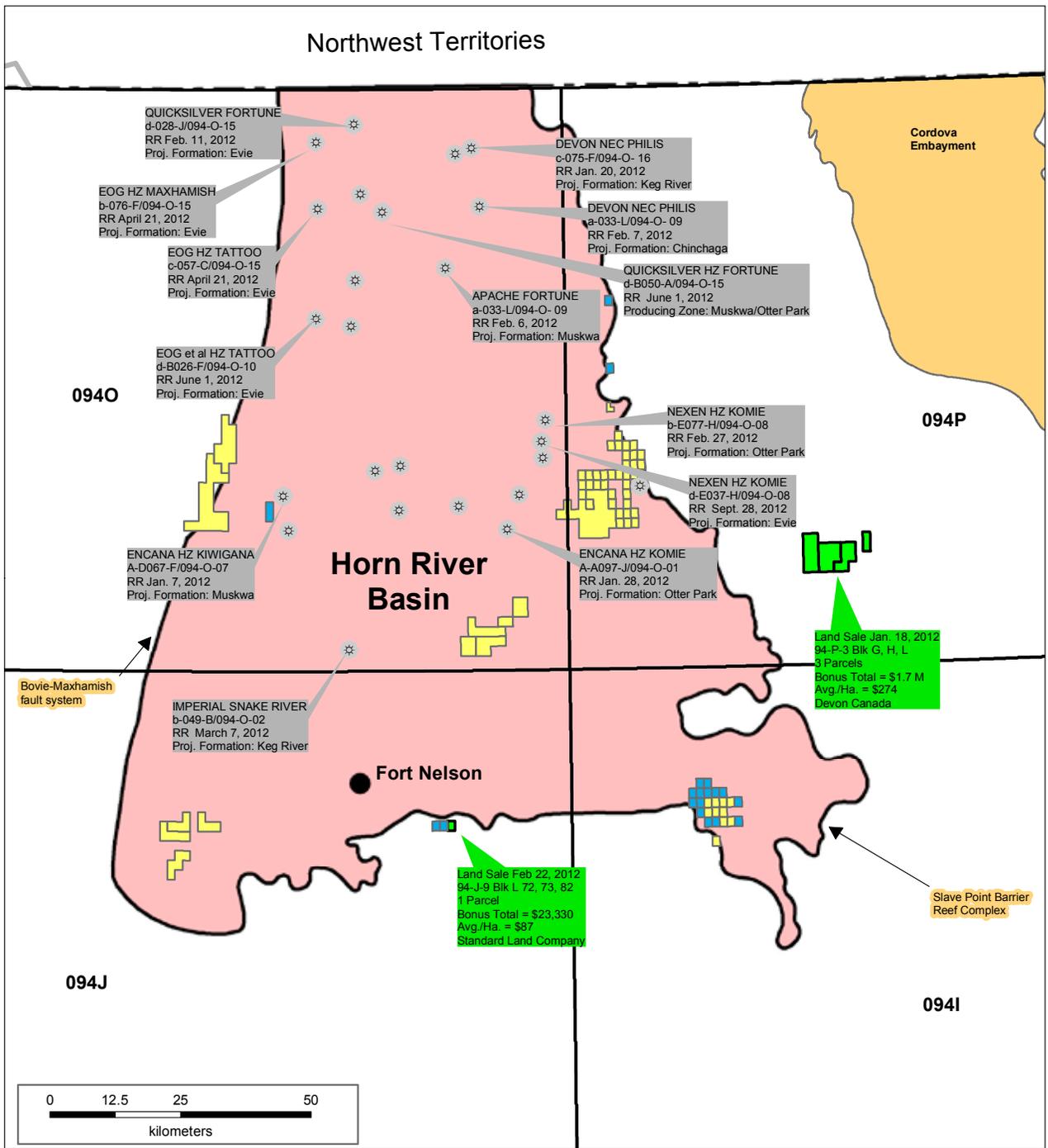


Figure 3. Horn River Basin rig releases in 2012 and areas of land sale activity from 2010 to 2012.

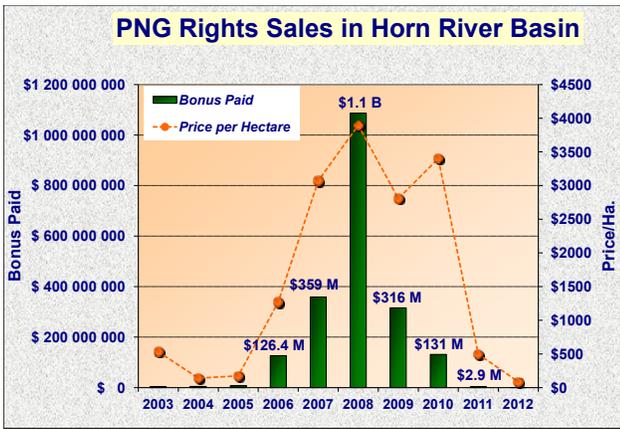


Figure 4. Bonuses from PNG rights sold in the Horn River Basin have leveled off considerably after reaching a record total of \$1.1 billion in 2008. Only \$23 331 was paid for rights on the southern edge of the basin.

Apache Canada Ltd. has been one of the most active shale gas operators in the Horn River Basin since 2003. The producer’s activity in the Horn River Basin is primarily centered in the **Two Island Lake** area (consisting of the **Etsho** and **Ootla** areas), where it estimates a net recoverable resource of 9.2 Tcf (Apache Canada Ltd., 2012a). The producer continued to optimize its Horn River acreage in 2012 with drilling activity at Two Island Lake and further north in the **Fortune** area. Production reached 90 mmcf of gas per day (net to Apache’s working interest) in 2012 with 79 wells producing from seven pads. Apache has the choice of marketing its natural gas through the proposed \$4.5 billion Kitimat liquefied natural gas (LNG) export terminal, where it now holds a 50% interest with **Chevron Canada Ltd.** Chevron will be responsible for marketing the LNG and will operate the LNG plant and pipeline assets. Apache will continue to operate upstream development of its 260 000 hectares in the Horn River Basin (Apache Canada Ltd, 2012b).

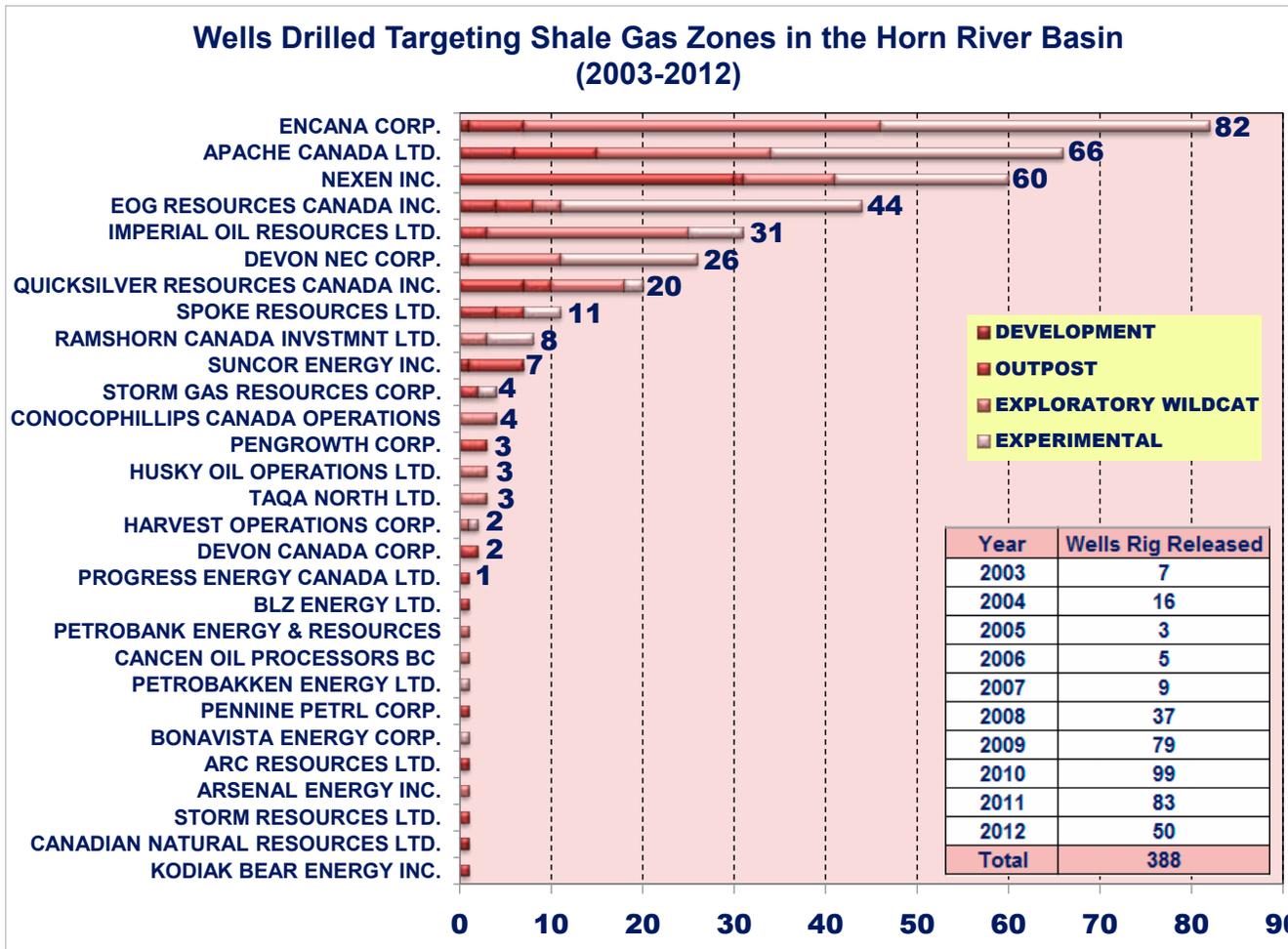


Figure 5. Since 2003, operators in the Horn River Basin have drilled 388 shale gas–directed wells under various Lahee classifications. Drilling peaked in 2010 with 99 wells rig released. That number has fallen to 50 in 2012.

Nexen Inc. is a significant player in the Horn River Basin with access to one of the highest reservoir quality portions in the basin. Nexen drilled six shale gas-directed wells in 2012—all in the **Komie** area (NTS 0940/01). It has also secured tenure for ten more years on the majority of its 100% working interest lands at **Dilly Creek**, which could contain as much as 6 Tcf of recoverable contingent resources (assuming a 20% recovery factor). Production testing of an 18 well pad began in September 2012 with an industry record of more than six fracture stimulations a day (Nexen Inc., 2012). Nexen could be producing as much as 175 mmcf/day out of the Horn River Basin by early 2013. In August 2012, Nexen closed a joint venture agreement to create a strategic partnership with **INPEX Gas British Columbia Ltd.** (IGBC), a consortium led by Japanese oil and natural gas producers to develop shale gas in the Horn River Basin, the Cordova Embayment and the Liard Basin (Nexen Inc., 2012). The agreement is a significant part of Nexen's shale gas strategy in Northeast BC because it provides substantial upstream expertise and offers a joint effort in studying the feasibility of potential downstream projects and the export of liquefied natural gas (LNG).

