NEW BRUNSWICK COMMISSION ON HYDRAULIC FRACTURING – VOLUME II

Potential Economic, Health and Environmental Impacts of Shale Gas Development

FEBRUARY 2016

NB Commission on HYDRAULIC FRACTURING | Commission du N-B sur la FRACTURATION HYDRAULIQUE

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About Volume II

This volume is the Commission's review of the potential benefits and risks of shale gas activities, including hydraulic fracturing in the province of New Brunswick. It draws heavily on the work of technical experts and peer-reviewed research much of it conducted in other jurisdictions. While the Commission's mandate was to specifically review the impacts of hydraulic fracturing, residents' concerns relate to all aspects of shale gas development. Therefore, should the Government of New Brunswick decide to proceed with hydraulic fracturing, this volume provides a guide for developing a system to mitigate potential risks and manage potential benefits across all shale gas activities.

Towards an Integrated Risk Management Strategy

Big forces of change are bearing down on New Brunswick and taken together it is apparent that New Brunswick must significantly increase wealth creation – for individuals, Indigenous people, businesses and government – to achieve sustainability.

Getting there will require a mix of existing and new pathways that reflect our changing values and priorities. This will require strategic investments designed to get us where we want to go. As stated in the 2015 Speech from the Throne, "Changing how government works will lead to better, more effective programs and services that have improved outcomes."[1]

Policies need to be addressed that move us as quickly as possible to a value-added economy in a way that provides the greatest benefits to New Brunswick residents. All developments carry a degree of risk; our goal must be to manage and mitigate those risks that have the greatest potential to disrupt community life. This is a concept that resonates with many New Brunswick residents, regardless of cultural identity or personal opinion about shale gas.

Where New Brunswickers differ is on our concept of risk. What is an acceptable level of risk? How should risk and benefits be shared? These questions are the major dividing line in the shale gas debate, pitting natural gas producers against anti-shale gas advocates in an unending tug-o-war over who can lay claim to being a responsible steward of our land, air and water: the residents concerned about the impacts shale gas development will have on their lives, or the producers who believe technology and management processes can mitigate potential risks?

Traditionally New Brunswick has been supportive of development for a variety of reasons including the promise of jobs and strong attachment to the ideals of property rights, on both land and water. This second point has been illustrated by our collective inability to develop substantive rural land management policies over the past 60 years. Following the adoption of the Equal Opportunity reforms, power was centralized at the provincial level, which meant from the mid-1960s onward development in unincorporated areas has proceeded largely unimpeded by provincial regulations.

A number of reports have been produced over the past half century that address rural development, such as Jean-Guy Finn's 2008 report, *Building Stronger Local Governments and Regions*, which stated, "There is clearly a need for more land use planning in the unincorporated areas of the province. It is our view that this planning gap could be addressed, in part, through greater emphasis on community governance."[2]

Our conversations with New Brunswick residents during the course of our work has led us to the same conclusion as it relates to managing the risks associated with shale gas activities. We would add that an open and transparent planning process that enables ongoing community participation is a path towards providing all residents with the evidence-based information needed to make an informed choice.

Shale gas development has the potential to impact New Brunswick residents in three important ways:

- economic, through private sector job creation and public sector revenue, most notably taxes and resource royalties;

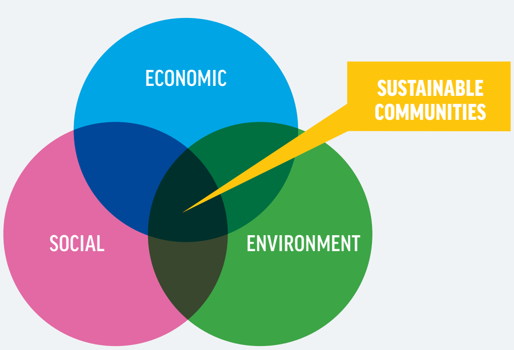
- environmental, which includes water, air and land resources; and,
- human health and safety, which is influenced by the physical environment, such as air, soil and water quality; the social environment, such as accessible health care, and crime rates; the economic environment, such as employment and income; and the lifestyle environment, such as drug use and alcoholism.[3]

Taken together, these are the core elements required for sustainable community development.

Sustainable Community Development

This is a common theme in the bulk of reports written about potential shale gas risks and benefits: in order for exploration and commercial production to proceed, a balance must be maintained among these three interconnected elements. Why? Because this is what people want – a quality of life that guarantees them financial security, good health and access to a clean environment.

Diagram of sustainable development



New Brunswick society's understanding of economic and environmental sustainability is well-developed, as is our understanding that resource developments, including shale gas, must be able to manage and mitigate risks in order to reap benefits and achieve social license.

The least understood of the three elements is social sustainability. Innovation, Science and Economic Development Canada in its *Corporate Social Responsibility Implementation Guide for Canadian Businesses* explains it in this way, "Global consensus is emerging that businesses have a greater social remit than creating jobs and paying taxes. Increasingly they are expected to take social considerations into account in how they conduct their daily business and use their sphere of influence in fulfillment of their overall 'social responsibility'…The result is that more and more firms are incorporating a social lens on their day-to-day activities (their direct impacts), and considering social factors in how they affect those with whom they have a relationship (their indirect impacts)."[4]

This concept of social responsibility was a common theme heard from the people we spoke with, regardless of their specific opinion of shale gas. Generally speaking, New Brunswick residents support the concept of social sustainability as part of a larger sustainable development goal. It is through this lens that the potential risks and benefits of shale gas development should be examined. This is a perspective we share with a number of recent reports, including the Council of Canadian Academies' 2014 report, *Environmental Impacts of Shale Gas Extraction in Canada*; Nova Scotia's *2014 Report of the Nova Scotia Independent Review Panel on Hydraulic Fracturing*; and the 2012 *Chief Medical Officer of Health's Recommendations Concerning Shale Gas Development in New Brunswick*. Hand-in-hand with the shift towards public policy that integrates social sustainability into the mix is the transition away from project-specific impact analysis and towards a cumulative impacts analysis.

Developing a Cumulative Impacts Methodology

According to the Canadian Council of Ministers of the Environment, cumulative effects are changes "in the environment caused by multiple interactions among human activities and natural processes that accumulate across space and time."[5] Cumulative effects can be felt across a geographic region (space) or over a period of time that could be days, months or years. Here in Canada, the federal, provincial and territorial governments have been working together to define how to measure, monitor and mitigate cumulative effects on human and environmental health.

In April 2014 the Cumulative Effects Working Group released the following principles for cumulative effects management.[6]

- **Knowledge-based:** Effective science and monitoring systems are needed to assess the cumulative effects of activities on air, water, land and biodiversity and support the development of outcomes and objectives.
- **Outcomes and environmental objectives-based:** Defined outcomes regarding the air, water, land and biodiversity quality must recognize the economic, environmental and social implications.
- **Future-focused:** Recognizes the combined impacts of past, present and reasonably foreseeable future human activities on a region's objectives, which requires a broader, forward-looking approach to planning.
- **Place-based:** Designed to support shared stewardship of an area and outcomes must support and reflect the interests of the area and its people.
- **Collaborative:** Recognized to be a significant and challenging component of cumulative effects management.
- **Adaptive:** Recognizes a shared responsibility to adapt and take corrective action if outcomes or objectives are not being achieved.
- **Comprehensive:** Will use both regulatory and non-regulatory approaches.

In its 2014 report on shale gas, the Council of Canadian Academies concluded that developing a monitoring program to measure cumulative effects will be "particularly challenging" but is important because it is at the watershed level that the cumulative impact of human activities needs to be understood. "In the face of development with incomplete knowledge, an adaptive monitoring and management philosophy emphasizing transparency would identify unanticipated impacts as soon as possible."[7] However, New Brunswick's current EIA process can be a frustrating experience for people with deep concerns for their individual and community health because it does not consider the cumulative effects of a variety of activities on an ecosystem.

The EIA process is a project-planning tool that can consider cumulative effects of known activities or those forecasted to occur within five years of the review at hand. From a practical perspective, this means that individuals and organizations that are concerned with risks such as water and/or air quality – such as the New Brunswick Lung Association, the Conservation Council of New Brunswick, Mi'gmaq Sagamaq Mawiomi and the National Farmers Union of New Brunswick – currently make submissions based on specific projects, even though their concerns can be applied broadly to a variety of initiatives. This is time-consuming and more importantly can weaken trust in public institutions because it leaves individuals and groups with the opinion they are simply repeating themselves to a government that is largely unresponsive to their larger concerns.

This frustration is particularly acute for Indigenous people, who as noted in Volume I, often lack the capacity to adequately assess the full impact of developments on their territories and way of life. As the Mi'gmaq Sagamaq Mawiomi, stated in its submission to the Commission, "Consultation is not translating into acceptable outcomes for the Mi'gmaq. Mi'gmaq input is seldom influencing decisions resulting in adversarial and contention Mi'gmaq/Crown relations [and] the problem is exacerbated by structural barriers and procedural flaws. Current processes are ultimately enabling development while failing to protect critical ecosystems and Mi'gmaq rights."[8]

Integrating Human Health Analysis into the Regulatory Process

Introducing Health Impact Assessments (HIA) to the regulatory process would enable regulators to assess cumulative impacts because its intent and scope is broader than a traditional environmental impact assessment (EIA), which is project-specific and only triggered if a project is going to have an impact on the natural local environment. This was a key recommendation of the Chief Medical Officer of Health's 2012 report on shale gas development in New Brunswick because an HIA is a "systematic but flexible process that considers the determinants of health and uses data, research and stakeholder input when evaluating how a project or policy will impact the health and well-being of individuals and communities."[9] Under the current regime, EIAs are managed by the Department of Environment and Local Government, which can invite Public Health officials to join the technical review committee. However, both departments have reported that a clearer definition of roles is required.

For instance, the disclosure of chemicals used in the hydraulic fracturing process is a particular concern for residents who live near potential well sites. Current New Brunswick regulations require shale gas producers to fully disclose to the Department of Environment and Local Government, pre-fracturing, all chemicals to be used and post-fracturing to list the chemicals on the website FracFocus. The Commission recognizes this is inadequate within our current environment of deep distrust among residents, government and industry and believes public disclosure of chemicals should be timely. In its submission to the Commission, Corridor Resources listed the following chemical additives for future shale fracture stimulations: cellulose polymer, sodium borate salt, cellulase/hemicellulase, polyacrylamide, surfactants, DBNPA (amide) and hydrochloric acid. [10]

Currently, human health risk assessments (HHRA) can be produced as part of a larger EIA process. The HHRA is "a quantitative evaluation of the health risk resulting from exposure to a chemical or physical agent or other environmental substances or processes. It combines exposure assessment results with toxicity assessment results to estimate risk."[11] It is expert-driven and does not consider the socio-economic determinants of health. This lack of a public health lens makes it difficult for New Brunswick residents and policy makers to understand the depth and breadth of human activities on people's health and quality of life. The World Health Organization defines health as "a complete state of physical, mental and social well-being, and not merely the absence of disease or infirmity."[12]

The Commission's review of HIAs conducted in Quebec, Pennsylvania, Colorado, New York, and Texas found that, generally speaking, HIAs highlight the:

- wide variety of information that is required in order to accurately assess risks to human health;

- gaps in the available information;
- difficulties associated with assessing future risks resulting from activities that have not yet taken place; and,
- the importance of accurate and relevant monitoring of environmental contaminants (emissions and transportation).

Several of the assessments listed contain useful recommendations about how to protect human health during the development of unconventional oil and gas.

While water and toxicity issues are the two largest concerns, other health issues can have a significant impact on personal health and quality of life. Chief among those is the anxiety and stress the arrival of this form of industrial production could have on some rural residents. This factor was noted by the Council of Canadian Academies' 2014 report, which stated, "Shale gas development can place quality of life and well-being in some communities at risk due to the combination of diverse factors related to alienation of land, construction of new infrastructure, degradation of water quality, the introduction of nuisances such as truck traffic and noise, loss of rural serenity and anxiety about unknown impacts." [13]

A number of New Brunswickers living in areas where shale gas could occur told the Commission they have very real concerns that their quality of life will be disrupted. The Corn Hill Area Residents Association wrote, "For people living in protected urban areas, the proposed regulations may sound reasonable and seem to address the key issues. For those of us living in a potential gasland, nothing that we have heard to date has given us any more confidence that this type of development makes sense in a community like ours."[14]

Our tour of the Susquehanna Valley in central Pennsylvania helped us understand what happened in the early years and gave us the opportunity to speak with experts in public health and land use planning who shared with us how to avoid the very real social challenges. The concern is existing public services such as local policing, mental health services, social services and primary health care will be inadequate to address this sudden arrival of these health and social problems, if shale gas development proceeds. We believe this can be mitigated, if the Government chooses to proceed, because New Brunswick has time to design and implement a country-leading regulatory regime for sustainable community development for two reasons.

- First, rapid development is not likely to happen due to current market conditions, which means the Government has time to develop an integrated monitoring process, which includes human health impacts, should it decide to proceed.
- Second, New Brunswick is a small jurisdiction that is heavily networked. As noted in Volume I, there are an increasing number of examples of New Brunswick residents, businesses and governments working together to drive change, most notably around poverty reduction and literacy. The shale gas issue presents us with the opportunity to work collaboratively to build a community-focused regulatory process.

At its core, shale gas development is about local land use and its impact on the people who live and work there. Our conversations with local government officials illustrated to us the importance of municipal governance and leadership around this issue. As Marco Morency of the Association francophone des municipalités du Nouveau-Brunswick told the

Commission, “The law does not recognize the role of municipal politics. Municipalities should be given more involvement in the permitting process.”[15] Kent Regional Service Commission chair Marc Henri echoed a similar sentiment.

The 2012 Public Health report further states, “Involving local government would also enable upfront prevention and mitigation including reinforcement of roads, more appropriate siting of well pads, and enhancement of local services. Providing local governments with some of the decision-making power could empower the local community to participate in the process and thereby achieve development that is more acceptable to local residents.”[16]

This is of particular importance for Indigenous people whose connections to New Brunswick’s land and water resources is both deeply cultural and highly practical. In reference to the latter, Indigenous people depend on locally harvested vegetation and wildlife far more than the general population. Their concern regarding toxicity levels in their local ecosystems and loss of land to development has the potential to have a very real and lasting impact on their quality of life.

Current Risk Management Practices in the Shale Gas Industry

Reducing risk in the oil and gas industry is in part the domain of professional engineers and geoscientists, who are tasked with designing technologies and processes that meet the safety standards set by provincial regulators. Risk management has long been an integral part of the oil and gas sector, taking precedence over other activities and involving all employees, especially those directly connected to field operations. In recent years the industry has taken a more proactive role in formalizing how it reports its safety performance. For instance, the Petroleum Services Association of Canada (PSAC) has created a Hydraulic Fracturing Code of Conduct[17] for its members. PSAC represents the service, supply and manufacturing sectors within the upstream petroleum industry, which encompasses the exploration and production of oil and gas. The code focuses on five areas: water and the environment; fracturing fluid disclosure; technology development; health, safety and training; and community engagement.

In addition, PSAC along with the Canadian Association of Petroleum Producers (CAPP) and other industry associations fund Enform[18] which provides the public and industry members with information on safety performance. It issues safety alerts, develops industry-recommended practices and provides safety training.[19] On the academic side, the University of Calgary’s Hydraulic Fracturing Innovation (HFI) initiative, announced in 2014, is an example of an interdisciplinary research group that will concentrate on peer-reviewed research in the areas of technology, public policy, and environmental research.[20]

Corridor Resources has a comprehensive risk management program that includes a full health, safety and environment program, which is run by trained employees, and accredited professionals, and the company uses qualified service and consulting companies. Service providers, including those providing fracturing services, also have extensive risk management programs of their own, which are integrated into Corridor’s program. Multiple risk assessments are conducted from design through to implementation of shale gas activities. The Commission was briefed on Corridor’s risk management practices during a tour of the company’s operations.

The Commission witnessed a similar commitment to risk management, health and safety in Pennsylvania during our tour of a Southwestern Energy (SWN) drilling site. In addition to meeting industry standards, Southwestern Energy has initiated ECH2O, short for Energy Conserving Water. This is a plan to offset 100 per cent of the volume of fresh water used in all its North American operations by the end of 2016 through water conservation, reduction, protection and innovation. This includes reducing, recycling and reusing water and the adaption of completion technology to reduce freshwater use.[21] The company has also set a goal to reduce methane emissions to less than 1 per cent of production across the full natural gas value chain.

Case Study: Water Management in New Brunswick

Water is of greatest concern to New Brunswick residents in regards to shale gas activities. Knowing that, the Commission reviewed the province's current water management system as an example of how Government manages and mitigates risks.

New Brunswick's water resources are a defining feature of life in our province. For New Brunswick residents the location of our communities, the development of our regional economies and the routes our roadways traverse are based on the province's river systems and access to the seacoast. In New Brunswick, people access fresh water in two primary ways: surface water and groundwater. Surface water is water found in natural watercourses such as lakes, rivers, streams, ponds and creeks. About 40 per cent of New Brunswickers get their water supply this way.

Communities dependent on surface water for municipal water supplies

Baker Brook	Bathurst
Campbellton	Dalhousie
Edmundston	Eel River Crossing
Green River	Moncton
Oromocto	Petit Rocher
Riverside Albert	Rothesay
Saint John	Saint Quentin
St. Andrews	St. Hilaire
St. Stephen	

Groundwater is located underground, usually within 100 metres of the surface. It can be found in the spaces between particles of rock and soil, or in crevices and cracks in the rock. The groundwater we use comes from aquifers, which are underground formations of permeable rock, such as sandstone or limestone, or loose materials, such as gravel, that can be tapped by a well. About 450,000 New Brunswickers get their drinking water supply from groundwater, making the province one of the most groundwater-dependent jurisdictions in Canada.[22] Of that number, about 40 per cent of people use groundwater to supply personal residential wells, while about 20 per cent of people, living in over 50 communities, depend on groundwater for municipal water supplies.

Communities dependent on groundwater for municipal water supplies

Alma	Aroostook
Atholville	Baker Brook
Balmoral	Caraquet
Bath	Blacks Harbour
Bouctouche	Charlo
Clair	Doaktown
Dorchester	Drummond
Edmundston	Fredericton
Fredericton Junction	Grand Falls
Hartland	Hillsborough
Kedgwick	Lameque
McAdam	Memramcook
Miramichi	Moncton
Nackawic	New Maryland
Penobsquis	Perth-Andover
Plaster Rock	Port Elgin
Quispamsis	Richibucto
Riverside-Albert	Rothesay
Sackville	Saint Hilaire
Saint John	Saint-Andre
Saint-Antoine	Sainte-Anne-de-Madawaska
Saint-Francois-de-Madawaska	Saint-Leonard
Saint-Louis-de-Kent	Shediac
Shippagan	St. Margarets
St. Martins	St. Stephen
St. George	Sussex
Sussex Corner	Tide Head
Tracadie	Woodstock

Many land use activities, such as agriculture, forestry, industrial development, septic systems and landfills have the potential to contaminate wells. Industrial use of New Brunswick's water resources is primarily surface water, with the exception of aquaculture and agriculture, both of which use a mix of surface and groundwater sources. The Department of Environment and Local Government does not regulate agricultural water use. Food processing plants in New Brunswick rely primarily on groundwater sources, with the exception of one large facility that uses both sources.

Comprehensive mapping and monitoring of New Brunswick's groundwater aquifers is a required first step in assuring residents have the necessary baseline data to properly determine how to balance human activities with maintaining the health and viability of our watersheds. The Department of Environment and Local Government currently forecasts water resource conditions and generates long-term trends. Water data and information is collected from:

- the hydrometric network (surface and groundwater levels);
- precipitation-temperature-snow survey networks;
- water quality network – rivers and lakes;
- newly drilled private wells (water chemistry); and,
- both surface and groundwater drinking water supplies. Since 1999, the Department of Environment and Local Government has also worked with volunteer-based community organizations to monitor the health of our local water systems, particularly in rural areas.

The Council of Canadian Academies' 2009 report, *The Sustainable Management of Groundwater in Canada*, identified New Brunswick's Wellfield Protection Program as a successful approach to protecting recharge areas, where water can easily enter and replenish an aquifer.[23] For instance, the Wellfield Protection Program identifies and designates three zones around the wellfield. Each has specific restrictions on permitted land uses and activities to account for the differences among contaminants that persist in the environment for different time frames, move at different rates, and pose different health risks."[24] However, management of the Water Classification Regulation has eroded public confidence and was the subject of an August 2014 report by the New Brunswick Ombudsman.

The Water Classification Regulation, which came into force on March 1, 2002,[25] was designed to protect water systems for their intended uses, such as drinking, recreation and wildlife habitat. Community environmental groups, considered important stakeholders by the Department of Environment and Local Government, were responsible for applying for the classifications, based on baseline environmental testing. Nineteen groups conducted the tests, many courtesy of funding from the department's Environmental Trust Fund, and then applied for classification. None were ever granted and the groups, comprised of volunteers, were never told why. The Ombudsman wrote that, " a reading of Regulation 2002-13 leaves no doubt that the Lieutenant Governor in Council directed that one should exist, and provided detailed instructions as to how it should be enforced. Over 12 years have passed, and the Clean Water Act has been amended, yet Regulation 2002-13 exists primarily as a mirage, misleading observers to their detriment."[26]

Following the Ombudsman's report, the Department of Environment and Local Government placed the regulation under review while it develops a broader land and water management framework. As the Ombudsman noted, this 12-year long experience eroded the trust these local watershed groups had in the Department of Environment. "Recall that these are in large part volunteer groups who invested many volunteer hours in conducting monitoring, public meetings, and preparing reports – all in expectation of a successful classification and in reliance upon the Department's assurances that their work was not in vain. The tone of their correspondence over the intervening years bears witness to the decay of trust and goodwill between these citizens and their government."[27]

In the midst of this growing tension between community groups and the Department of Environment, representatives from shale gas producers, known as landsmen, arrived at people's doors in rural New Brunswick to request permission to talk about shale gas.

Case Study: Community Experiences

This was how most people in rural parts of New Brunswick first became aware of shale gas and hydraulic fracturing: a knock on the door from a stranger representing an unfamiliar company, wanting to talk about an unfamiliar process.[28] It was, as some people who spoke with the Commission described it, unsettling. "Asking to test our wells, that really kicked up a hornet's nest. People asked, 'Why do you need to test my water?' And the answers they got back were evasive," said Stephen Gilbert, a resident of Durham Bridge. "Water is the tie that binds us. People are concerned about the watershed because the river means a lot to a lot of people. That's what got people riled up, something was happening that involved our water and we didn't know why."[29]

The rural community of Taymouth, which is located about 30 kilometres north of Fredericton in the Nashwaak Valley, was one of the first to reach out to the provincial government for answers following the first round of visits in 2010. These meetings were requested by the Taymouth Community Association's volunteer environmental committee, which had gotten started a few years earlier by residents wanting to talk about and learn how to live sustainably. This included research around groundwater monitoring and testing, and they were one of the groups that had applied for designation under the Government's failed Water Classification System.

Eventually the group, which had long enjoyed an open and largely positive relationship with elected officials, asked for and received a public meeting with officials from both Energy and Mines, and Environment and Local Government. These two departments held a series of meetings in communities around New Brunswick where shale gas development could occur. This particular meeting in Taymouth took place June 1, 2011 and was attended by about 140 people. Unsatisfied with the answers, the community requested a second meeting, which occurred on June 15, 2011 and included the unexpected attendance of representatives from SWN Resources, the company that held the exploration license for the area. That meeting attracted about 200 people – so many that people spilled out of the basement meeting room and into other rooms, including the old hall's kitchen. This was notable because it was also the seventh game of the Stanley Cup playoffs between the Boston Bruins and the Vancouver Canucks. Nonetheless, most of Taymouth crowded in and around the old school hall, listening via speakers set up in the parking lot and on the ground floor. It was an eclectic mix of people, reflecting Taymouth's population, which includes farmers, some who are fifth generation; small business owners, some who work out of their homes; people who worked in Fredericton; and retirees, including civil servants and academics. When someone downstairs said something the crowd liked, they would cheer and stomp on the floor – enough to be heard through the ceiling below. "It was quite a meeting," says Taymouth resident Jim Emberger, who would go on to become the spokesperson for the New Brunswick Anti-Shale Gas Alliance. "There were lots of questions but only one answer, 'We have this thing under control. