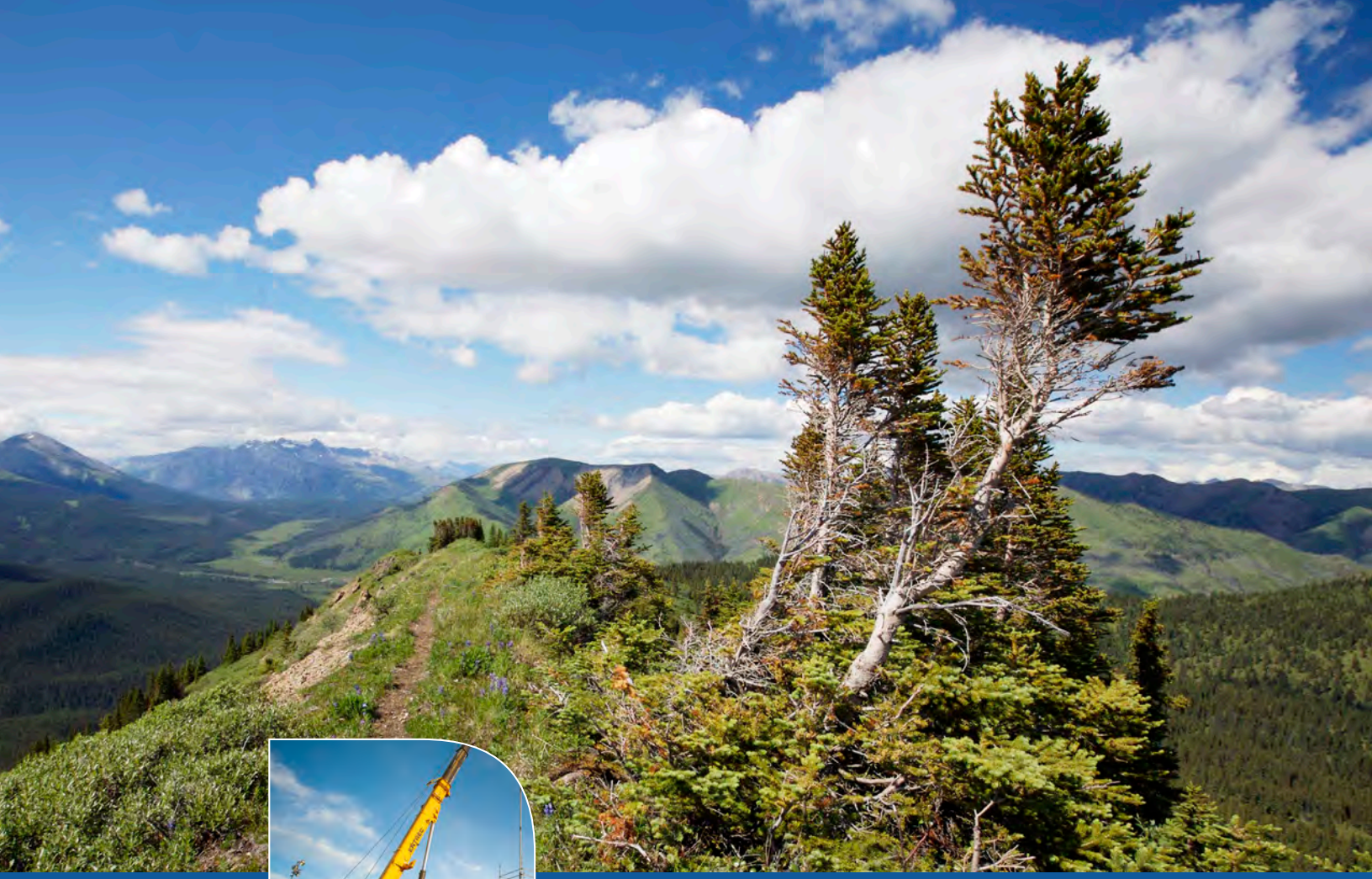

NORTHEASTERN BRITISH COLUMBIA

Climate Risk Assessment for the Oil & Gas Sector

May 2015

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Natural Resources Canada | Ressources naturelles Canada
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Executive Summary

Background

Northeastern BC has experienced a more rapid rate of warming over the last 100 years (2.2 °C) than has BC overall (1.2°C). Significant changes in climate are projected for the future. The region is expected to see increases in average temperature and precipitation, and in the frequency and severity of extreme precipitation, drought and flood events.

At the same time, oil and gas exploration and development activities have increased in the region and are expected to continue to increase in the future. Increases in gas production may be significant if new export markets for liquefied natural gas (LNG) become available. While the natural gas resource itself is not vulnerable to changes in climate, extraction of natural gas is dependent on a number of climate-sensitive resources and infrastructure, such as water, pipelines, drilling pads and roads. The oil and gas sector has responded to date by adjusting operations in response to changes in extreme weather and other factors; the challenge for the sector now is to make specific plans to adapt to future changes in climate.

To better understand the impacts of climate change in Northeastern BC, detailed climate projections were developed for the region. In early 2015, this information was used in focus group discussions and interviews with many stakeholders (including industry, local government and other interests in the region) to identify key climate vulnerabilities and opportunities in the region.

Key Climate Vulnerabilities and Opportunities in Northeastern BC

A number of vulnerabilities and opportunities were identified in the focus group discussions and interviews:

- **Water supply:** Non-conventional natural gas extraction requires significant amounts of water. The sector has faced droughts in three of the last five summers, with many operators trucking water from nearby sources to drilling sites. Projections suggest that low-flow conditions will become more frequent in the future, resulting in a greater need to develop water storage facilities to support natural gas operations.
- **Flooding:** Floods during late spring and early summer appear to be occurring more frequently. This trend is expected to continue in future, given projections for warmer winter temperatures – leading to early snowmelt – and projections for increased rainfall. Depending on design standards, floods can impact roads, drilling pads, wells and other infrastructure.
- **Landslides:** Landslides appear to be occurring more frequently in Northeastern BC. In the northernmost areas, slides may be linked to changes in permafrost. Landslides are also associated with extreme precipitation events. Linear infrastructure such as roads and pipelines are particularly at risk, although drilling pads and other infrastructure have also been affected.
- **More variable weather conditions:** Warmer and more variable winter conditions have a significant impact on road infrastructure, particularly in the Northern Rockies region where there is often dependence on winter ice roads and bridges to gain access to drilling sites.
- **Forest fires:** Warm, dry summers have increased the frequency and magnitude of forest fires in Northerneastern BC. An increase in forest fire frequency and severity is concurrent with an increase in other stressors on forest systems, including private, commercial and industrial development on the land base and the effects of mountain pine beetle infestation.
- **Shifts in species distributions and habitats:** Climate-related shifts in species distributions have been documented in BC, and future climate change is expected to result in the expansion, contraction and fragmentation of habitats and species distribution. Climate change will become an important issue for land and resource managers charged with maintaining biodiversity and protecting species at risk.

Although the oil and gas industry is experienced in planning for uncertainty, responding to a rapidly changing climate is a relatively new and largely unexplored issue. It requires an ongoing assessment and evaluation of industry plans, protocols and actions. Floods, droughts and variable winter weather conditions have negatively affected operations in Northeastern BC in the recent past. Although the industry has found ways to respond to these impacts, future changes in climate may require fundamental changes to industry practices beyond short-term adaptations.

Next Steps

The following next steps were identified as helpful to the oil and gas industry in understanding and managing climate risks:

- **Collaboration:** Increased collaboration between companies — as well as between the oil and gas industry and other industries — is important so that climate risks can be addressed at a strategic level.
- **Information and Capacity-Building:** Also important is capacity-building and greater availability of information for the industry – smaller companies in particular – about climate change, potential impacts and adaptation options. An example of capacity-building is the development of risk and asset management tools to support the business case for climate-resilient infrastructure.
- **Water Supply and Demand:** Water is the keystone issue in relation to climate risk in the Northeast. Improving information on future water supply and demand, and encouraging innovative water practices within the industry, are very important.
- **Professional Practice Guidelines:** Given that the oil and gas industry is heavily reliant on professionals to design and manage operations, professional practice guidelines should be improved to ensure that climate risk is taken into consideration.

Report Structure

The Report is organized as follows:

- **Section 1** offers an introduction to project objectives and methodology
- **Section 2** provides brief background and contextual information about Northeastern BC, as well as an overview of the oil and gas sector and other sectors in the region
- **Section 3** summarizes past and future climate changes in Northeastern BC
- **Section 4** discusses the importance of natural resource sectors managing the risks and opportunities associated with a changing climate
- **Section 5** summarizes impacts, risks and opportunities in Northeastern BC. This information was gathered primarily through focus group sessions and interviews with those in the oil and gas industry, local government and other regional interests.
- **Section 6** concludes the report with a discussion of key information requirements, possible next steps, and priorities for moving forward.

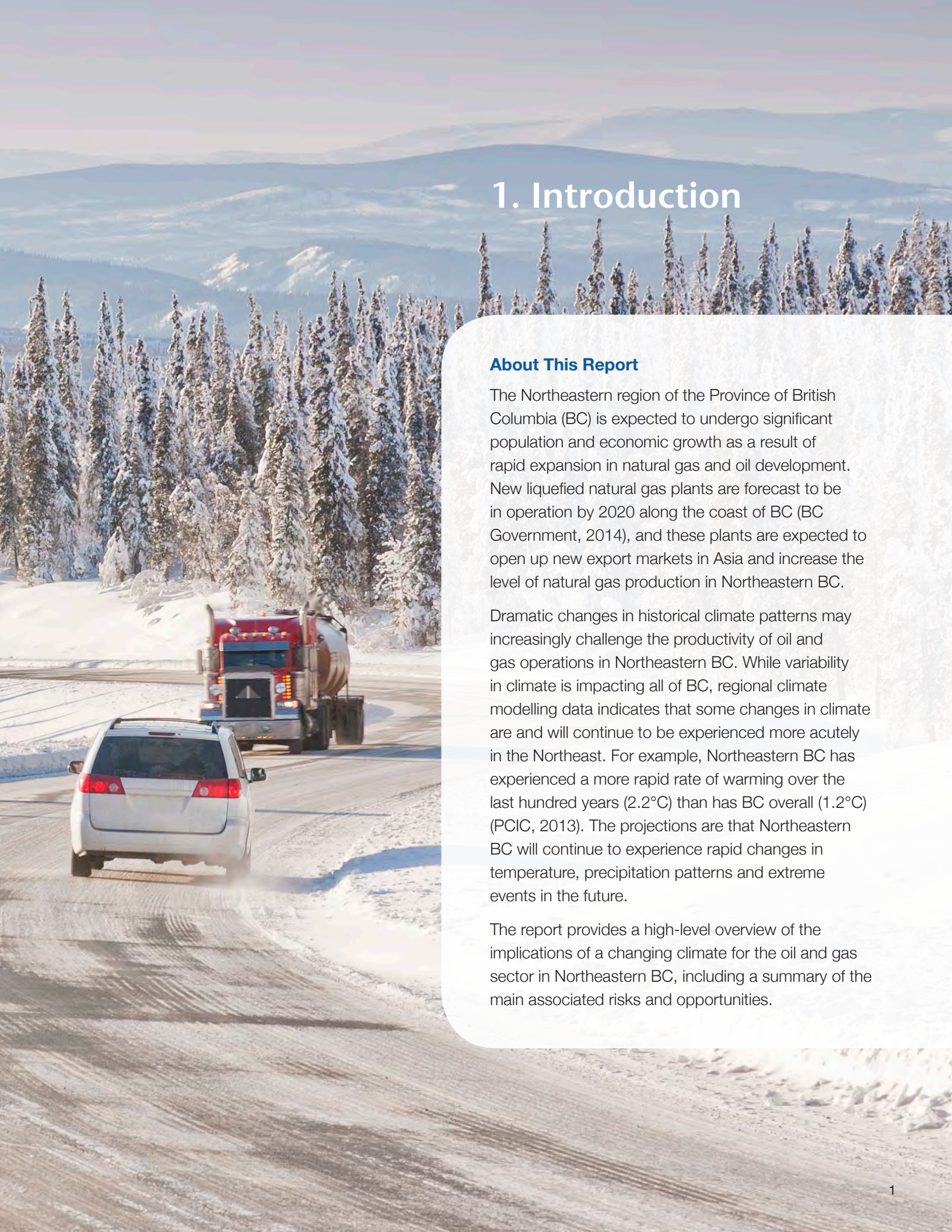
Table of Contents

List of Tables & Figures

Tables

Figures

1. Introduction



About This Report

The Northeastern region of the Province of British Columbia (BC) is expected to undergo significant population and economic growth as a result of rapid expansion in natural gas and oil development. New liquefied natural gas plants are forecast to be in operation by 2020 along the coast of BC (BC Government, 2014), and these plants are expected to open up new export markets in Asia and increase the level of natural gas production in Northeastern BC.

Dramatic changes in historical climate patterns may increasingly challenge the productivity of oil and gas operations in Northeastern BC. While variability in climate is impacting all of BC, regional climate modelling data indicates that some changes in climate are and will continue to be experienced more acutely in the Northeast. For example, Northeastern BC has experienced a more rapid rate of warming over the last hundred years (2.2°C) than has BC overall (1.2°C) (PCIC, 2013). The projections are that Northeastern BC will continue to experience rapid changes in temperature, precipitation patterns and extreme events in the future.

The report provides a high-level overview of the implications of a changing climate for the oil and gas sector in Northeastern BC, including a summary of the main associated risks and opportunities.

Project Objectives

The objectives of this project are to:

- Increase awareness and understanding of the potential impacts of changing climatic conditions in Northeastern BC
- Identify potential risks and opportunities in the oil and gas sector, as well as the sector's ability to respond and adapt to impacts in the face of a variable climate regime, and
- Identify gaps in the information and resources available to support the oil and gas sector with possible management options, and adaptation tools and techniques.

An assessment of the region's future risks and opportunities provides a starting point for integrating climate adaptation measures into planning, risk management and decision-making throughout the oil and gas sector.

A companion document to this assessment, *Backgrounder: Future Climate In Northeastern British Columbia* (Picketts, 2015)[1], summarizes past and future climate trends, focussing on changes in temperature and precipitation, as well as on projections of seasonal flows in sample tributaries in the Peace watershed. Section 3 of this assessment report includes a brief summary of the information contained in this companion document.

Steps on the Project

The project was guided by historical climate change data and 2050 climate change projections, as well as by the perspectives of representatives of the oil and gas sector operating in Northeastern BC and of other public and private sector interests in the region. There were five main steps taken to accomplish the project objectives. This report focuses on communicating the outputs of Steps 3, 4 and 5.

[1]Available on www.retooling.ca

Summary Of Steps

1. **Advisory Committee:** An Advisory Committee was established early in the process to provide high-level guidance for this project throughout its duration. Representatives on the Advisory Committee consisted of private sector interests, including those with experience in oil and gas operations, emergency response and recovery, transportation and energy services. Other committee members included provincial and local government representatives. Perspectives from the Advisory Committee guided the approach that was taken in the climate risk assessment.
2. **Interviews:** Interviews were conducted — primarily with members of the oil and gas and energy services sectors — in late 2014 and early 2015. These interviews were used to frame the initial analysis of priorities, determine what information would be included in the backgrounder document, and determine the topics and participants for the focus group sessions.
3. **Climate Projections:** Based on feedback from Steps 1 and 2, detailed and relevant information about past climate trends and projected changes in the region was prepared (Picketts, 2015).
4. **Focus Groups:** Focus groups were held in Fort St. John (January 20, 2015) and Calgary (January 26, 2015). Participants received climate information, discussed what changes are most significant for the oil and gas sector, and identified key concerns and priorities for moving forward. An agenda from the Fort St. John focus group is included in **Appendix 1**, and a copy of a news article summarizing the event is included in **Appendix 2**.
5. **Qualitative Analysis:** A qualitative analysis on the interviews and focus group discussions was completed, followed by additional research.

Figure 1 | Overview map of Northeastern BC

2. About Northeastern British Columbia

Land and People

The Northeastern region of BC is a large, diverse and economically vibrant part of Canada. It represents 21.8% of the land area of the province (20,494,470 ha). As **Figure 1** illustrates, Northeastern BC is delineated by the Yukon and Northwest Territories to the north, Alberta to the east, the Rocky Mountains to the west. It is the least populated region in BC, having just 1.6% of the population (about 69,068 people). Major centres in the region include Fort St. John (pop. 18,600), Dawson Creek (pop. 11,600), Fort Nelson (pop. 3,900), Tumbler Ridge (pop. 2,700) and Chetwynd (pop. 2,600). The population is expected to increase by 30% over the next 25 years (BC Stats, 2014). Fort St. John is the oldest non-Native settlement in BC. First Nations in Northeastern BC remain key stewards of the land, and are seeking partnerships based on meaningful consultation and respect for their aboriginal and treaty rights (Fraser Basin Council, 2012).

Environment

Long, cold winters and short, warm summers typify Northeastern BC. The average annual precipitation in the region is moderate, typically ranging from 350 to 500 mm. Surface water drains into three main river systems: the Peace (south), Liard (northwest) and Hay (northeast) Rivers. Important drainages of the Liard system include the Sikanni Chief–Fort Nelson Rivers, the Muskwa River and the Prophet River. Major drainages flowing into the Peace River include the south-flowing Halfway River and the north-flowing Moberly River. Groundwater in the region helps sustain and recharge river flows when water levels in rivers and creeks are low.

Northeastern BC is characterized by diverse topography and a variety of biogeoclimatic zones. From west to east, the landscape changes from Rocky Mountains and foothills with aspen, spruce and pine forests to muskeg, and to prairies with black spruce and tamarack. Of particular note, the Muskwa-Kechika Management Area, which covers most of the Northwest of the region, is one of the largest wilderness areas in North America (6.4 million ha). A critical component of the ecology of Northeastern BC is the presence of the forest-dwelling Woodland Caribou (Boreal population), which was listed under the federal *Species at Risk Act* (SARA) in May 2002.

Economy

Over recent decades, there has been rapid economic growth in Northeastern BC. The largest export sector is oil and gas, followed by mining and forestry. The region accounts for 91% of the total value of BC's exports of oil and gas and 14% of BC's mining production (Urban Futures, 2011).

Oil and Gas

Located in the resource-rich Western Canada Sedimentary Basin (WCSB), Northeastern BC has an abundance of natural gas, making BC the second largest producer of natural gas in Canada. Marketable natural gas production was 3.9 billion cubic feet per day (Bcf/d) in 2014 (National Energy Board, 2014). The ultimate potential for unconventional and conventional natural gas is estimated at approximately 2,914 trillion cubic feet of raw gas-in-place, of which 461 Tcf is marketable. Production of crude oil has been relatively small, accounting for only 21,000 barrels per day in 2012 (Canadian Association of Petroleum Producers, 2014).

Most of the future natural gas exploitation opportunities in Northeastern BC are from unconventional sources such as shale gas, tight gas and coal-bed methane (i.e., gas embedded in coal seams). Extraction of these sources is different from conventional production, which typically involves drilling a well vertically into gas-bearing geological formation. Unconventional gas extraction relies on a combination of techniques to reach previously inaccessible gas supplies; these techniques involve directional drilling and hydraulic fracturing (also known as fracking) (Invest in Northeast BC, 2014).

Unconventional shale gas and tight gas now account for 68% of BC's annual gas production (National Energy Board, 2013). It is expected that the WCSB will continue to see production increases in tight and shale gas and declines in non-tight conventional and coal-bed methane production. With the focus of deeper tight and shale gas resources, conventional gas is expected to account for only 6% of production by 2035, with tight gas making up to 62% and shale gas 28% (National Energy Board, 2013). The growing potential supply of natural gas in BC has led to proposals for major export facilities of liquefied natural gas (LNG) on the BC coast and major transmission pipelines from Northeastern BC to these facilities. These projects could be the catalyst to the export of Canada's natural gas to international markets other than the United States.

There are four shale basins in Northeastern BC that are currently being explored and/or developed: Montney Play, Horn River Basin, Cordova Embayment and Liard Basin. Exploration and production activity is occurring in the Montney Play and Horn River Basin, with only minimal production in the Cordova embayment, and early exploration in the Liard Basin.

In 2012 the gas industry provided over $1 billion in payments to the BC government. Exploration and development investments accounted for $5.2 billion in 2012 (Canadian Association of Petroleum Producers, 2014). Employment from BC gas extraction grew by over 400% from 1999-2012, and jobs in support activities grew over 130% (from 1999 to 2012). In 2013, the BC gas extraction sector employed over 4,900 direct workers (Employment and Social Development Canada, 2013).

Figure 2 | Shale gas plays

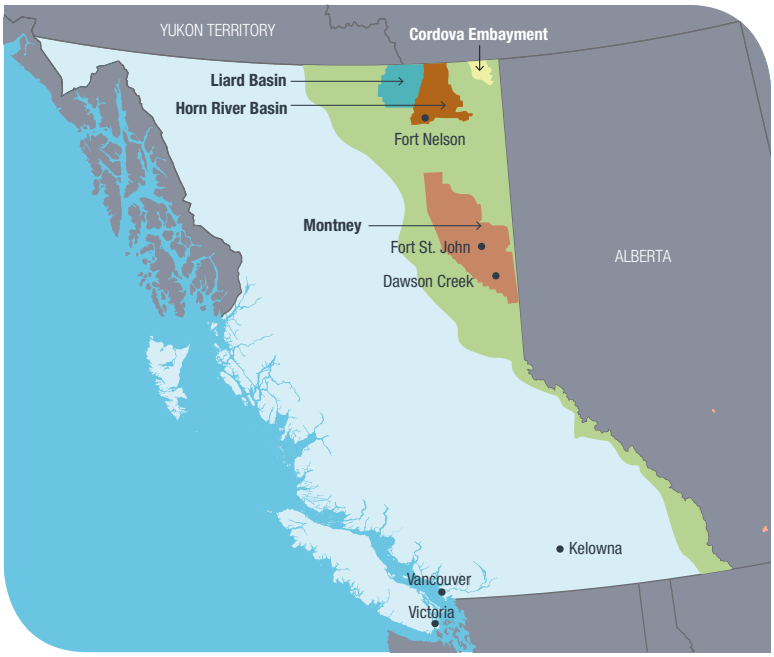


Table 1 | Main economic sectors in Northeastern BC (excluding oil and gas)

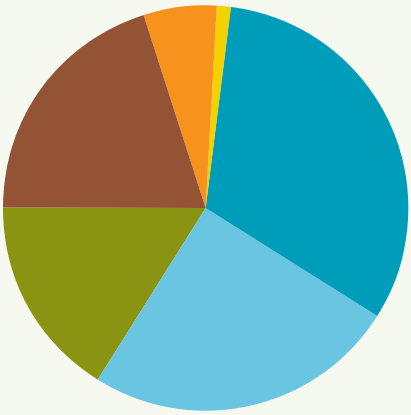
Sector	Resource Overview	Current Developments
Mining	The Peace River coalfield in the Northeast has in place mineable resources of over 1 billion tonnes of coal (Invest in Northeast BC , 2014) Coal mines in the region include: Brule, Trend and Wolverine near Willow Creek and Tumbler Ridge. Barite mines: Fireside mine, closer to the Yukon border.	There are currently six proposed coal mining projects in the Northeast; three projects — Carbon Creek, Central South and Roman Mountain — are in advanced exploration, and three — Gething, Hermann and Horizon — are awaiting environmental assessment approval.
Forestry	In 2013 BC's softwood lumber exports amounted to over $2.5 billion, which accounts for just under half of the province's forestry exports. The US, China and Japan represent the other major importers of BC lumber (Trade and Invest BC , 2013). Forest activities are primarily located in the Fort Nelson and Peace Forest Districts.	Major projects and investment opportunities are present in the Chetwynd Forest Industries Biomass Project — which will generate 13 MW of power by using wood chips converted to biomass fuel — and the Tumbler Ridge Community Forest — 22,000 hectares of Crown land secured through a 25-year agreement that will allow the District of Tumbler Ridge to harvest 20,000 cubic metres of timber each year.
Agriculture	32% of the farmland and 8% of the total number of farms (1,700) in BC are located in the Peace region (Statistics Canada, 2012). These farms generate total revenue of $77 million per year (North Peace Economic Development Commission, 2014). The primary agricultural commodities of the Peace region include grains, oilseeds, forage seed and cattle and forage. Overall, the region produces up to 90% of BC's grain and 95% of its canola (North Peace Economic Development Commission, 2014). Approximately 22% of the province's beef cattle were located in the Peace River Regional District (Ministry of Agriculture, 2011).	While the number of cattle has dropped in recent years, the Peace region remains a proportionally significant cattle production area in BC. Moisture availability is considered the primary limiting factor for much of the agricultural land in the Peace River Valley (BC Agriculture & Food Climate Action Initiative, 2013).
Hydroelectric Energy Generation	Two large facilities in the Peace Region (Peace Canyon Dam and WAC Bennett Dam) produce 38% of the province's hydroelectric power (Invest in Northeast BC, 2014).	In December 2014, the BC government approved the Site C Clean Energy Project (Site C), expected to provide enough energy to power the equivalent of about 450,000 homes per year in BC (BC Government, 2014).
Renewable Energy	The AltaGas Bear Mountain Wind Park, located to the southwest of Dawson Creek, is the first operational wind park in BC. The wind park contributes to a total of 102 MW of power — enough to power most of the South Peace region. In addition, the Dokie Wind Project in Chetwynd is fully operational and estimated to generate enough power for 32,000 homes (Invest in Northeast BC , 2014).	The Finavera Wildmare Ridge Wind project near Chetwynd, is currently underway with a signed a 25-year electricity purchase agreement with BC Hydro.
Manufacturing	The Northeast region has a small but strong manufacturing sector, which includes wood, paper and food & beverage manufacturing, and employs 3% of the workforce (Invest in Northeast BC, 2014)	
Tourism	Popular attractions in the area include mountains for hiking and skiing; lakes and rivers for swimming, canoeing and fishing; and camping, snowmobiling, hunting, and wildlife viewing. (Invest in Northeast BC, 2014).	

Other Sectors

There are several sectors and industries that operate in the region and contribute to the economy of BC and Canada, including (but not limited to): mining, forestry, agriculture, hydroelectric energy generation, renewable energy, manufacturing and tourism **(Table 1 – see previous page)**.

Water Resources

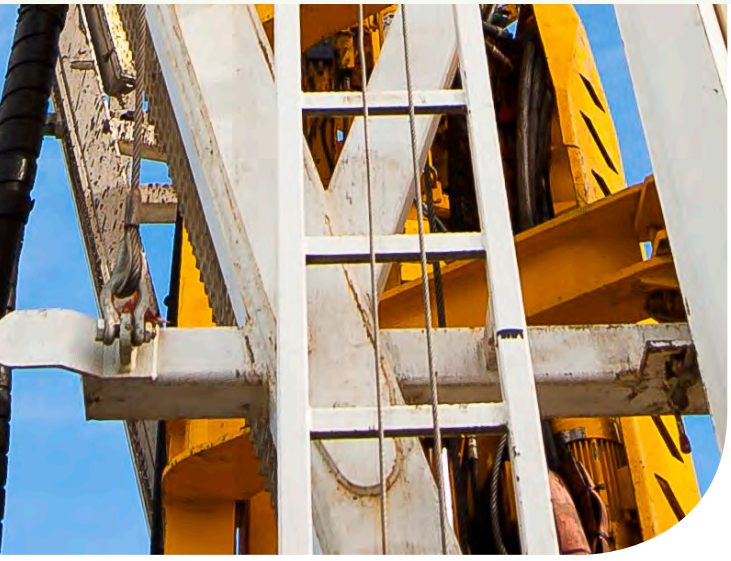
All people who live and work in Northeastern BC need a sustainable supply of water. As economic activity and the population of the Northeast expands, the demand for surface water and groundwater is also expected to increase. **Figure 3** illustrates the current licensed surface water allocation in the region for consumptive uses. The amount of surface water licensed for use is generally more than the amount actually used (BC Government, 2015).



- **Mining 20%** 12.6M m^3/yr
- **Agriculture 6%** 3.6M m^3/yr
- **Road Maintenance 1%** 0.6M m^3/yr
- **Oil & Gas 32%** 20.0M m^3/yr
- **Domestic 25%** 15.1M m^3/yr
- **Forestry 16%** 9.8M m^3/yr

Figure 3 | Approved licensed surface water allocation in Northeastern BC for consumptive uses, by sector

The total allocation of surface water in Northeastern BC was 61.8 million m^3/yr as of December 31, 2014. (BC Government, 2015)[2] The oil and gas sector was allocated for consumptive uses 20 million m^3/year through water licences (shown in piechart) and an additional 11.3 million m^3/year through short-term water use approvals. The total amount of water actually used by the sector was much less, reported at 8.3 million m^3.



[2] This number does not include First Nations on-reserve water rights that are held by the federal government. Water allocation values also do not reflect short-term water use approvals under section 8 of the *Water Act*.

Table 2 | Projected climate-related changes for Northeastern BC (2050s)

Metric	Season/ time	Median projected change	Range of projected changes (10-90%)
Mean temperature change	Annual	+ 3.2°C	+ 1.9°C to 4.7°C
	Winter	+ 4.0°C	+ 2.3°C to 5.9°C
	Summer	+ 2.9°C	+ 1.7°C to 5.0°C
Mean precipitation change	Annual	+ 14%	+11% to +19%
	Winter	+ 16%	+4% to +24%
	Summer	+ 10%	-1% to +20%
Extreme (1:20 year probability) temperature change	Min. winter night-time	+ 5.7°C	+ 4.4°C to 7.5°C
	Max. summer day-time	+ 4.0°C	+ 2.4°C to 8.1°C
Extreme (1:20 year probability) precipitation change	Max. event	+ 34%	+19% to +54%
Frost free day changes	Annual	+ 29 days	+25 to 43 days

3. Past & Future Climate Change in Northeastern BC

The information in this section is summarized from the companion backgrounder document (Picketts, 2015).

Climate change refers to shifts in patterns of weather over long periods of time, usually several decades or more. Climate change results in alterations in temperature, precipitation and extreme weather events. When it comes to climate change, people may think only of changes in average temperature, but the related extreme or unusual weather events can cause very significant problems. The impacts of a changing climate vary by sector and by location. Therefore, it is important to carefully consider the risks and opportunities associated with changing climate patterns in a specific region and for specific activities.

Climate change should not be confused with climate variability (i.e., changes that occur over seasons to a few years) or with weather (i.e., changes that occur at very short timescales).

Past Climate Changes in the Northeast

Climate records reveal that Northeastern BC warmed at a rate of 0.22°C per decade between 1901 and 2009. Over this same period, precipitation increased by 12 mm per decade. Winter temperature increases have become particularly high, and more precipitation now falls as rain than as snow. These trends illustrate that climate change is an issue of the present as well as of the future. The mountain pine beetle epidemic is an example of how climate change is affecting Northern BC and its forestry sector. Although temperature change has not been the only factor contributing to the epidemic, warmer winter temperatures have greatly increased the beetle's ability to survive and reproduce (Kurz et al., 2008).

Water flow projections for Peace River sub-basins

High-Flow Events

Projections for extreme (1:20 year probability) high-flow events for the Peace River sub-basins were analyzed. These events are expected to become 2 to 25% larger in future. Based on this information, a 1:20 year high-flow event can be expected to occur from between 1:9 years to 1:19 years in the sub-basins by the 2050s.

Low-Flow Events

Projections for extreme summer low-flow events (1:10 year probability) were analyzed. These event are expected to become 22 to 65% lower in future. Based on this information, a 1:10 year low-flow events can be expected to occur at 1:2 years or more frequently in the seven sub-basins by the 2050s.

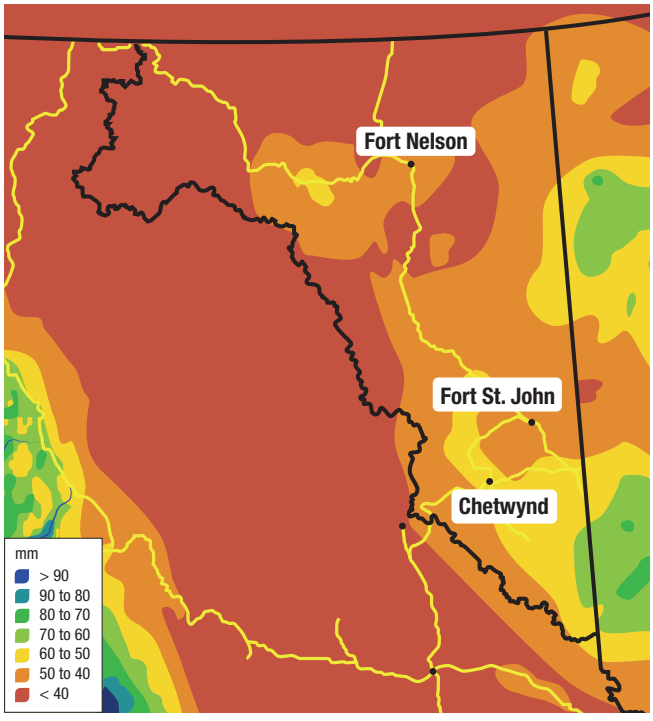
Future Climate Change in the Northeast

Global climate models (GCMs) enable projections of future climate change in the region. **Table 2 (page 7)** summarizes the projected changes for Northeastern BC in the 2050s. The results are from multiple GCMs, using several different emissions scenarios. Both the median value and the range of projections are shown.

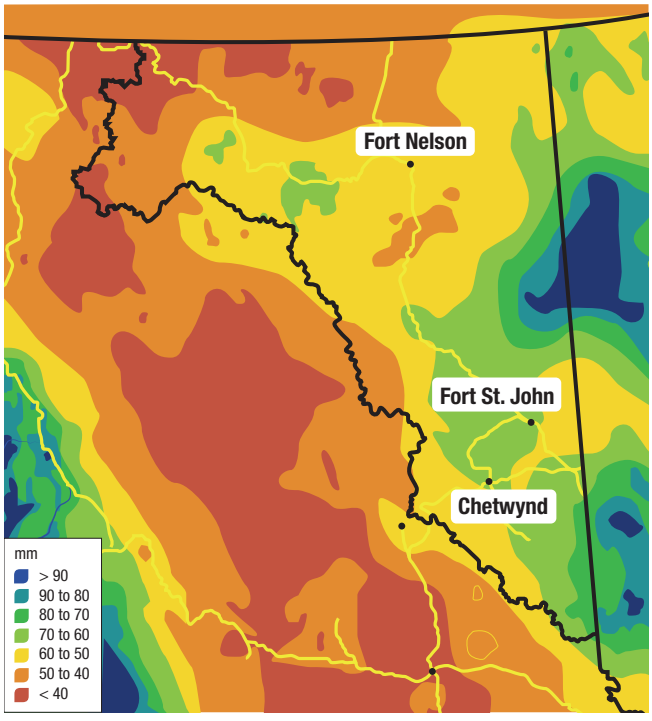
Figure 4 shows two sample maps that illustrate the spatial variation in extreme precipitation change throughout the region. Projected changes for shorter time periods (such as the 2020s) or longer time periods (such as the 2080s) can be readily created.

Changes to streamflow are significant in Northeastern BC as they relate closely to water quality and water availability. Changes in streamflow were analyzed for seven sub-basins in the Peace River watershed, but not the entire Northeastern region. The projections for the sub-basins consistently show an increase in flow from November through May, which relates closely to more winter precipitation falling as rain. In contrast, flows are projected to decrease from June to September due to lower snow packs and earlier spring freshet floods. Extreme streamflow changes are a great concern for the region as they relate to water shortages and floods. Extreme high-flow and low-flow events are expected to become more severe and more frequent in future.

Figure 4 | Extreme (20-year return) precipitation events for Northeastern BC

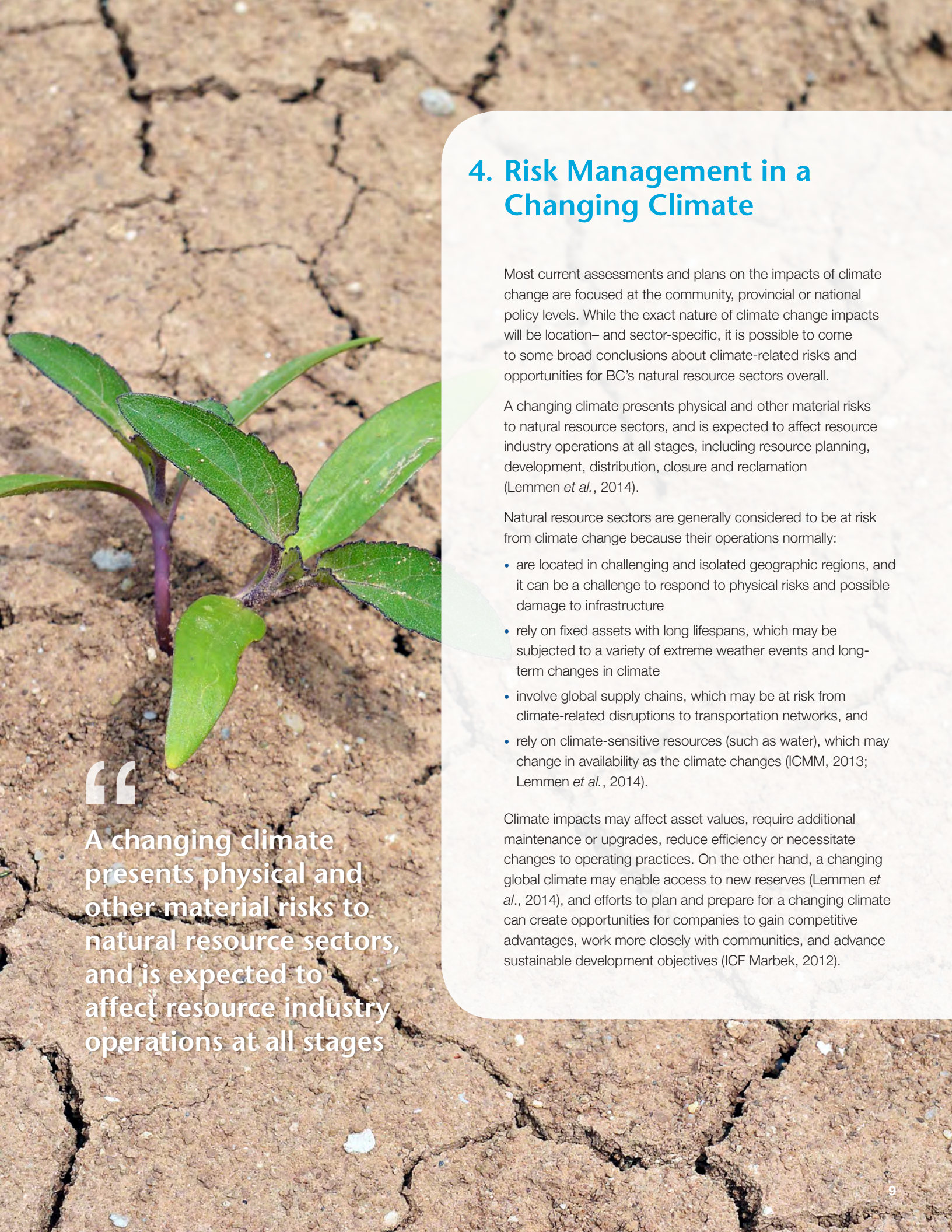


Map A: Baseline (1971-2000)



Map B: Future projected changes (2050)

Figure 4 shows a baseline in 1971-2000 (Map A) and future projections by 2050 (Map B) for extreme precipitation events (20-year return) in Northeastern BC. Maximum precipitation events over a 20-year return period are projected to increase by 34% (+19% to +54%).



4. Risk Management in a Changing Climate

Most current assessments and plans on the impacts of climate change are focused at the community, provincial or national policy levels. While the exact nature of climate change impacts will be location– and sector-specific, it is possible to come to some broad conclusions about climate-related risks and opportunities for BC's natural resource sectors overall.

A changing climate presents physical and other material risks to natural resource sectors, and is expected to affect resource industry operations at all stages, including resource planning, development, distribution, closure and reclamation (Lemmen *et al.*, 2014).

Natural resource sectors are generally considered to be at risk from climate change because their operations normally:

- are located in challenging and isolated geographic regions, and it can be a challenge to respond to physical risks and possible damage to infrastructure
- rely on fixed assets with long lifespans, which may be subjected to a variety of extreme weather events and long-term changes in climate
- involve global supply chains, which may be at risk from climate-related disruptions to transportation networks, and
- rely on climate-sensitive resources (such as water), which may change in availability as the climate changes (ICMM, 2013; Lemmen *et al.*, 2014).

Climate impacts may affect asset values, require additional maintenance or upgrades, reduce efficiency or necessitate changes to operating practices. On the other hand, a changing global climate may enable access to new reserves (Lemmen *et al.*, 2014), and efforts to plan and prepare for a changing climate can create opportunities for companies to gain competitive advantages, work more closely with communities, and advance sustainable development objectives (ICF Marbek, 2012).

> **"A changing climate presents physical and other material risks to natural resource sectors, and is expected to affect resource industry operations at all stages**

Companies are called on by government regulators, shareholders and others to identify, disclose and plan for the risks and opportunities presented by a changing climate. Some companies are responding to the changing expectations of external financial stakeholders in relation to climate risks (e.g., Carbon Disclosure Project, Global Investor Coalition on Climate Change). Regulators are also increasingly asking for details on how climate change risks have been integrated into project design and operations, such as through the environmental assessment process (e.g., Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment, 2003), and guidelines related to infrastructure (e.g., Ausenco Sandwell, 2011, BC MoTI, 2014). Newly amended or developed legislation and associated regulations can also build in long-term flexibility in order to better respond to changing conditions (e.g., *Water Sustainability Act*, Government of British Columbia, 2014).

Natural resource sectors are very experienced in identifying, addressing, adapting to and managing risks though various decision-making processes. Since these sectors are already responding and adapting to various weather-related extremes, it is possible to build on these approaches. In many cases, preparing for and adjusting to climate change does not require a new or separate process, but rather the integration of climate impact scenarios within existing risk management and planning procedures.

The oil and gas sector already deals with significant climate risks; operations and infrastructure are generally designed to cope with the demands of a variable climate (ICF Marbek, 2012).

The oil and gas industry, however, is not immune from the physical impacts of climate change, and climate change may contribute to or create impacts that exceed design and operational thresholds (Dell and Pasteris, 2010; ICF Marbek, 2012; IEA, 2013). Therefore, it may be of value to assess how climate change may alter the risks that the industry faces (e.g., floods, sea level rise, extreme events, permafrost thawing and water availability) in its operations, supporting infrastructure and value chains (IPIECA, 2013).

Potential risks of climate change for the sector include:

- **Exploration:** delays due to shifts in seasons and unpredictable weather
- **Production:** loss of surface water access, and storm impacts on key infrastructure
- **Transport and terminals:** damage to coastal facilities and shipment interruptions, and
- **Pipelines**: thaw subsidence (IPIECA, 2013).

There are regionally downscaled climate change projections (e.g., Pacific Climate Impacts Consortium) and assessments of climate-related risks in BC communities (Eyzaguirre and Warren, 2014), in the provincial government (e.g., Morgan and Daust, 2013) and in other sectors such as agriculture (e.g., Crawford *et al*., 2012; BCCAI, 2013). The understanding of climate change risks for the oil and gas sector in Northeastern BC, however, has only just begun.

5. Risk and Opportunities

This section identifies many of the climate-related challenges that the oil and gas sector has encountered in Northeastern BC and how the sector has managed these challenges to date. It describes how these challenges may be exacerbated in the future given climate change projections, and describes the opportunities that may emerge.

The Fraser Basin Council carried out individual interviews and focus group sessions to better understand the sector's perceptions of risks and opportunities and its ability to mange both. Interviews and focus group discussions were conducted in late 2014 and early 2015. The impacts identified from this process are summarized in **Table 3**, and each is discussed in more detail in the subsequent sections. It is important to understand that these are potential impacts based on climate change projections and expert judgement.

Table 3 | Potential climate-related impacts on the oil and gas sector in Northeastern BC

Issue	Changing conditions	Sector impacts
Water supply	Higher temperatures leading to more evaporation, lower snowpack and longer precipitation-free periods in summer and fall	• Water for industrial use from nearby water sources not available or restricted during low-flow periods
Flooding	Extreme precipitation events, in conjunction with changes in freshet floods, and more rain than snow in the winter and spring	• Rapid erosion affecting well sites and pipelines • Road washouts and closures • Adverse driving conditions
Landslides	Changes in permafrost and extreme precipitation events	• Infrastructure damage • Cut-off of transportation networks
More variable weather conditions	Temperature increases and unstable permafrost	• Flooding • Erosion • Road damage, including ice roads and bridges • Increased infrastructure costs
Forest fires	Warm and dry summers in conjunction with mountain pine beetle infestation	• Property damage • Changes in hydrology (affecting water supply) • Poor air quality • Emergency evacuation from remote sites • Delays and disruptions in operations
Shifts in species distributions and habitats	Warming temperatures	• Challenges in maintaining biodiversity and species at risk due to changes in landscapes, habitats and species distribution • Unknown policy changes and/or other legal implications

Climate change may increasingly challenge the ability of decision-makers to balance the demand for water with available supply and ecological needs

Water Supply

Water is a critical need of the natural gas industry. Most notably, completion technologies for unconventional natural gas wells depend on hydraulic fracturing, which requires considerable amounts of water. At present, these demands are being met in Northeastern BC primarily through surface water and fresh groundwater sources. Other sources include: saline groundwater sources, reused municipal wastewater, and recycling flowback and produced water.[3] While water demand decreases as gas fields are fully developed or mature, the industry has faced some challenges in meeting its water needs in recent years.

Although allocated consumptive use of surface water in the region is small compared to the total amount of surface water available (0.05% of mean annual flow of all rivers in the region) (BC Government, 2015), careful management is needed to minimize impacts in headwater areas, wetlands, small lakes and streams during low flow times. The Oil and Gas Commission has suspended water use in times of low flows in Northeastern BC in 2010, 2012 and 2014.[4] In response to low water flows and water restrictions, some natural gas companies that held water licences on smaller tributaries were forced to truck water from larger rivers such as the Peace and the Pine Rivers. While truck transport has been effective in the past to deal with short-term shortages, this approach may no longer be economically viable as droughts become more common.

Operations in the northernmost part of the region, such as the Horn River Basin, have been minimally affected by summer water restrictions in recent years due to the slow growth of drilling in the area. If drilling activity increases in the north, these areas may be particularly at risk due to the remoteness and lower availability of water. Operations in the Horn River Basin also have lower rates of produced water (groundwater extracted along with natural gas), and would therefore have higher surface water needs than operations in other regions.

There is a growing concern in Northeastern BC about water use, water requirements and water access. Other users, particularly local governments and the agriculture sector, are expressing concerns about how water is allocated and used. Local governments are increasingly concerned about the adequacy of infrastructure to meet the water needs of a growing resident population and transient workforce. Currently, some oil and gas companies are relying on municipal water supplies to meet potable water needs for their workforce at work camps.

The industry is beginning to take a more proactive approach to water use and conservation, with some companies developing water programs to reduce intake and manage water availability risk pre-emptively. Actions include building water reservoirs or dugouts to access water during low-flow periods, water recycling, and use of municipal wastewater. These new approaches have been driven by a greater understanding of historical seasonal variability in streamflows, alignment with corporate sustainability objectives, recognition of the value of social licence to operate in the region, and potential costs savings. Constraints exist, mainly among smaller operators that may not have the capacity to implement certain actions, may not have a similar long-term investment in the region, or may be willing to assume additional risks.

As the frequency and duration of low-flow periods increase, further long-term planning may be necessary. Climate change may increasingly challenge the ability of decision-makers to balance the demand for water with available supply and ecological needs. In extreme cases, companies may have to change the timing and logistics of drilling programs. Projections indicate that the region can expect climate change to influence seasonal patterns, with streamflows likely to be higher in the fall and winter because of increased rainfall, and lower in the summer because of higher evaporation rates and reduced runoff. Warmer spring temperatures may trigger an earlier start to the spring snowmelt.

[3] Flowback water is water-based hydraulic fracturing fluid that flows back to the wellbore after a hydraulic fracturing treatment is completed and before the well is in production. Produced water is from an underground formation that is brought to the surface along with the natural gas from the well.

[4] In BC the BC Oil and Gas Commission is the regional water manager for the oil and gas sector, and therefore manages all water authorizations for the sector. *The Oil and Gas Activities* Act also provides authority to the Commission to issue short-term water use permits under Section 8 of the *Water Act*.

Flooding

Flood events, often associated with extreme precipitation, were identified during focus group discussions as a key risk to oil and gas operations. Flood events can lead to rapid erosion, road washouts and closures, adverse driving conditions and stresses on municipal resources (e.g., stormwater infrastructure). For example, two 1-in-10 year events occurred on the Kiskatinaw River in the Dawson Creek area in a two-week period in 2011. These floods considerably impacted infrastructure, including resource roads, public roads and well sites.

Flooding in the northeast, particularly in the Peace River region, is typically related to spring snowmelt, often in conjunction with precipitation events. Focus group participants highlighted that extreme short-term precipitation events during the summer months are also of great concern. Storms from the east can get trapped in the Northern Rocky Mountains and lead to periods of intense precipitation. When this precipitation occurs over land that is snow-covered and/or already saturated, it can result in flooding.

Landslides

Landslides appear to be occurring more frequently in Northeastern BC. In the northernmost part of the region, the slides may be linked to changes in permafrost and can occur even in locations with limited slopes.

Extreme precipitation events can also cause flooding and landslides in spring and summer, and there can be higher impacts when there is still snow on the mountains. In June and July 2011 there was extreme precipitation in the south Peace River region that resulted in flooding and mass wasting (slope displacement) events.

Landslides have in the past damaged infrastructure, such as drilling pads and roads, and cut off transportation networks. These events can disrupt or shut down operations and result in increased costs for maintenance and rebuilding. Engineering and design standards have improved and are generally seen within the oil and gas sector to be more robust in the face of current landslide risks; however aging infrastructure is at risk, particularly linear infrastructure such as pipelines and roads.

Increases in temperature and frost-free days are expected to continue to affect the degradation of northern permafrost, and extreme rainfall events are expected to lead to rapid erosion and damage to important infrastructure under current conventional design parameters.

More Variable Weather Conditions

Like many northern inland regions, Northeastern BC has experienced a rapid rate of warming over the last 100 years, particularly in the winter season. Participants at the focus group sessions noted that the region appears to have experienced more warm spells in the winter season and more freeze/thaw cycles than in the past. For instance, warm spells and snowmelt during winter months has led to flooding on the roads. Maintenance crews have needed to respond to erosion and flood control needs during the winter season (e.g., opening up ditches), which has resulted in increased operational costs. Participants also noted that more repairs on roads are needed in the spring due to extreme freeze/thaw cycles.

Changes in winter weather conditions, such as more frequent freeze/thaw cycles, have also made winter driving much more challenging for transportation operations. Additional skill and specialized training may be required for truck drivers to safely manage and adapt to rapidly changing winter road conditions.

Fall freeze-up and spring break-up during the winter drilling season can also pose important challenges to the industry, particularly in the northernmost part of the region where the natural gas sector still relies on ice roads and bridges in the winter and river barges in the summer to gain access to exploration and drilling sites. For instance, ice roads and bridges may have shorter periods of use during shoulder seasons, and may become too weak and unreliable to transport heavy drilling equipment or to provide access to sites for general maintenance and inspections. General warming trends in the winter will likely lead to continued permafrost melt in the northernmost part of the region, potentially causing more stability and infrastructure issues on drilling platforms, pipelines and roads.

Some companies have responded to these conditions by building more permanent roads, or flying in staff and equipment when feasible. These responses, however, come at an increased cost to the industry and will only be available in some operations and only when oil and gas prices are high.

Concerns about site access have been alleviated in the southern part of the region with the move to more non-conventional gas developments because these use centralized drilling pads and a more centralized road system.

Larger oil and gas companies are continuing to work closely with the provincial government on road improvements; however, road construction and maintenance remains variable throughout the region.

Forest Fires

Warm, dry summers have increased the frequency and magnitude of forest fires in BC. At the same time, there is increased private, commercial and industrial development on the land base, and the effects of the mountain pine beetle infestation are evident. These contribute to a more complex wildfire environment in BC. The impacts of forest fires can include loss of homes, property and critical infrastructure, and damage to watersheds. As well, smoke can interfere with road and air transportation and cause serious public health problems.

Extreme fire events are predicted to increase as the climate changes. Projected impacts include longer fire seasons, more extreme fire behaviour and more area burned

Focus group participants felt that fires have increased in magnitude and are becoming more difficult to control. Previous fires have led to disruptions in operations and the need to evacuate workers from remote work sites. For example, in 2014, wildfires caused 200 workers in the Ojay, Red Deer Creek and Grizzly South gas fields to be evacuated. Delays and disruptions in operations can lead to companies applying for permission to operate through the fire season; however, it was reported that the industry is generally better prepared to respond and is willing to assume a greater risk of operating under these conditions.

Although the industry has existing processes in place for emergencies and extreme weather-related hazards, previous wildfire events have highlighted the need for robust emergency response plans to protect worker safety and infrastructure.

There has been a move to increase collaboration among various industries working in remote locations in order to coordinate response plans and make emergency equipment available on a regional basis.

Regional districts are responsible for emergency response in rural areas, and they rely on communities to provide shelter and other support for rural residents and evacuated work camps. This can put pressure on local governments that may already be challenged in meeting emergency response requirements.

Extreme fire events are predicted to increase as the climate changes. The projected impacts of climate change on wildfire include: longer fire seasons, more extreme fire behaviour and more area burned. In Northeastern BC, warmer temperatures are expected to result in more frequent and more severe forest fires by the 2050s and even more by the 2080s. The Taiga Plains ecoregion is particularly vulnerable to fire.

Broad-scale projections suggest that the length of the fire season will continue to increase as the climate warms, particularly in the spring (Haughian *et al*., 2012). Proactive management will be required to meet the growing wildfire risk under climate change and the consequent threats to communities, infrastructure and worker health and safety.

Shifts in Species Distributions and Habitats

Climate-related shifts in species distributions have already been documented in BC. Future shifts are expected to include expansion, contraction and fragmentation of habitats and species distribution. For example, earlier onset of spring is changing the timing of growth and reproduction of plant species that provide food and habitat for animal species. Current evidence indicates that suitable ranges for many species will likely shift in response to warming temperatures and other climatic changes. For some species, the current and projected rates of environmental change may exceed their natural ability to adapt. Changes are also expected to create suitable habitat for the expansion of invasive species (Nantel *et al.*, 2014).

Climate change may become an important issue for land and resource managers charged with maintaining biodiversity and protecting species at risk. Focus group participants expressed concern, however, about uncertainties in projections and about what impacts the sector will face from any changes to policies, guidelines and industry standards for conservation and restoration, especially impacts on projects with long timelines. For instance, participants were concerned about new targets for ecosystems and endangered species, and what baseline the industry should reclaim.

Current evidence indicates that suitable ranges for many species will likely shift in response to warming temperatures and other climatic changes

6. Towards A More Resilient Sector

When it comes to climate change, the oil and gas industry is primarily focused on mitigation – reducing anthropogenic greenhouse gas emissions. Adaptation – preparing for and responding to the risk and opportunities associated with the impacts of climate change – is still largely unexplored in the sector.

Oil and gas companies are, however, now required to address risks from variable weather, changing environments and challenging geographies. Many of the approaches, tools, information, resources and people necessary for identifying and adapting to climate risks and opportunities may already exist within oil and gas companies or support organizations. Examples of existing functions that are relevant to climate change adaptation include: internal risk management policies, emergency response planning, asset management, environmental health and safety programs, ecological management and community engagement.

Adaptive actions are intended to involve a broad range of people and entities that have roles to play in planning for and responding to climate change in Northeastern BC, including various levels of government, research institutions, industry and professional associations and the private sector.

This section builds on information collected during the engagement process. It addresses the sector's ability to manage future climate risks and take advantage of future opportunities, and identifies some capacity constraints. The section also includes key actions for enhancing the ability of the sector to adapt to climate change.

Opportunities and Constraints

While the BC oil and gas industry can learn from the global industry experience on how to become more resilient in the face of a changing climate, there are a number of BC-specific constraints and opportunities that were identified during the engagement process.

Geography: Northeastern BC has a diverse geography, which poses specific challenges and opportunities for natural gas exploration and extraction. For example, natural gas basins in the northernmost part of the region are typically located in muskeg environments, which are more isolated and lack permanent regional infrastructure and services. These regions tend to rely on ice roads and bridges in the winter, and suitable river flow in the summer for site access. Building semi-permanent or permanent infrastructure in these areas tends to be more costly and may only be viable when profit margins are high. Regions in the south, mainly in the Montney Basin, tend to be better positioned due to the site (e.g., permanent road network) and resource accessibility (e.g., water).

Economics: In general, commodity prices and economic forecasting will drive where and when exploration and drilling is deemed feasible. During periods of high prices, barriers related to site access and building infrastructure may not be a hindrance for some companies. For example, companies will begin to pay for costly infrastructure when returns are thought to be positive; however, companies must take risks and invest during the initial stage of exploration. High commodity prices may also drive new and innovative research and development for technologies that reduce climate-related risks and promote conservation and recycling of goods and services (e.g., water recycling technologies).

Company size: Large companies have greater capacity to incorporate climate change risk management into their business practices, whereas smaller companies may have limited capacity to do so. Smaller companies, because of limited geographic diversification, shorter planning horizons and limited forecasting abilities, may also be more at risk from unforeseen changes. In the future, climate change risk management may offer a competitive advantage. For example, companies that have proactively managed and planned future water use may be less vulnerable to costly disruptions during periods of drought when access to water is restricted.

Policy and regulatory environment: Some oil and gas industry representatives noted that high degree of regulation in the sector can limit long-term proactive planning. The regulatory environment needs to maintain some flexibility to meet current goals and objectives and to respond to changing conditions such as climate change. The industry is also bound by established guidelines and standards laid out by governments and professional associations. Many of these guidelines and standards may need to be updated to reflect a changing climate and to facilitate adaptation in the sector.

Challenges and opportunities of non-conventional gas: Non-conventional gas is dependent on climate-sensitive resources such as water, yet water shortages are becoming more frequent under climate change. One advantage of non-conventional gas production over conventional gas production, however, is that infrastructure is more permanent and can more easily be serviced through the construction of permanent roads, bridges and other structures.

Industry risk management practices: The oil and gas industry has a high level of capacity in planning and risk management. In many companies, climate risk could be integrated into existing planning frameworks and processes. Additionally, there may useful analogues in terms of climate adaptation in other natural resource sectors operating in similar environments (e.g., mining and forestry).

In the future, climate change risk management may offer a competitive advantage

Adaptive Actions

The following future actions for climate change adaptation were raised in focus group discussions and interviews.

Table 4 | Summary of adaptive actions identified (continues next page)

	Action	Climate issue
Information requirements and decision-making tools	Better information on water availability is critical for the industry. As a first step, there is a need to improve the existing water inventory in the Northeast so that there is more accurate information on current streamflow, groundwater, water use and water availability.	Water availability
	It is important to address priority knowledge gaps, such as on groundwater, and the effects of climate change on water resources in the Northeast.	Water availability, flooding
	In order to account for climate change in water decisions, the hydrologic modelling of streamflow in the 2050s as part of this project (focusing on a small area of the southern Peace) should be expanded to the remainder of the region.	Water availability, flooding
	It is useful to develop regional water demand models and plans in critical watersheds so that future water use by all users (e.g., industrial, agricultural and municipal) can be forecast and better managed in areas already experiencing periods of low flow. This is particularly critical for dry areas such as the Horn River Basin.	Water availability
	Resources and decision-making tools are needed to help assess future water availability. Currently the BC Oil and Gas Commission's Northeast Water Tool (NEWT) provides valuable information on water use approvals and licences; however, this tool is based on historic records and does not incorporate future projections of streamflow.	Water availability
Best-practices guidelines and standards	It is important to encourage innovation on water usage, recycling and disposal by sharing best practices within the industry, and by continuing to monitor policy to ensure that it provides appropriate flexibility to protect both industrial and environmental needs under a changing climate.	Water availability
	Water demand can be reduced by supporting research on, and implementation of, water reuse and recycling methods and technology.	Water availability
	Guidelines and standards should be developed or updated to provide clarity to professional engineers and geoscientists on the integration of climate change considerations into the design, building and maintenance of road, bridge and other critical infrastructure.	Water availability, flooding, landslides, warmer winter temperatures
Infrastructure needs	Periods of seasonal low flows have highlighted the need for additional water infrastructure to supply future demand. Key infrastructure needs could include: • Additional producer-built storage facilities (such as dugouts and reservoirs) • Centralized water storage infrastructure, accessible to multiple users, and • Pipelines or other water infrastructure to bring water supplies into remote areas where there are regular water shortages.	Water availability
	Continued collaboration between the industry and the provincial government is needed on infrastructure upgrades (e.g., roads) to meet changing climate conditions.	Flooding, landslides, warmer winter temperatures

Table 4 (continued) | Summary of adaptive actions identified

	Action	Climate issue
Infrastructure needs (continue)	Where ice roads and bridges are no longer feasible, permanent roads may be needed to access drilling sites. There has been a significant transition toward permanent roads and bridges in the Peace River region. This issue will need ongoing monitoring in the Northern Rockies where ice roads and bridges remain the critical infrastructure to access most sites.	Warmer winter temperatures
Long-term regional planning	Long-term planning should take into account current climate-related challenges and future risks and opportunities. This will help better evaluate future regional water availability risks and potential costs to the sector; assess requirements for additional water licenses on larger watersheds if supplies continue to decrease; and coordinate research and action among industry, local governments and other water users.	Water availability
	The northernmost part of the region will be particularly challenged by low water availability. As exploration and drilling programs progress, long-term planning and risk assessments will be critical to ensure long-term water availability for multiple uses (e.g., private sector, communities and ecosystem services).	Water availability
Emergency management	Regional flood protection and response plans should be developed, particularly in isolated regions in the Northeast.	Flooding, landslides
	Increased collaboration within industry working in the same region could facilitate shared emergency plans and emergency equipment.	Flooding, landslides, forest fires
	Cooperative, proactive emergency preparedness planning and management on a regional basis is important. It would bring together communities, municipal and provincial governments, First Nations and the private sector.	Flooding, landslides, forest fires

Next Steps

Adapting to the impacts of climate change is, in large measure, about managing risks. The oil and gas sector is experienced in managing a variety of operational and business risks. These risks include uncertainties in market conditions and pricing and uncertainties in geological conditions that dictate the financial feasibility of a company's operations. Changes in climate are a new consideration. The impact of recent droughts, floods and fires in Northeastern BC have heightened awareness of climate risks within the oil and gas sector.

During focus group sessions, representatives of the sector said they believe that risks are dealt with most efficiently and effectively if they are well understood and allocated to those who have the decision-making authority and are best placed to manage them. Preparing for climate change is a shared responsibility in BC. It involves governments at all levels, the private sector, academia and other support organizations, which have distinct and complementary roles. Adaptation measures are increasingly being implemented within the private sector; and in many case focus group participants saw the private sector as best placed to adapt its own infrastructure and operations to manage climate-related risks. Governments also have an important role to play in developing and protecting critical infrastructure and land use, promoting research to enhance climate science understanding and engineering solutions, and strengthening observation networks.

Although some actions and information needs for specific climate change issues are outlined in **Table 4 (see previous pages)**, further action is needed to build regional capacity and resilience overall. Here is a synopsis:

Collaboration: Increased collaboration and knowledge-sharing among regional interests is important. There is broad recognition that industries, communities and other groups face similar challenges, and that strategic partnerships are required to tackle climate risks. Collaboration may be pursued through existing organizations, such as the Canadian Association of Petroleum Producers (CAPP), or through new initiatives focussed specifically on climate. Opportunities include:

- Industry working together to share information, best practices and tools. This could be facilitated through industry associations or similar organizations.
- Partnerships beyond the energy sector to work on regional long-term plans related to shared climate opportunities, risks and information requirements (e.g., water supply and demand, infrastructure design and maintenance and emergency response).
- Collaboration to maximize opportunities that align with related strategic planning, research and other activity in the region (e.g., Northeast Water Strategy).

Capacity Building: The industry needs more information and extension resources on climate change, potential impacts and adaptation. There is a need for specific support and capacity-building in smaller companies that are at greater risk and have limited capacity to manage long-term issues such as climate change. While CAPP can play this role on a national scale, support is also needed for a network of those with an interest in future climate risk management within the oil and gas sector in Northeastern BC.

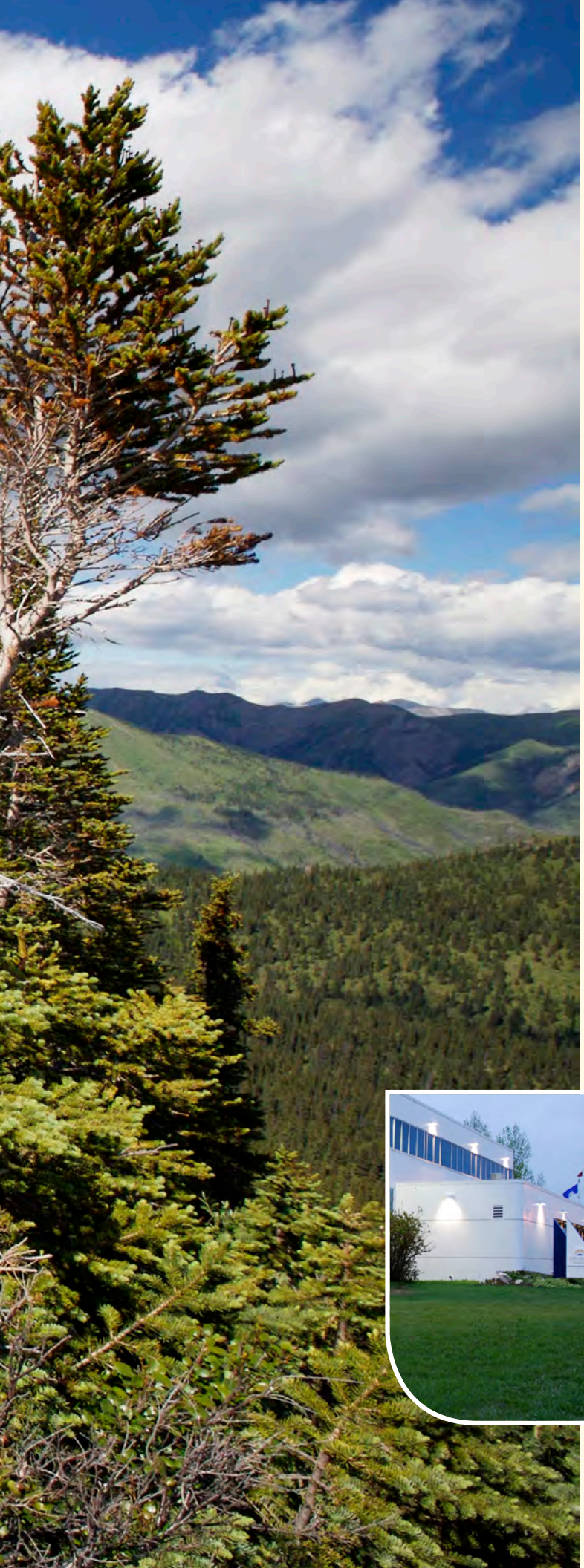
Risk and Asset Management Tools: There is a need to integrate climate risk management into existing planning and risk management tools. Examples could include guidance documents provided by CAPP on topics such as wildfire management and water planning, in addition to documents from the provincial government. In some cases, there may also be a need for companies to do more long-term asset management planning, which would include a consideration of climate change and the investments required to address climate change. In some cases, this would allow companies to make the business case for up-front investments that are amortized over the life of a project.

Policy and Regulation: There is a need for collaboration on government policy and regulation to ensure that these are conducive to future adaptation. It may be appropriate to examine the current regulatory environment and assess whether existing guidelines and standards support or hinder adaptive decision-making and action. There may be a need for governments to provide incentives to industry in order to facilitate investment in infrastructure that is costly upfront but provides more resilience over the long-term.

Water: Of all the climate risks discussed with industry during this project, those associated with water supply and demand garnered the most attention. There is a need to improve information on future water availability and flood risk, enhance collaborative planning with other sectors, and encourage innovative industry practices to reduce water use.

Professional guidelines: The industry relies heavily on professionals, so it is critical that these professionals have the capacity to integrate climate change considerations into their practice, and that relevant professional guidelines are updated to include consideration of future climate risk. These steps will help ensure that companies' intentions on climate adaptation are translated into changes on the ground.

Knowledge resources: Further information about climate change and its implications for the industry is required. Priority gaps in information can be closed through: an expanded network of weather stations for standardized data collection in the region; further research on groundwater characterization; and when climate change information exists, further characterization of that information in terms of relevant implications for the sector.



Conclusion

This project made a significant contribution to increasing regional awareness and understanding of changing climatic conditions in Northeastern BC. Many participants in the engagement process said that they were not aware of climate change or its impacts in the region, although some had observed sharper changes in temperature over the past few years.

A number of the oil and gas sector participants expressed appreciation at being involved in the project. They saw value in being part of a collaborative process designed to identify gaps in information and resources to support the sector's next steps for climate adaptation.

A changing climate poses a number of challenges and opportunities for the oil and gas sector operating in Northeastern BC. Although the sector has had some success in adapting its operations to climate variability, projections are that future climate change will be significant, and this calls for further consideration. The project was an initial effort to engage in a discussion with the oil and gas sector and other entities in Northeastern BC to assess future climate challenges and opportunities and to enhance the ability of the sector to adapt. Participants in the project recognized the importance of the oil and gas sector integrating climate change into decision-making and planning processes to enable the sector's continued safe operation in the region.

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Appendix 1: Focus Group Agenda

Northeast Climate Vulnerability Assessment
Focus Group Working Session

Fraser Basin Council

OBJECTIVES

1. To report on past and current climate trends and discuss impacts that may have affected the natural gas industry in Northeastern British Columbia (NEBC)
2. To present future climate information in NEBC, and identify and prioritize industry risks and opportunities
3. To explore proactive risk management strategies in a changing climate for the 2050s

AGENDA

1. Welcome and Introductions – 15 minutes

- David Marshall (FBC) (workshop facilitator) to provide opening remarks and welcome participants
- Round of brief introductions of participants
- Overview of session timeline, goals and objectives

2. Past and present climate change – 45 minutes

- Ian Picketts (QUEST University) to provide an overview of the NEBC backgrounder document
- Jennifer Pouliotte (BC Ministry of Environment) to present summary of current climate challenges and opportunities affecting the natural gas sector in NEBC (based on feedback provided by industry and other regional experts)
- Exercise #1 - participants will provide feedback on industry experience with weather changes in recent years:
  - In the past 5 years, how have changes in NEBC climate-related conditions (e.g. floods, droughts, changes in winter temperatures, etc.) affected the natural gas industry?
  - What have been the consequences of these experienced changes to the region and to industry?
  - What actions were taken to respond to these conditions?
  - If this trend continues, what additional actions may need to be taken in the near future by industry to be more resilient?

3. Future Climate Change & Scenario Planning – 120 minutes

- Ian Picketts (QUEST University) to present a summary of future climate trends in NEBC
- Exercise #2 - participants will engage in a discussion on future impacts and risks to the industry up to 2050:
  - Imagine we are in 2050 and the natural gas industry is operating following practices similar to those in commonly used today. Looking at the projected changes in NEBC for temperature, precipitation and streamflow, what are the risks and opportunities that might be faced if the industry?
  - What might be the top 5 climate risks faced by the NEBC natural gas industry the 2050s?

- Exercise #3: Looking at the top 5 risks that emerged in Exercise #2 (Risks to the Industry in 2050):
  - To what degree is industry in NEBC impacted by each risk (high – medium – low, whether positively or negatively)?
  - To what extent is the industry capable of managing each risk (high – medium – low)?
  - What are potential strategies for managing each risk? Strategies that would be priorities?
  - Are there needs that need to be filled to address priorities? (e.g. information, policy, coordination, technological, etc.)

4. Next Steps and Conclusions – 10 minutes

- David Marshall (FBC), and to explain further work and next steps
- David Marshall (FBC) to provide wrap-up remarks and conclude the meeting

5. Lunch and Further Discussion

Appendix 2: Media Coverage Related to Project

Alaska Highway News

Some of the major implications climate change will have on Northeast B.C.

Warmer weather expected to have implications for industry, particularly in agriculture, oil and gas

William Stodalka / Alaska Highway News | January 27, 2015

Ian Picketts speaks about climate change at the Quality Inn on Jan. 20. Photo By William Stodalka

In 35 years, Fort St. John could have Quesnel's current climate, and Fort Nelson could have the current climate of Prince George, according to climatology research. This may not sound so bad, but the changes would also mean that there would be more extreme weather events — including days with heavy snowfall or rainfall.The Fraser Basin Council presented the findings to about 12 representatives from industry, transportation, agriculture and government. David Marshall, the executive director of the council, said that they were asked to focus on northeastern B.C. by Natural Resources Canada. "Working within, we're trying to get a handle on, really, what the risks are associated with a changing climate to oil and gas operations and other operations in the northeast."

Ian Picketts, a physical sciences tutor with Quest University, using information from the Pacific Climate Impacts Consortium, projected the future climate of northeastern B.C. From around 1900 to 2010, the temperatures measured over a year increased by about 0.22 degrees a decade. But over the next three decades, projections show it go up by nearly five times that. Fort St. John and area is expected to shift by a few degrees. The temperature weather over the winter is projected to raise by four degrees Celsius. Over the summer, the temperature could raise by about three degrees Celsius from the current average. The coldest winter temperatures would be about six degrees warmer. "A lot of the area is not expected to go regularly below minus 40 anymore in the 2050s," Picketts said.

This may sound nice, but the report also noted that this would affect the mountain pine beetle, as very cold winter temperatures are necessary to keep these bug populations under control. High mountain pine beetle populations have negatively affected the lumber industry in the past. The amount of frost-free days is also expected to increase. Currently, the area around Fort St. John experiences 106 to 120 days annually without frost. That number is expected to increase by anywhere from 25 to 43 days."Increases in frost-free days can lengthen growing seasons, affect winter roads and winter access, and alter spring break-up timing and length," information presented by Picketts noted. Some at the meeting mentioned the potential positives of a warmer climate. One attendee joked about opening up a winery in the Peace Region. But this will also mean that when it rains in the 2050s, there could be a lot more rain than was historically present. For the whole year, it's expected to rise between 11 to 19 per cent.

In winter, annual snowfall is expected to rise between four to 24 per cent. In summer, the rain could actually go down one per cent, or rise by 20 per cent. "There's a need to prepare for a range of future conditions," Picketts said. "(The precipitation is) a fairly big uncertainty." Allan Chapman, a BC Oil and Gas Commission hydrologist who attended the meeting, said that industry should prepare for this type of weather, since natural gas wells rely on water to get the gas out of the ground. "When you think about planning, they do need to be thinking about long term water planning," he said. "Where are you going to get your water from a 50 year period of time?" Chapman compared it to the Romans building aqueducts that remain in effect today. But others were not so convinced.

One industry person said that he didn't think that was necessary, given the amount of water re-used by industry. Industrial attendees said that the new climate that is projected to happen over the next 35 years would mean more problems with the initial projects of exploration (when they are trying to figure out where to place the natural gas well) but not once these sites are found. "Once you're in there, if economics warrant it, there'll be a road," said one meeting attendee. Either way, Chapman said that people could expect "a later winter, shorter season, and probably periods in the winter where you'll get a melt."

The projections also showed that in the 2050s, extreme weather events would be more common. The days with the heaviest rain or snowfall over a 20-year return period are projected to increase between 19 to 54 per cent. One meeting attendee noted that in recent years, they have seen these types of extreme precipitation events, which can bring down as many as seven inches of rain in four hours.

The days when it gets really hot or really cold are also expected to increase. "Extreme short term precipitation events are the ones that are of biggest concern," he said. The number of days where it is extremely hot are also expected to increase. "Hotter extreme summer temperatures can affect worker health and safety, increase forest fire risk, and lead to warmer water temperatures and lower water levels (that affect fish, agriculture, and hydroelectric activities)," information presented by Picketts noted.

Another meeting to discuss the issue took place yesterday in Calgary. Marshall noted that a report from the sessions will be presented to Natural Resources Canada in March. The meeting in Fort St. John did not discuss the causes of climate change, but many agree that it is man-made. A study of thousands of papers stating a position on climate change found that just over 97 per cent of their writers agreed that humans are the cause of climate change.

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Social well-being supported by a vibrant economy and sustained by a healthy environment

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