EOG Resources Inc. was the first company to nominate and purchase large tracts of land in the Horn River Basin in 2004 and 2005. The producer has slowed its pace of activity in the basin and has obligated only the minimum drilling capital required to hold leases in 2012; however, it has remained somewhat active in the **Maxhamish** and **Tattoo** areas in the basin's northwest portion. Seven wells were drilled during the first half of 2012, all targeting the Middle Devonian Evie member. EOG holds approximately 63 740 net hectares of land in the Horn River Basin. The producer will allow production to grow incrementally while it works on securing long-term transportation and processing agreements for its gas from the area. **Chevron Canada Ltd.** has announced it will purchase EOG's 30% share of the proposed Kitimat LNG export terminal and the associated Pacific Trial Pipelines project. EOG is also selling approximately 11 500 net hectares of undeveloped land in the Horn River Basin (Nickle's Daily Oil Bulletin, 2012b).

Devon Canada Corp. maintains a solid position in the Horn River Basin. Since 2007, Devon has drilled 26 wells, mainly in the **Komie**, **Petitot River** and **Tattoo** areas. Capital spending in these areas has been significantly reduced as the producer waits for year-round roads and the expansion of gas-gathering facilities. Capital expenditures in 2011 reached \$115 million, after spending \$165 million in the previous year. Drilling in 2012 consisted of three vertical wells rig released early in the year. All were drilled in the Petitot River area with projected targets in the Middle Devonian Keg River and Chinchaga. Devon will conduct minimal drilling in the Horn River Basin in 2013 in order to hold its acreage. The producer holds more than 70 000 net hectares with the potential to produce up to 700 mmcf/day from more than 1500 risked locations and a net risked

resource of 7.0 trillion cubic feet equivalent (Tcfe; Devon Canada Corporation, 2012).

Storm Resources Ltd. has primarily focused on its land inventory along the eastern edge of the Horn River Basin. Its core producing area around the Gote field is 30 sections in size, where the average gross shale thickness for the Middle Devonian Muskwa–Otter Park formations is approximately 92 m. As many as 43 horizontal wells could ultimately be developed in this project area, where the best estimated discovered petroleum initially in place (DPIIP) is 3.1 Tcf gross (Storm Resources Ltd., 2012b). Storm's first horizontal well in the area (UWI b-19-D/94-P-12) was drilled in October 2010 to 1800 m (laterally) into the Muskwa–Otter Park. Twelve fracture stimulations were performed with gas production beginning in March 2011. The well is producing at a rate of 2.7 mmcf/day with cumulative production of 2.5 billion cubic feet (Bcf) as of August 2012. The drilling of a second horizontal well in the area was completed in January 2011 and is listed as standing after fracture stimulations were performed in the Otter Park in late 2011. Future horizontal wells in the area are expected to see a fracture density of 15–18 fracture stimulations per well. Storm has six years remaining on its land tenure, of which the majority is land in the Horn River Basin. The producer has indicated that activity on its lands will be deferred until there is an improvement in natural gas prices (Storm Resources Ltd., 2012a).

Imperial Oil Resources Limited has initiated production at its multiwell pad pilot development project in the **Komie** area (NTS 0940/01). The eight-well horizontal pad, which began production in August 2012, is expected to produce at approximately 30 mmcf/day and will help Imperial evaluate longer-term well productivity and assess development costs in the area (Imperial Oil Limited, 2012). Imperial's work in the Horn River Basin has resulted in multiple productive reservoir intervals with average test rates in the range of 500 thousand cubic feet (mcf) to 1.5 mmcf/day from a single stage fracture stimulation during a 30 day test period (Nickle's Daily Oil Bulletin, 2011). Recoveries of up to 800 mmcf per fracture stage have also been modelled. Imperial Oil and ExxonMobil Canada Energy are 50-50 partners in the Horn River Basin and have more than 130 000 hectares leased in the basin.

Quicksilver Resources Inc. continues with its successful horizontal well program in the **Fortune** area of the Horn River Basin. The producer completed work on an eight-well pad in August 2012. Wells on the pad were completed with lateral sections ranging from 1646 to 2621 m with 16–26 fracture stimulation stages in each well (Quicksilver Resources Inc., 2012b). Each well (five Devonian-aged Muskwa and three Klua targets) exceeded initial production expectations with initial test flow rates ranging from 23 mmcf to 34 mmcf/day (Quicksilver Resources Inc., 2012a). These elevated levels during the flowback period

are expected to show significant improvement in type curve analysis, particularly highlighting the Klua primary pay sections. It is now estimated that Quicksilver's wells in the Horn River Basin are capable of producing more than 150 mmcf/day. One of the most productive of those was a Fortune area well rig released in February 2010. The well, at surface location c-29-D/94-O-16, reported average rates of more than 11 mmcf/day during the first three months of production (Figure 6). Quicksilver began ramping up its raw gas production to 100 mmcf/day in late 2012 after acquiring discounted treating capacity on an interim and interruptible basis in an existing gas plant. This arrangement will continue until a third-party plant, in which Quicksilver has firm capacity, is commissioned. Most of the ramped-up production is coming from ten wells; four legacy wells are producing at 15 mmcf/day and another six are producing a total of 85 mmcf/day from a multiple-well pad at d-50-A/94-O-15 (Quicksilver Resources Inc., 2013). Quicksilver, a Texas-based oil and gas producer, owns 100% interest on approximately 52 600 hectares in the Horn River Basin. It has converted all of its 20 exploratory licenses to 10 year development leases.

PRODUCTION

The OGC reports in the *Hydrocarbon and By-Product Reserves in British Columbia 2011* that the gas trend daily rate from the Horn River Basin reached 382 mmcf/day from 159 producing wells at the year end of 2011. The region had cumulative gas production of approximately 237 Bcf. The formations found within the Horn River Basin accounted for just over 9.7% of the 1.48 Tcf produced in the province in 2011. Many wells in the Horn River Basin remain on confidential status under the terms of Innovative Technology approvals, which were previously categorized as special projects and experimental schemes (BC Oil and Gas Commission, 2013).

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 an area of

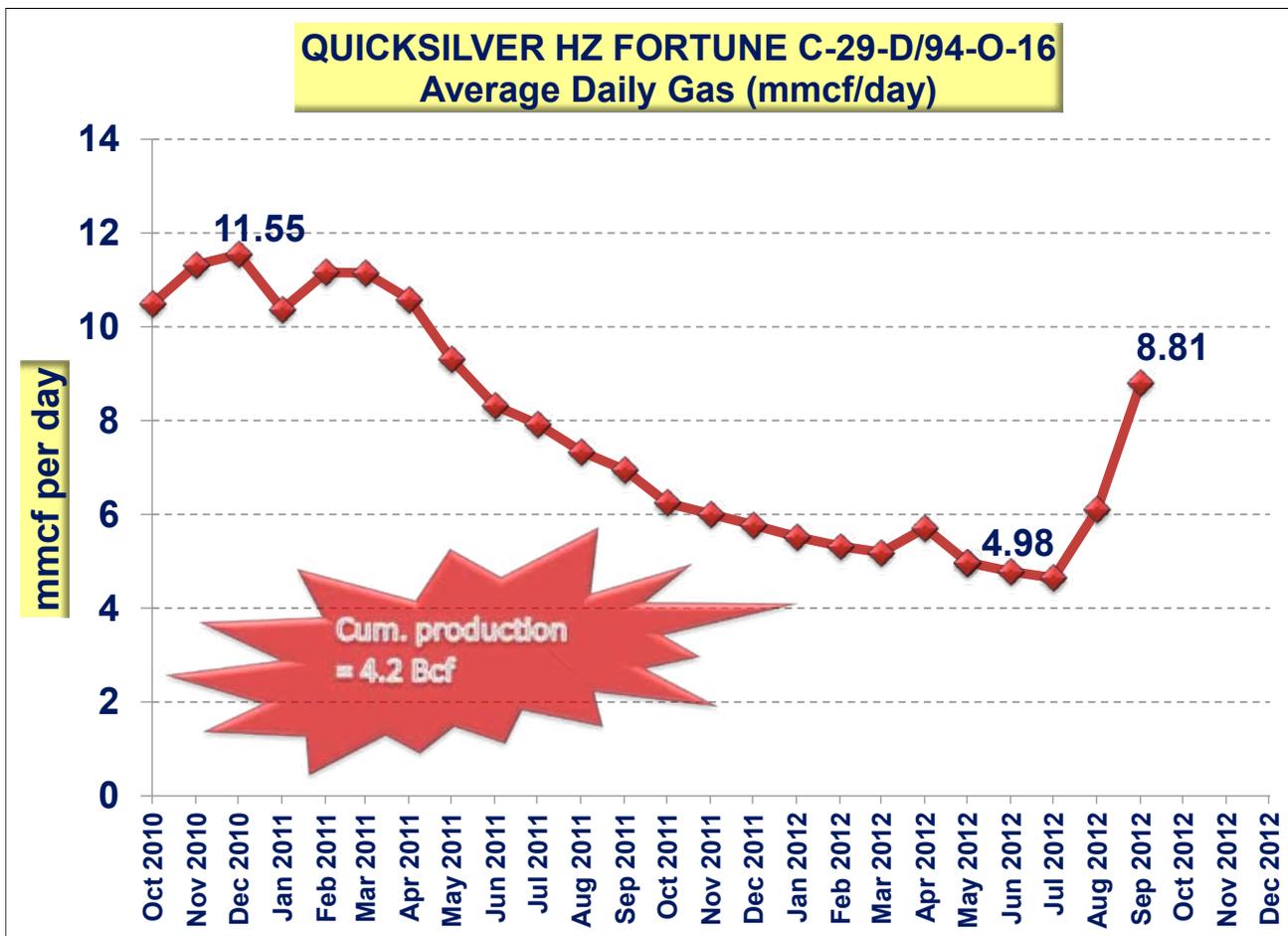


Figure 6. Quicksilver's Fortune area well at surface location c-29-D/94-O-16 tested a 1400 m lateral section of the Devonian Muskwa Formation and has been the most productive well to date, averaging 8 mmcf/day since it began production in October 2010.

approximately 1.25 million hectares and contains more than 5 km of Cambrian to Upper Cretaceous sedimentary strata. Potential hydrocarbon objectives occur in the Devonian Dunedin–Nahanni formations; the Mississippian Banff, Debolt and Mattson formations; the Permo-Pennsylvanian Kindle and Fantasque formations; the Triassic Toad Formation; and the Cretaceous Chinkeh and Scatter formations. The Nahanni holds significant potential in dolomitized reservoirs in the structural belt. The Debolt, Mattson, Kindle, Fantasque and possibly the Triassic Grayling and Toad formations are potential objectives in structural closures on the Bovie Lake structure on the margin of the basin. The Banff and Debolt formations are also potential objectives in stratigraphic traps on the platform to the east (Walsh et al., 2005).

LAND SALE ACTIVITY

Interest continues to develop in and around the Patry area, located approximately 110 km northwest of the city of Fort Nelson in the central region of the Liard Basin. The area is a potentially high-impact shale gas play that may have prospects comparable to the adjacent Horn River Basin. In 2009, the most significant land sale in the Liard Basin occurred at the July 15 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 the Patry area in NTS 094O/12 and 094O/13. At the June 23, 2010 PNG rights disposition, 14 licences were purchased to the northwest and southwest of the Patry area totalling \$110.4 million on 66 645 hectares (Figure 7). Well activity in the area indicates that Apache Canada Ltd. drilled two experimental vertical wells in 2010, one of which was rig released in late

December of that year at d-34-K/94-O-5. The d-34-K well lists the Upper Devonian Fort Simpson as the projected formation. There were no PNG rights sales in the Liard Basin in 2011 and 2012.

INDUSTRY ACTIVITY

Since early 2009, **Apache Canada Ltd.** has been working in the east-central region of the Liard Basin in the **Patry** area (Figure 8). The producer holds approximately 171 600 hectares in the area, with six wells drilled to date; three of those are producing into an existing pipeline. In 2012, Apache acknowledged that one of these wells (Apache HZ Patry d-34-K/94-O-5) recorded a 30 day initial production rate of 21.3 mmcf/day on a six-stage fracturing operation (3.6 mmcf/day per hydraulic fracture). The well was drilled in 2010 to a vertical depth of 3843 m with a horizontal leg of 885 m and has an estimated ultimate recovery (EUR) of 17.9 Bcf. It is considered to be one of the best shale gas resource tests in any of North America’s unconventional reservoirs (Apache Canada Ltd., 2012). Apache is targeting the Upper Devonian Lower Besa River Black Shale and estimates that its Liard Basin lands carry a net gas-in-place of 201 Tcf, which could yield net sales gas of 48 Tcf. Although Apache has a superior land position in the Liard Basin, it has stated that the pace of activity in the region will depend on North American natural gas prices. The producer rig released one well in the Patry area in October 2012 at b-23-K/94-O-5 (Figure 8). The projected formation is listed as Fort Simpson, at a projected total depth of 3800 m.

Nexen Inc. plans to develop shale gas resources in the Liard Basin in a strategic partnership with a consortium led by the INPEX Corporation of Japan. Nexen holds 51 800 hectares of 100% working-interest land in the Liard Basin, which is estimated to contain 5–23 Tcf of prospective resources (Nexen Inc., 2012). The first planned location for appraisal and development in the Liard Basin project area is a single vertical well located in the La Jolie area at c-66-I/94-N-9. The well was licenced in early September 2012 to evaluate Middle Devonian–Early Mississippian shales (Nexen Inc., 2012).

Paramount Resources Ltd. holds more than 51 000 net hectares in the Liard Basin that are prospective for shale gas in the Middle Devonian Besa River. In October 2012, the company began drilling operations on its second well in the **Patry** area (b-40-I/94-O-5). The horizontal well, with a vertical depth of 3400 m and a horizontal leg of 1200 m, was completed in early March 2013. Sixty-nine hours of metered gas flow indicated rates of 5–14 mmcf/day on clean-up (Nickle’s Daily Oil Bulletin, 2013d). The flow back data is considered preliminary as pressure transient analysis and well test evaluation has yet to be carried out. Paramount’s first Besa River shale gas evaluation well in the **Dunedin** area suspended operations in the spring of 2012 because of warm weather. The vertical well resumed

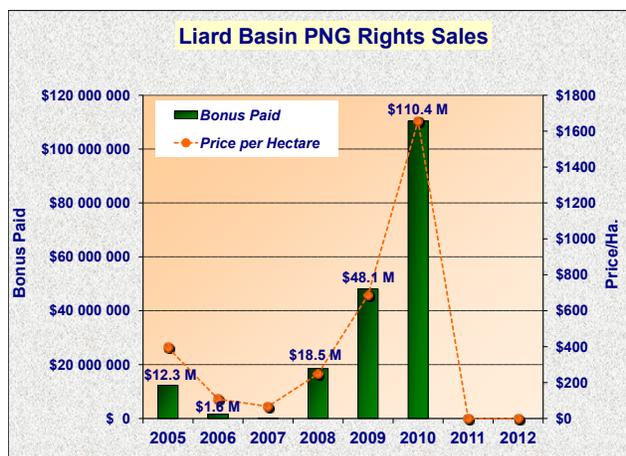
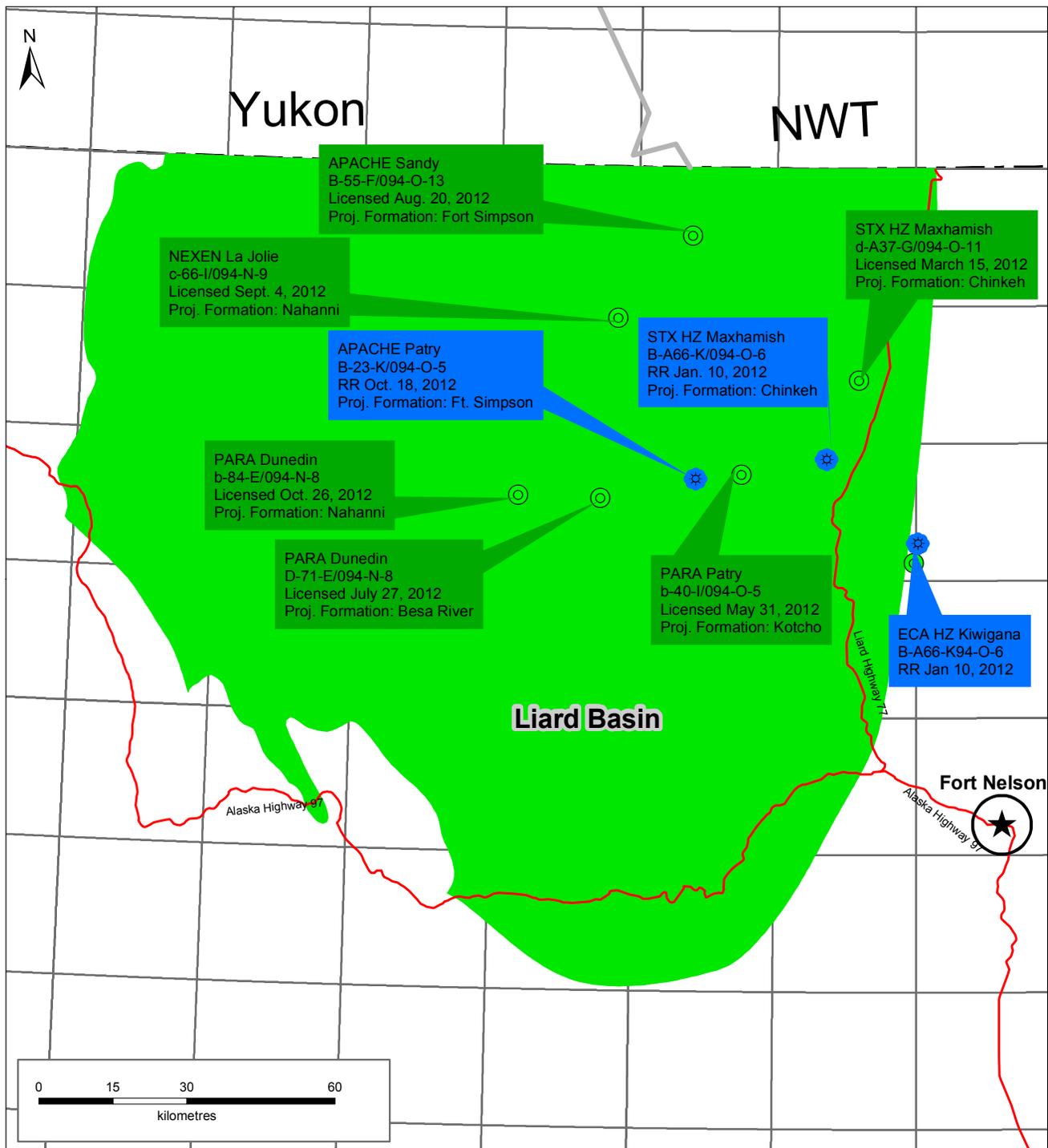


Figure 7. Bonus totals in 2010 reached \$110 million at the June 23 Crown petroleum and natural gas rights sale. Fourteen licences covering 66 645 hectares were sold in the La Jolie–Beaver River areas (NTS 094N/09 and 094N/16) and to the southwest of the Patry area (NTS 094O/05 and 094N/08). There were no PNG rights sold in the Liard Basin in 2011 and 2012.



Liard Basin 2012 Rig Releases and Well Licences

- Liard_RR_2012
- Licensed_2012

Cartography by Mike Fournier and Talitha Castillo



Ministry of Natural Gas Development

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Geoscience and Strategic Initiatives Branch



Figure 8. Recent rig releases and well licensing activity in the Liard Basin.

operations in February 2013 and will be drilled to a total depth of 4500 m. Further plans are to complete the vertical wellbore and possibly drill a horizontal leg. The most recent test results released from Paramount indicate that the Liard Basin holds an original gas-in-place of 170–500 Bcf per section with expected recovery of 20% (Paramount Resources Ltd., 2013a).

The **Beaver River** area lies within the Liard Basin and is located west of the Kledo–Bovie Lake fault near the border between the Yukon Territory and BC. It is a relatively unexplored area and is of interest to producers looking to evaluate shale gas prospects in the Upper Mississippian Mattson–Golata intervals and the extensive Devonian–Mississippian Besa River. **Transeuro Energy Corp.** has been conducting operations in the Beaver River field to evaluate these shales as a potential resource play and has had some encouraging results from testing completed to date. The producer had three wells on production in 2012 with average rates from all three ranging from 2.7 mmcf/day recorded in January 2012 to 1.5 mmcf/day recorded in December 2012 (Transeuro Energy Corp., 2012c).

The Beaver River natural gas field on surface is expressed as an anticline approximately 16 km long and 4 km wide. It includes a series of shale formations, thought to contain producible gas columns, over an approximate total thickness of 3000 m. The potential for a significantly enhanced shale gas play in the shallow sections of the Beaver River field has been identified in three distinct horizons: the Mattson–Golata intervals from approximately 1200 to 2100 m, the Besa River shale from 2000 to 3000 m and the Muskwa shales from 3000 to 4000 m. Re-entry and perforating operations were conducted in three old wells called A-2, A-6 and B-2 (Figure 9). Wells A-2 and A-6 were recompleted in the Mattson and hydraulically fractured to stimulate production. Well A-2 has been in production since March 2006 and well A-6 produced successfully at approximately 0.5 mmcf/day prior to fracturing, but encountered water production issues. Operations on well B-2 were suspended and the wellbore was retained for a future deep sidetrack into the Middle Devonian Nahanni Formation.

Transeuro continued with its development program in summer 2008. Compression was added to the A-2 well with good initial results and production increasing to 4.5 mmcf/day. Later that year, another well called A-5 was tied into a local gathering system. The tested interval was a brittle layer, rich in dolomite at the top of a thick sequence of organic-rich shale. The appraisal strategy for the A-5 well was to target the more brittle rock intervals that contain higher carbonate and silica content, which is expected to respond favourably to stimulation. The brittle rocks contain free gas and may serve as a pathway for the shale gas to enter the well. The A-5 well has been producing at rates as high as 3 mmcf/day with periodic interruptions due to operating issues. As the well produces, Transeuro hopes to

see clear evidence of the surrounding shales contributing gas into the carbonate sequence and that the well rates and pressures stabilize. Another well, A-7, was the first shallow well at Beaver River and was drilled in the north section of the field to target the same intervals producing successfully in the A-2 well. Following drilling and mechanical problems, A-7 failed to reach the target and was completed and fractured in the Mattson. The well is currently on production at approximately 0.25 mmcf/day. Both wells A-2 and A-7 have experienced relatively low decline rates. In 2012, average daily gas rates in A-2 decreased gradually from 2.3 mmcf/day in January to 650 mcf/day in November.

The next phase in shale appraisal for the Beaver River field is a review of the fracturing technology completed to date, the installation of compression to reduce wellhead pressures and to increase production from the A-2 and A-7 wells. The 2012–2013 work program at Beaver River will focus on Nahanni exploration targets and potential initial flow rates of 15 mmcf/day per well (Transeuro Energy Corp., 2012b). The program involves multiple wellbore re-entry, hydraulic fracturing and acid stimulation. Further appraisal will target up to 14 horizons in six wells across the field to assess the commercial potential of all three horizons (Mattson, Besa River and Muskwa).

Cordova Embayment

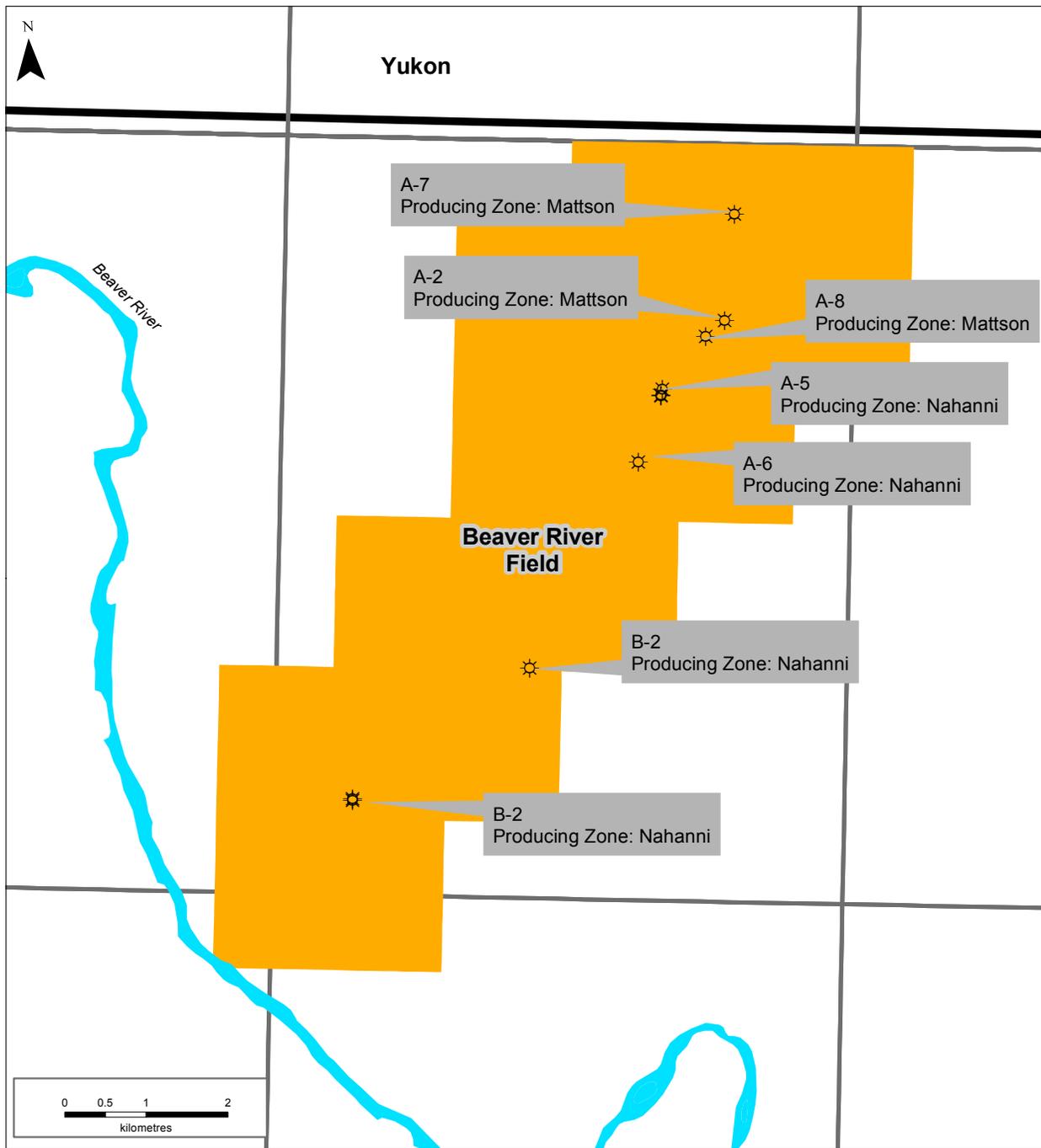
The Cordova Embayment covers an area of 379 000 hectares and sits approximately 150 km northeast of Fort Nelson in the far northeastern corner of the province. The area lies east of the well-established Devonian Jean Marie gas production and deeper exploration targets such as the Slave Point and Pine 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 are now focusing on drilling and resource appraisal.

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



Transeuro Energy Well Activity (Northern Liard Basin)

Transeuro Energy Corp

Cartography by Mike Fournier and Talitha Castillo



Ministry of Natural Gas Development

Oil and Gas Division
Geoscience and Strategic Initiatives Branch



Figure 9. Transeuro Energy Corp. has been conducting operations at Beaver River to evaluate Mississippian shales of the Mattson–Besa River Formation as a potential resource play. Shallow shows in the Mississippian Mattson in the Beaver River area are likely due to the presence of a significant shale gas reservoir. Three wells are currently in production. The Mattson is producing from well A-7, the Upper Besa River from well A-2 and the deeper Golata–Muskwa shale from the A-5 well.

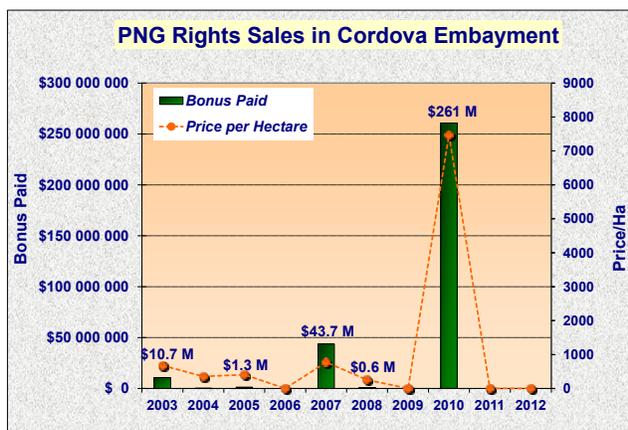


Figure 10. The Cordova Embayment saw a sizable increase in the level of land sale activity in 2010, with bonuses reaching a high of \$261 million. That total was achieved at the June 23 Crown petroleum and natural gas rights sale, where 18 licences and 4 leases covering 34 877 hectares were sold in NTS 094P/10 and 094P/15. There were no PNG rights sold in the Cordova Embayment in 2011 and 2012, but drilling picked up in those years with 21 and 12 wells rig released, respectively.

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.

Penn West Exploration Ltd. has been evaluating the Devonian shale sequence in the **Helmet North** area of the Cordova Embayment since 2008. The producer has acquired more than 95 000 hectares in the region and continues to direct more capital towards its Cordova Gas project. The Cordova Embayment drilling program consists of drilling 20–25 wells on several multiwell pads with the completion of 10–15 wells in 2012 (Penn West Exploration, 2012). Penn West’s rig release count for 2012 totalled ten (eight horizontal and two vertical wells), with five of those wells listed as producers. Four wells were producing from the Muskwa–Otter Park at an average of 1.7–2.7 mmcf/day each. Penn West has stated that existing gathering and processing infrastructure in and around the Cordova Embayment enables the Cordova shale gas joint venture project to move at a quicker pace with better economic returns. Longer-term development costs could be lower in Penn West’s Cordova appraisal area compared to areas within the Horn River Basin. The Devonian shale sequence in the Cordova Embayment is at a shallower target (approximately 1780 m) and there is a lower CO₂ cut (5% compared to 12% in the Horn River Basin). There is also spare gas processing capacity at Penn West’s **Wildboy** plant (Figure 11). **Mitsubishi Corporation** is now a joint venture partner with Penn West to develop shale gas in the area. The goal is to increase production from assets in the area to 500 mmcf/day.

Nexen Inc. remains in the early stages of development in the Cordova Embayment and is continuing with a series

of drilling, well completion and production testing programs in the **Helmet** area. Nexen has acquired more than 3300 hectares in the region and now holds a 60% operated interest in its joint venture lands with **INPEX Gas British Columbia Limited**, which holds the remaining 40%. Nexen drilled two horizontal wells early in 2012—one targeting the Upper Devonian Muskwa and the other targeting a 14 m window within the Evie member (Middle Devonian). Both wells are cased and listed as standing.

PRODUCTION

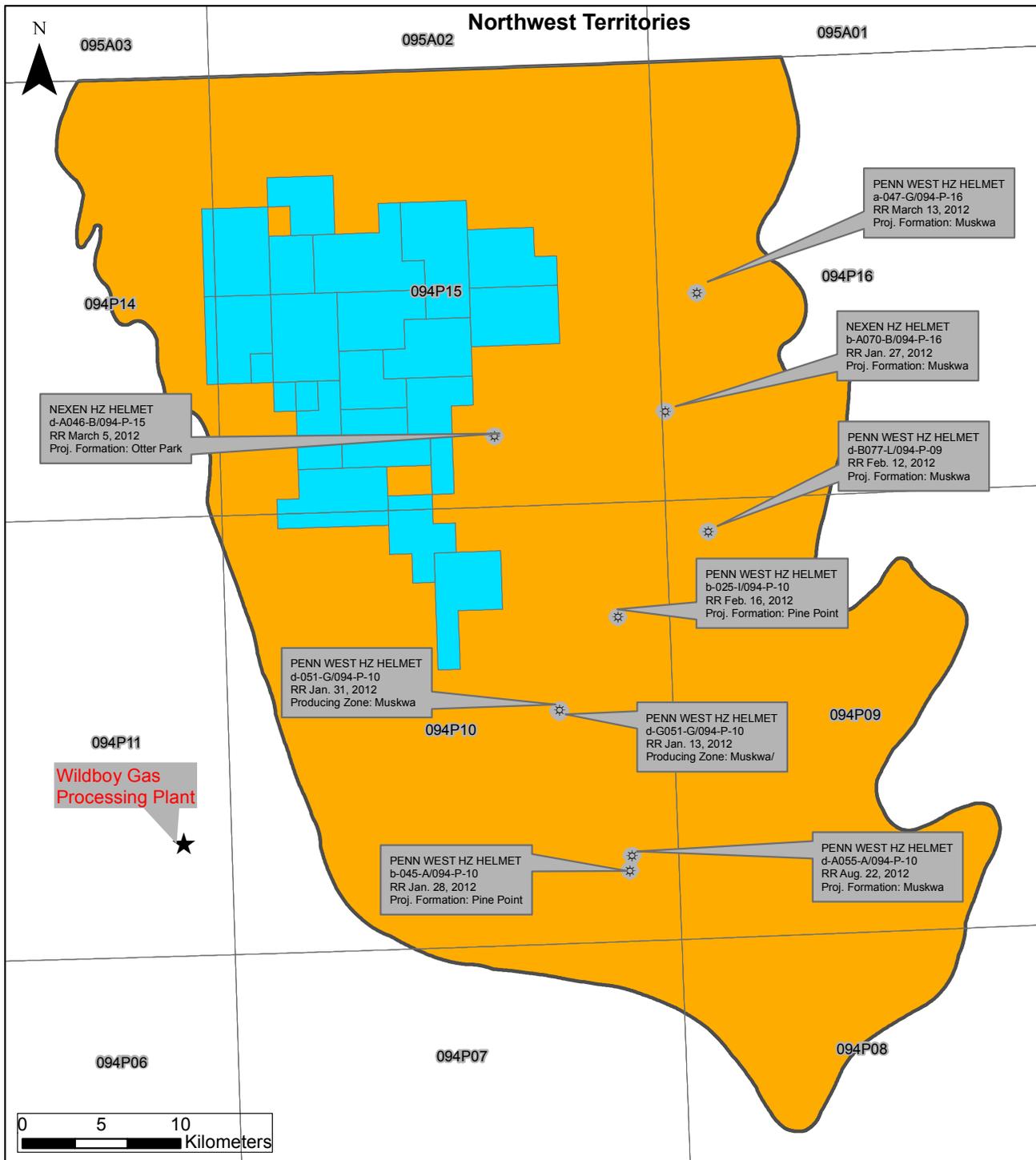
Up to December 2012, 21 wells in the Cordova Embayment have recorded 12.0 Bcf of gas production from Devonian shale sequences in the Muskwa, Otter Park and Evie (Figure 12). These producing wells were drilled by Canadian Natural Resources Limited and Penn West Exploration Ltd. from 2008 to 2012. Prior to shale gas exploration, the Cordova Embayment saw cumulative gas production of approximately 600 Bcf, primarily from the Upper Devonian Jean Marie and the Middle Devonian Slave Point and Keg River in the Helmet North and Midwinter areas.

Montney play trend

The Montney play region continues to be one of the most active natural gas plays in North America. Since 2005, the development of gas from the sandstone, siltstone and shale sequences has exceeded the expectations of many producers working along the trend. 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 13). The fairway covers approximately 2.6 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. Producers continue to push 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 rose from \$85 million in 2005 to a record \$1.32 billion in 2008 (Figure 14). The increase can be directly correlated with an industry shift to incorporate unconventional gas reservoirs, which include Triassic targets such as the



Cordova Embayment Well Activity 2012

- Cordova Land Sales 2010
- Cordova RR 2012

*no land sales in 2011 & 2012

Cartography by Talitha Castillo

Ministry of Natural Gas Development

Oil and Gas Division
Geoscience and Strategic Initiatives Branch

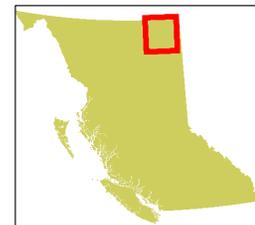


Figure 11. Almost all land sale and well activity in the Cordova Embayment from 2010 to 2012 has been directed towards shale gas targets. Penn West Exploration Ltd. was the most active operator in the region in 2012 with ten wells recorded as rig released.

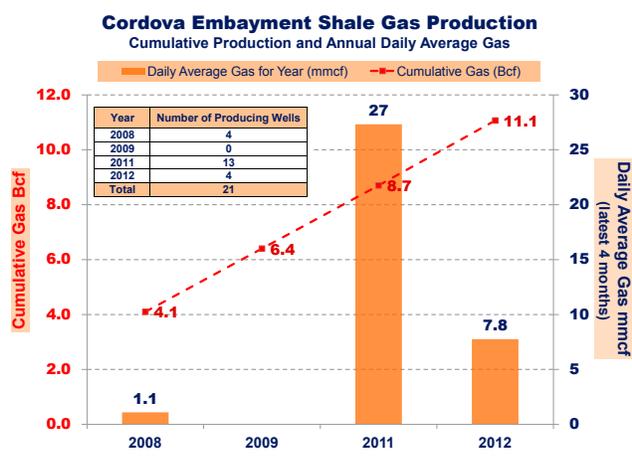


Figure 12. Between 2008 and 2012, 21 shale gas-directed wells began production in the Cordova Embayment. The most productive year was 2011 when a total of 13 wells were producing a daily average of 27 mmcf/day.

Upper, Middle and Lower Montney as well as the Doig and Doig Phosphate. Land sale bonuses have dropped steadily since that period, with 2012 bringing in total bonuses of \$121 million, down 33% from 2011. Some of the highest monthly bonuses in 2012 were collected early in the year. At the January 2012 PNG rights disposition, six drilling licences and six leases totalling 17 051 hectares (all for Montney rights) accounted for 94% of the \$32.1 million in bonuses collected at the auction. Some of the most expensive parcels were purchased in the southern Beg and Aitken Creek areas and further east in the Nig Creek area. Windfall Resources Ltd. (land broker) tendered the highest bonus bid at the auction with \$7.52 million for a 3104 hectare licence in the Beg area. The broker paid an average of \$2424 for the PNG rights to several block units in NTS 094B/16, 094G/01 and 094A/13. Windfall Resources also acquired rights to a neighbouring licence for \$6.84 million on 2823 hectares. The parcel attracted the same price-per-hectare average of \$2424 and included several units in NTS 094A/13 in the Aitken Creek area and in 094H/04 on the southwestern edge of the Nig Creek area.

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**, **Altaires**,

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 366 wells were rig released within the Montney play region in 2012 (Figure 15). More than 90% listed the Triassic Doig and Montney formations as the projected target.

Shell Canada Limited continues to make investment choices that are driven by a global perspective and a focus on liquids-rich shale gas regions. Its work in Northeast BC's Montney region fits with that strategy as the major energy producer works towards new North American integrated gas potential (Royal Dutch Shell Plc., 2012). Shell's program in the **Sunset Prairie-Groudbirch** complex of the Montney play region continued in 2012 with noted success. Production from the complex in early 2012 reached 190 million cubic feet equivalent (mmcfe) per day from more than 250 wells. Shell holds PNG rights totalling more than 300 sections (80 000 hectares) in the complex, which now include five natural gas processing plants and more than 900 km of pipeline. The resource potential of Shell's Groudbirch venture has increased from 6 Tcfe to greater than 12 Tcfe (Shell Canada Limited, 2012). 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. Shell drilled 70 of its 80 Montney trend wells in the Sunset Prairie-Groudbirch complex in 2012. The remaining wells were drilled at **Blair Creek**, **Blueberry**, **Gundy Creek** and **Town**. In early 2012, Shell announced that **PetroChina Company Limited** had acquired a 20% stake in Shell's Groudbirch area assets. The acquisition could link to supply an LNG liquefaction plant off the BC coast. In the fall of 2012, Shell signed a 10 year agreement with the City of Dawson Creek to reclaim municipal wastewater for use in hydraulic fracturing operations. The Dawson Creek Reclaimed Water Project will treat sewage water so that it can be reused in Shell's Groudbirch area operations.

Encana Corporation's assets in the **Cutbank Ridge** resource play consist of gas production from the Montney, Cadomin and Doig geological formations from areas within the southern portion of the Montney play trend. Encana holds approximately 293 000 hectares of Montney rights in this resource play and uses a resource play hub design and development procedure to reduce supply costs and generate attractive results, while minimizing the surface impact. Natural gas production from the sandstone, siltstone and shale sequences of the Triassic Montney began in 1998 and continues to exceed Encana's expectations. Most of the 71 wells drilled in Encana's Cutbank Ridge play area in 2012 were directed towards Montney and Doig development. These wells were mainly drilled in the **Saturn**, **Sunrise**,

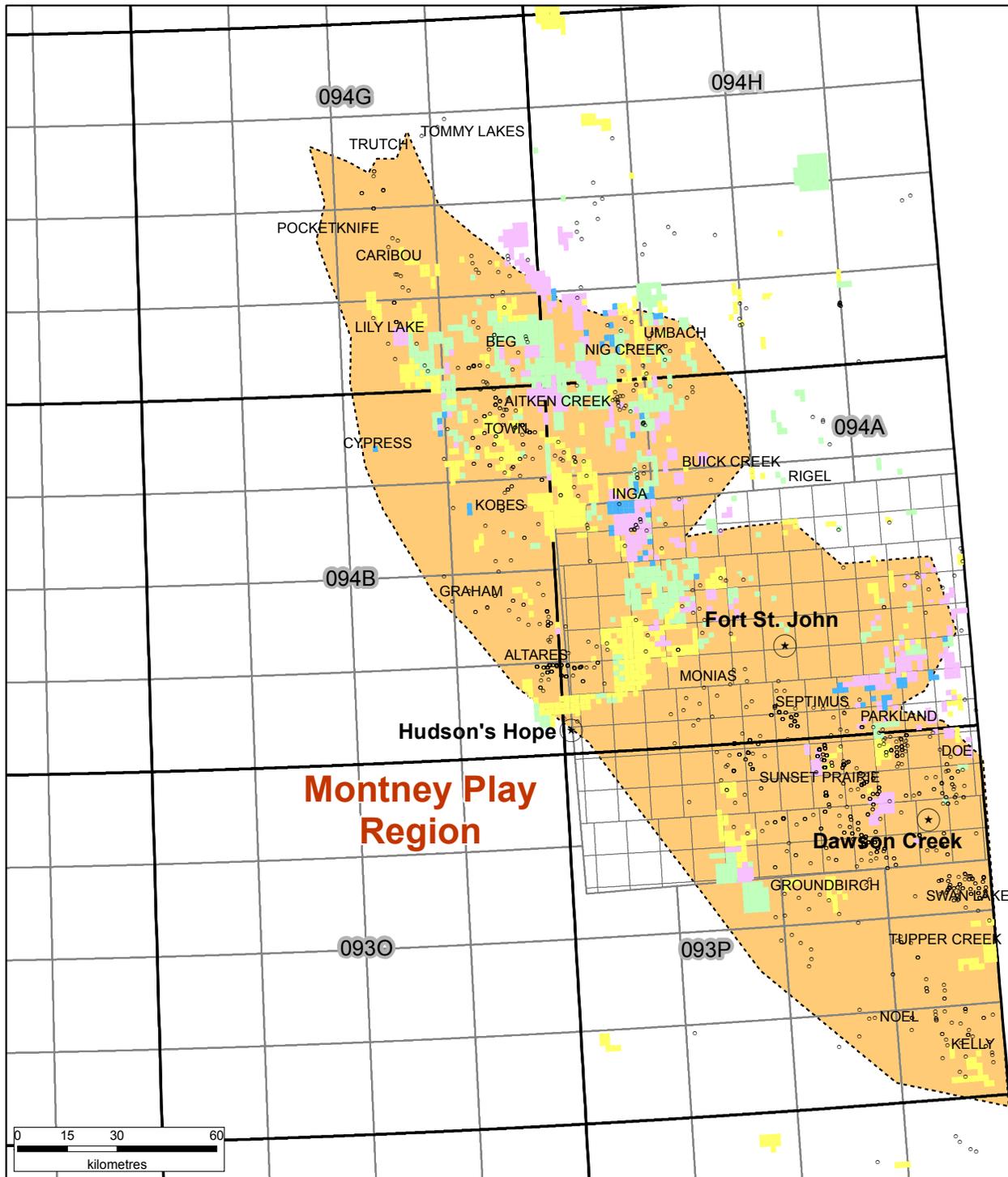


Figure 13. Petroleum and natural gas (PNG) rights sold and wells drilled within Montney play region from 2010 to 2012. The main play area of the Montney trend covers 2.64 million hectares (6.5 million acres) in the Fort St. John–Dawson Creek region of Northeast BC.

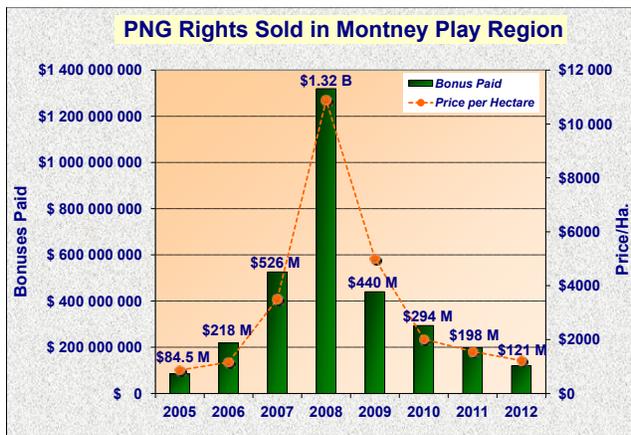


Figure 14. Bonuses from petroleum and natural gas (PNG) rights sales in the Montney play trend since 2005.

Dawson, Swan Lake and Brassey areas (Figure 16). Encana's strategy for its Montney trend wells in its Cutbank Ridge region is to increase its focus on liquids-rich areas and continue to reduce supply costs (Encana Corporation, 2013a). Joint ventures enacted in 2012 continue to help capital efficiency. Encana entered into a partnership agreement with **Mitsubishi Corporation** to jointly develop certain Cutbank Ridge lands. Mitsubishi agreed to invest approximately \$2.9 billion for a 40% interest in the partnership. Encana's operatorship of the assets was preserved and no existing production was sold in the deal (Nickle's Daily Oil Bulletin, 2013b). Encana plans to drill approximately 46 wells (gross) in the Cutbank Ridge area in 2013. Natural gas production volumes from the Cutbank Ridge play in 2012 totalled 433 mmcf/day, a slight decrease from 428 mmcf/day in 2011 (Encana Corporation, 2013b). The aerial extent of Encana's Cutbank region is 150 km wide and 600 km long within the southern portion of the Montney fairway. Encana estimates the region contains 130 Tcf and 1–2 billion barrels of petroleum initially in place (Encana Corporation, 2013a).

Progress Energy Canada Ltd. (the successor company by amalgamation of **PETRONAS Carigali Canada Ltd.** and **Progress Energy Resources Corp.**) holds approximately of 384 000 net hectares in Northeast BC's Foothills region (Progress Energy Canada Ltd., 2012a, b). Its north Montney joint venture continues with the goal of expanding the areal extent of productive Montney fairway with full-scale commercial developments in the **Caribou, Town South, Town North, Gundy Creek, Kobes** and **Altaires** areas. Progress' capital program is weighted towards these areas of the northern Montney fairway. For the nine months ending on September 30, 2012, Progress invested \$211.1 million in total capital expenditures (Progress Energy Canada Ltd., 2012b). The producer 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. Proved plus probable reserve bookings in the north Montney region are approximately 1.1 Tcfe (Progress Energy Resources Corp., 2012a). The producer now 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 (Figure 17).

Progress had seven active wells in its North Montney joint venture in late 2012; net capital spending in the third quarter of 2012 was \$73.7 million (Nickle's Daily Oil Bulletin, 2012d). A new 50 mmcf/day gas processing plant was scheduled to begin operating in the Altaires area at the end of 2012. According to Progress, gas production rates in the North Montney region compare favourably to those in the southern Montney play trend. For example, the Kobes area in the north sees first month production rates of approximately 6.5 mmcf/day, declining to 3.5 mmcf/day after 12 months. This compares to areas in the south Montney region such as the Groundbirch and Swan Lake areas, where first month production rates range from 2.5 to 3.2 mmcf/day, declining to 1.5 mmcf/day after one year. Progress Energy Canada Ltd. has selected **TransCanada Corporation** to design, build, own and operate its proposed \$5 billion **Prince Rupert Gas Transmission** project, which will transport natural gas primarily from the north Montney gas-producing region to the recently announced Pacific Northwest LNG export facility on Lelu Island in the District of Port Edward (near Prince Rupert). The large diameter pipeline would have an initial capacity of 2 Bcf/day and an estimated in-service date of 2018 or early 2019 (Progress Energy Canada Ltd., 2013).

Talisman Energy Inc. has attained large, contiguous land holdings in the Montney play trend. It holds approximately 74 000 net hectares along the fairway with a contingent resource of 29 Tcfe (Talisman Energy Inc., 2013a). Talisman's major focus is in the greater **Cypress, Farrell Creek** and **Groundbirch** areas where average net production from wells was 60–75 mmcf/day in 2012 (Talisman Energy Inc., 2013b). The bulk of well activity in 2012 was in the **Altaires** and Farrell Creek areas (NTS 094B/01), where Talisman targets the Upper and Lower Montney and Doig. Plans in 2013 are to move to a four-rig program in these areas, thus reducing gas-directed activity and allocating more capital to liquids-rich opportunities. Talisman, however, remains enthusiastic about its Northeast BC Montney program because of its competitive advantage with extensive land holdings, inherent operational expertise (e.g., reduced drilling times) and geological comprehension of the area. It portends well for future LNG export opportunities, which could raise wellhead gas prices in Talisman's project areas. In early 2011, Talisman sold a 50% net working interest in its Cypress 'A' Montney assets to South Africa's **Sasol Limited**. The \$1.05 billion deal encompasses a plan to develop stranded gas in Northeast BC by converting Talisman's significant Montney gas resource into liquids using

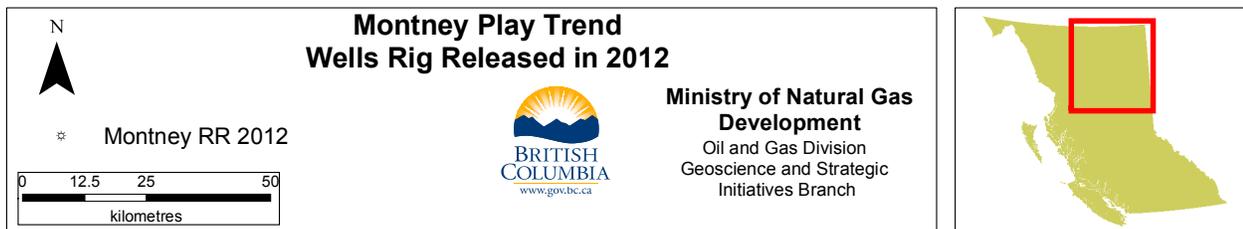
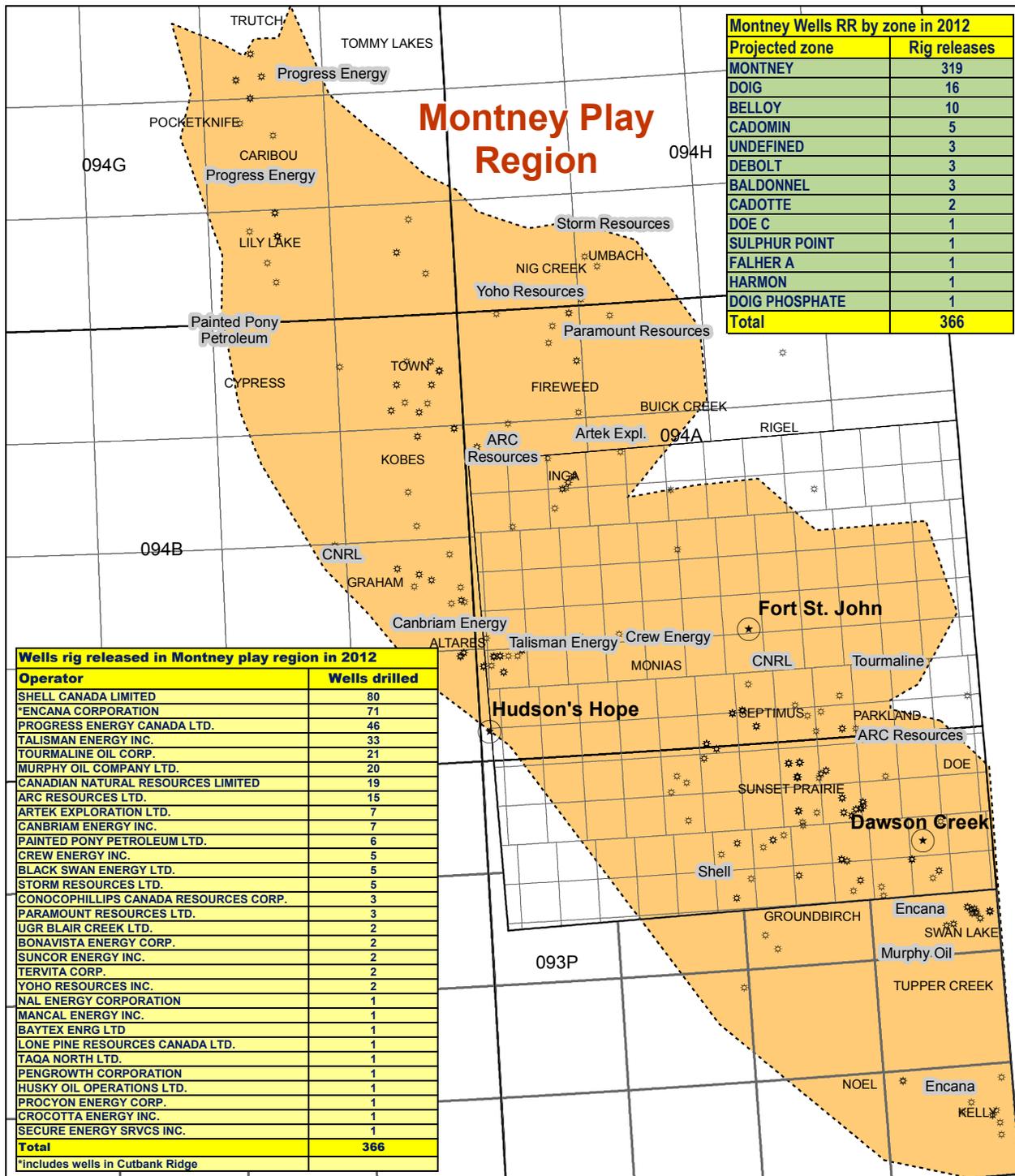


Figure 15. The key active producers operating in the Montney play trend in 2012. The Triassic Doig, Doig Phosphate and Montney formations encompassed most of the projected zones targeted by these producers.

fairway totals 423 net sections (109 553 hectares). At the year end of 2012, daily production from these assets was 235 mmcf/day and 2600 barrels/day of oil and liquids (ARC Resources Ltd, 2013a). According to an independent resource evaluation by **GLJ Petroleum Consultants Ltd.** in 2012, the discovered resource potential of ARC's Northeast BC Montney areas is significant at 27.5 Tcf of discovered gas initially in place (DGIIP; ARC Resources Ltd., 2013b). ARC's busiest area is the Dawson field, where production is now 165 mmcf/day of natural gas and 800 barrels/day of liquids. At the end of 2012, four completed gas wells were ready to be brought on stream. ARC is planning to spend \$52 million on development activities in the Dawson area in 2013. Plans include the drilling of nine horizontal Montney gas wells on two pads as well as the optimization of its 60 mmcf/day gas plant. In the Parkland–Tower Lake areas, ARC produces approximately 42.5 mmcf/day of gas and 1710 barrels/day of liquids. In 2012, 11 wells finished drilling in the Tower Lake area and nine operated wells were tied in with restricted production rates until new facilities come on stream. The first of two eight-well development pads are to be completed in the area in 2013. The year ahead will be busy for ARC in the Tower Lake–Parkland areas with the drilling of 11 oil wells at Tower Lake and 13 liquids-rich wells at Parkland. ARC has received all regulatory approvals for the construction of two 60 mmcf/day gas processing and liquids handling facilities in the Parkland–Tower Lake areas. The first facility is scheduled to come on stream in early 2014. In the Attachie area (West Montney lands), ARC is planning to drill two wells in 2013. Production continues from a pilot project on the eastern portion of the Attachie properties to assess options for commercial development and infrastructure requirements.

Tourmaline Oil Corp. has been focusing its activities in the **Groundbirch**, **Sunrise** and **Dawson** areas, where it believes the Triassic Montney is the thickest, most overpressured and liquids rich (Tourmaline Oil Corp., 2012). Tourmaline's late 2012 acquisition of Huron Energy Corporation has more than doubled its land base within the Montney trend from 78 sections to 186 sections (48 175 hectares). Tourmaline drilled 55 horizontal gas wells in the Dawson–Sunrise complex from 2010 to April 2012. Of the 55 drilled, 46 were completed with an average test rate of 8.5 mmcf/day and 213 barrels/day of condensate and liquids (Tourmaline Oil Corp., 2012b). Drilling in the complex in 2012 resulted in 13 rig releases with another nine wells coming on production. A total of 25 horizontal wells are planned for 2013. Tourmaline's Sunrise–Dawson play area has three distinct overpressured 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. Current production from the Sunrise–Dawson complex is 70–75 mmcf/day through Tourmaline's existing infrastructure (Nickle's Daily Oil

Bulletin, 2012f). A second Tourmaline gas plant in the **Doe** area is scheduled for completion in April 2013. The facility will add another 50 mmcf/day, bringing total Sunrise–Dawson complex production up to 125 mmcf/day and approximately 4000 barrels/day of condensate and liquids (Tourmaline Oil Corporation, 2012a).

Canbriam Energy Inc. has seen promising results from its Montney program with partner **Canadian Spirit Resources Inc.** (CSRI). Canbriam holds approximately 94 sections (24 379 hectares) in the west-central region of the Montney fairway, with activity principally directed toward development in the **Altares** and **Farrell Creek** areas. Canbriam's activity in 2012 focused almost exclusively on the Altares area (NTS 094B/08), where Canbriam estimates an original gas-in-place (OGIP) of 44 Tcf on its lands (Canbriam Energy Inc., 2013a). Two of its seven wells drilled in 2012 were placed on production; both are producing approximately 5.0 mmcf/day from the Doig–Phosphate–Montney A pool. Canbriam continues to focus on these area lands due to their prospectivity for natural gas liquids (Nickle's Daily Oil Bulletin, 2012a). In May 2012, Canbriam commissioned its 100% operated 50 mmcf/day gas facility at Altares. The facility, with capabilities for mechanical refrigeration and storage, marked the first phase of Canbriam's Montney development program. Canbriam has renewable firm access commitments for 50 mmcf/day on the Spectra T-North sales pipeline, which intersects with its Montney land base (Canbriam Energy Inc., 2013b).

Artek Exploration Ltd. is allocating more than 85% of its 2013 capital investment program in the **Inga** and **Fireweed** areas in the north-central region of Montney play trend. Artek has accumulated more than 21 300 hectares of land in these areas where it has multiple transportation and processing options that allow it to pursue greater liquids extraction alternatives. Six of the ten wells planned for 2013 will focus on the condensate-rich Doig play in the Inga area. First month gross production rates from its first ten horizontal wells drilled at Inga have averaged approximately 1200 barrels of oil equivalent (BOE) per day with 52% of natural gas liquids (Artek Exploration Ltd., 2013).

Crew Energy Inc. has increased its land interests in the Montney region to 373 sections (96 500 net hectares). In late February 2013, Crew acquired approximately 31 net sections in the liquids-rich gas window of the **Altares** and **Attachie** areas and another 28 net sections in the oil window of the **Goose** area. These acquisitions further enhance Crew's position in the overpressured regional Montney complex (Crew Energy Inc., 2013b). The producer continues to focus its efforts in the liquids-rich area of **Septimus**, where it has experienced exceptional results with wells testing at initial rates as high as 15 mmcf/day. The Septimus area is located approximately 50 km southeast of the city of Fort St. John (Figure 18). The Montney Formation at Septimus is approximately 300 m thick with gas-saturated rock

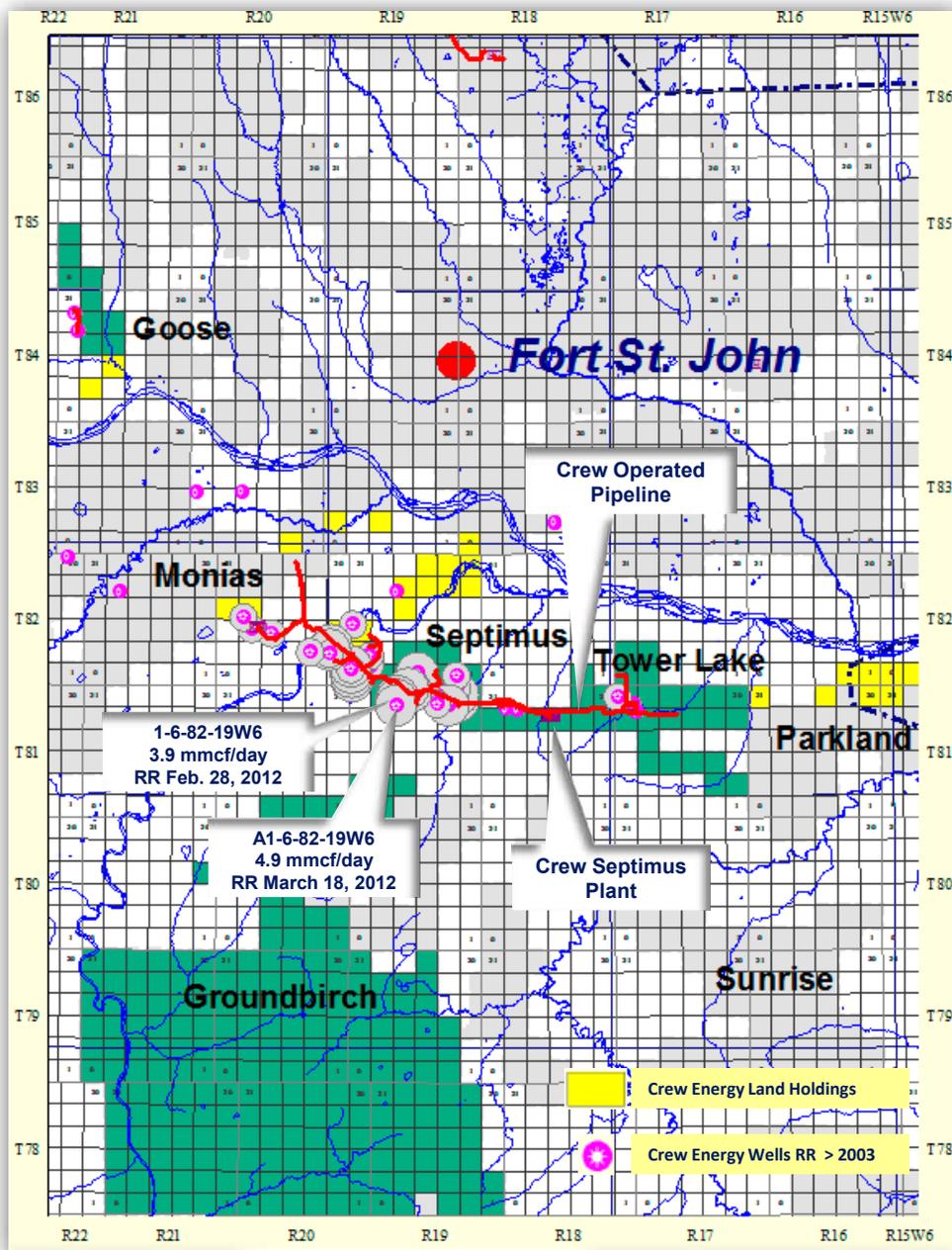
and is accessed through long-reach horizontal wells with up to five multistage, water-based fracture treatments. The area holds significant potential for Crew, with 3.2 Tcf of discovered petroleum initially in place (DPIIP) and only 15 of 234 sections with assigned reserves (Crew Energy Inc., 2013a). Total activity at Septimus in 2012 resulted in seven net wells being drilled; all were targeting liquids-rich gas. Crew's 2012 drilling program in these areas increased the average probable undeveloped reserves per well to 3.2 Bcf, which represents a 23% increase from 2011. In the nearby **Tower Lake** area, an oil well completed in the third quarter of 2011 was brought on stream at an average rate of 310 BOE/day, consisting of 210 barrels/day of oil, 20 barrels/day of natural gas liquids and 490 mmcf/day of natural gas. Crew continues to see improved well performance in the Septimus and Tower Lake areas. It has optimized capital with the use of pad drilling and modified completions techniques and it has invested in water source and disposal infrastructure. To accommodate production growth from the two areas, Crew will boost its Septimus gas processing facility capacity from 46 mmcf/day to 60–65mmcf/day.

Painted Pony Petroleum Ltd. continues to delineate and develop its large-scale Montney natural gas assets. The company's Montney rights now total 48 000 hectares (185 net sections), which include the **Cypress**, **Blair Creek**, **Daiber** and **Town** areas (NTS 094B/15 and 094B/16) along with its recently purchased assets in the **Townsend-Kobes** area (NTS 094B/09). More than 80% of Painted Pony's 2013 capital budget of \$140–145 million is earmarked for its north Montney area assets (Painted Pony Petroleum Ltd., 2013a). So far, multiple wells have been drilled to target 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 overpressured (Painted Pony Petroleum Ltd., 2013a). In late 2012, Painted Pony began production on two Montney wells in the Blair Creek area. Producing from the c-62-F/94-B-16 pad, these wells (one Upper Montney and one Lower Montney) are now producing to a third-party processing plant. In the Daiber area, a well located at a-80-E/94-B-16 completed initial production testing from the Upper, Middle and Lower Montney. The well was fracture stimulated with single stages in the Upper and Middle Montney and nine stages in the Lower Montney horizontal section (Painted Pony Petroleum Ltd., 2013b). Initial wellhead flow rates indicate that the Upper Montney represents the preferred target horizon in this area. Another two wells targeting the Upper Montney are planned for the Daiber area in 2013. In Painted Pony's newly acquired interests in the Townsend-Kobes area, production testing began on two horizontal wells on the company's a-11-J/94-B-09 pad. The first Montney well targeted liquids-rich gas from the Upper Montney interval and represents the first time that the Upper Montney has been targeted in this area.

The second well targeted the Lower Montney interval and is the third horizontal well in the area to do so. This second well was completed using a ball-drop packer-style system rather than perf-and-plug technology. The ball-drop packer-style system offers an increase in the number of completion stages per well (typically 17–19 stages, as opposed to 8–10 stages using in the perf-and-plug style). This style of completion also offers potential cost savings per well (Painted Pony Petroleum Ltd., 2013b). In 2013, a total of 12 wells are expected to be drilled on Painted Pony's north Montney assets. Drilling activity will take place in the Blair Creek and Daiber areas and at projects in the Cameron and Cypress areas. Painted Pony is one of the most active producers in the northwest section of the Montney play trend and is well positioned to be a key supplier to BC's proposed west coast LNG export terminals.

Storm Resources Ltd. holds 27 923 net hectares (69 000 net acres) of undeveloped land in the **Umbach** area in the northwest region of the Montney play trend (NTS 094H/03). The area is prospective for liquids-rich natural gas with Storm reporting fourth-quarter 2012 average production of 564 BOE and 29% natural gas liquids. Natural gas liquids recovery was 63 barrels/mmcf of natural gas sales, which included 47% condensate plus pentanes, 24% butane and 26% propane (Storm Resources Ltd., 2013). Storm's activity at Umbach entails two project areas: one with 63 sections of 57% interest lands and the other with 63 sections of 100% working interest. So far, nine horizontal wells have been drilled on jointly owned lands and one horizontal well has been drilled and completed on the 100% working interest lands. A large portion of Storm's 2012 drilling program focused on delineating the Montney resource in the Umbach area. Drilling in 2012 included six wells (four horizontals) and another three horizontal wells being completed and tied in to facilities. Resource delineation at Umbach will transition to development in 2013 as horizontal wells will be drilled from common pads. Storm remains in the early stages of development at Umbach. The producer will continue to modify its horizontal drilling techniques to improve production rates and reduce costs through operating efficiencies.

Paramount Resources Ltd. now holds acreage in the **Birch** area of the Montney play trend. The acreage was acquired as a result of Paramount's purchase of **ProspEx Resources Ltd.** in May 2011 (Nickle's Daily Oil Bulletin, 2011). The Birch area lands are east of successful Montney development in the **Town** area. The Birch area is interpreted to have a localized thickening of the Upper Montney zone, resulting in Upper Montney net pays close to those interpreted at Town (Paramount Resources Ltd., 2013a). Prior to ProspEx Resources being acquired by Paramount, ProspEx had conducted a preliminary evaluation of the Birch lands by recompleting and testing an existing vertical wellbore; it determined that the Upper Montney is overpressured in the area. Analysis of the gas produced from the recompleted



Ministry of Natural Gas Development	
Crew Energy Inc. Septimus/Tower Activity	
<small> Crowned in Accordance with Section 24(1) of the Natural Gas Act, S.S. 2007 Chapter 100 </small>	<small> Approved by the Director of the Ministry of Natural Gas Development on May 28, 2013 </small>
<small> Project Name: Crew Energy Septimus/Tower Activity Project No.: 100-10000 Project Location: Montney Play Project Operator: Crew Energy Inc. </small>	<small> Project No.: 100-10000 Project Location: Montney Play Project Operator: Crew Energy Inc. </small>
<small> Project Description: DR: 200-20000 SR: 200-20000 TR: 200-20000 CR: 200-20000 </small>	<small> Project Description: DR: 200-20000 SR: 200-20000 TR: 200-20000 CR: 200-20000 </small>

Figure 18. Wells drilled by Crew Energy since 2003 in the Septimus and Tower Lake areas of the Montney play trend. Crew's completion practices continue to be optimized, resulting in increased well performance and reduced costs. In the first quarter of 2012, Crew rig released two wells at Septimus that later produced at rates of 4.9 mmcf/day and 3.9 mmcf/day, respectively, after 57 days. So far, these rates are indicating a much lower decline rate that what was seen in the past. Liquids from the Septimus area are yielding approximately 30 barrels/mmcf on average (Crew Energy Inc., 2013c).

well indicates relatively high liquids content estimated at 30 barrels/mmcf (Paramount Resources Ltd., 2013a). In 2012, Paramount rig released three wells in the Birch area. Two of those wells have been completed and tied in. Paramount's initial well in the area at b-65-I/94-A-13 (drilled in the spring of 2011) was brought on-stream in December 2012 after modifications to surface facilities. Paramount is currently working to optimize production from these wells. The producer has 3 mmcf/day of raw gas processing capacity in the Birch area. Paramount's most recent Birch area well was rig released in September 2012. The well at c-A1-J/94-A-13 was drilled as a vertical evaluation well to assess the Lower Montney zone and to preserve surrounding petroleum and natural gas rights in the area (Paramount Resources Ltd., 2013b).

Black Swan Energy Ltd. plans to continue its delineation program in the **Beg** area of Montney play trend in 2013. Activity in 2012 included one development and four outpost wells drilled in the area. One of those outpost wells, rig released in late July (b-B079-G/94-G-1), recorded production from the Triassic Montney over the last two months of 2012 at an average rate of 3.1 mmcf/day and cumulative condensate production of 1362 barrels.

Yoho Resources Inc. is proceeding with its program in the **Nig Creek** area of Montney play region. In late 2012, one vertical well targeting the Montney was drilled on the southeast portion of its land block at Nig Creek (Yoho Resources Inc., 2012). Also completed late in the year was a 7.2 km Yoho-operated pipeline (50% working interest). The pipeline is part of Yoho's development plan in the Nig Creek area and will smooth the process for tie-in of future development wells. In fact, a gas-liquids well at d-97-H/94-H-4, with previously shut-in production, is now producing through the pipeline. Reported production from the well in November 2012 was of 815 mcf/day of natural gas and 33 barrels/day of condensate after 122 producing hours.

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 Montney and Doig Phosphate formations within the play trend has increased considerably since 2003 with the

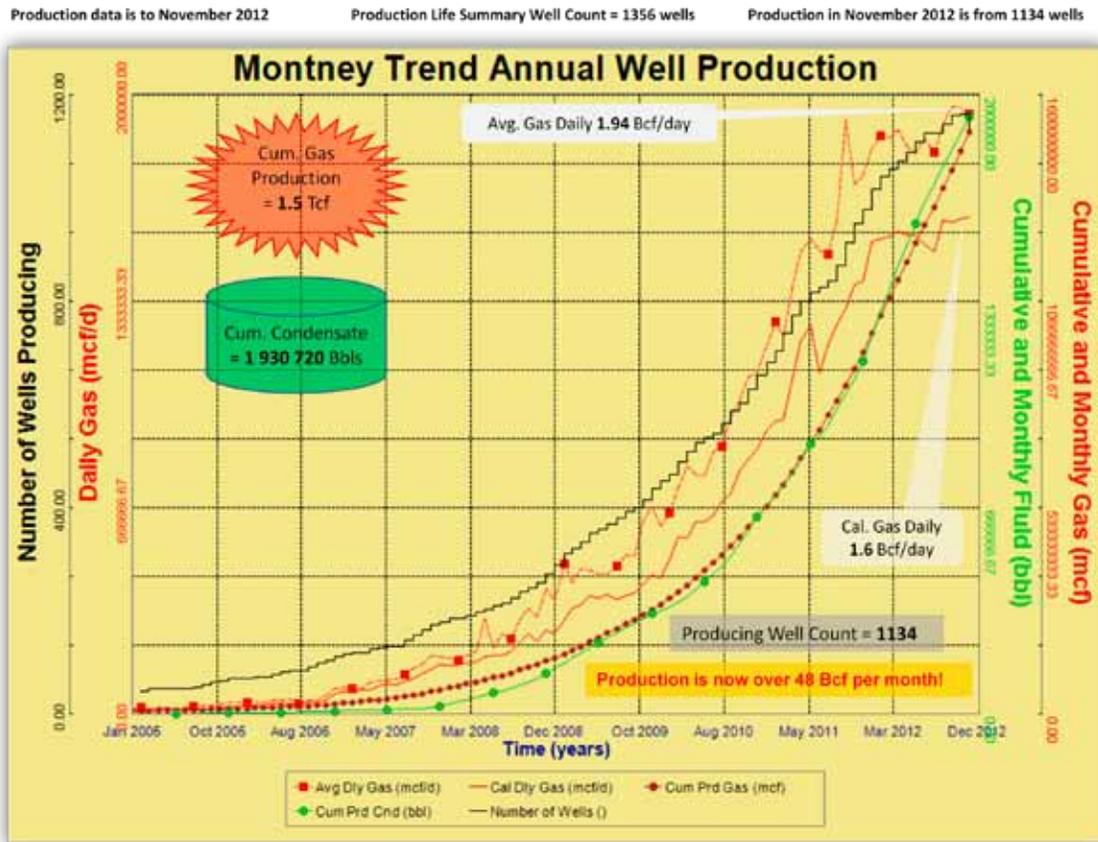


Figure 19. Approximately 1.5 Tcf of natural gas has been produced from the Lower Triassic Montney and Doig Phosphate formations from 2003 to November 2012. The average daily calendar rate in November 2012 was 1.6 Bcf from 1134 producing wells. Cumulative condensate production to November 30, 2012 was 1 930 720 barrels.

average calendar daily rate reaching 1.6 Bcf/day from 1134 producing wells at the end of November 2012 (Figure 19). The play region has seen cumulative gas production of approximately 1.5 Tcf.

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).

INDUSTRY ACTIVITY

Painted Pony Petroleum Ltd. has amassed approximately 38 500 net hectares (149 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 three years and feels that there is an 800 m thick section in the area that is suitable for vertical development of 16–32 wells per section (Painted Pony Petroleum Ltd, 2013b). So far, three wells have been tested and are on production at Blair Creek. A hydraulic fracturing program is planned for two existing wells in the area during the first half of 2013. 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.

In May 2009, **UGR Blair Creek Ltd.** (UGR) 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 Tcfe (Unconventional Gas Resources, 2012).

OUTLOOK

Industry announcements of higher resource and recovery estimates from BC's shale gas regions have had a significant impact on unconventional resource play development. British Columbia saw unprecedented growth in industry activity and investment with spending on exploration and development climbing from \$3.8 million in 2003 to \$6.7 billion in 2011 (a 76% increase). In late September 2012, the Government of British Columbia announced \$120 million in royalty deductions, which will lead to the construction of 21 new infrastructure projects in the north-east section of the province. These royalty reductions are expected to generate approximately \$260 million in new industry capital spending in British Columbia. On February 25th, 2013, the BC Ministry of Natural Gas Development requested applications from companies in the oil and gas industry to participate under the 2013 Infrastructure Royalty Credit Program. The program is designed to facilitate access to new and underdeveloped areas of BC, and/or provide all-season access to oil and gas resources (BC Ministry of Natural Gas Development, 2013).

As an oil and gas jurisdiction, Northeast BC continues to present a clear competitive advantage in terms of unconventional development and production. Shale gas operators have attained premium acreage positions in the province and are ready to match production in a variety of economic conditions. One key advantage seen by shale gas producers is the ability to control the pace of development because of the relatively short period between initial investment and early production. Despite the continuing slump in natural gas prices and the lower dispositions of petroleum and natural gas rights in 2012, 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 continue to have a noteworthy impact on shale gas activities and on future opportunities to export liquefied natural gas (LNG) to overseas markets.

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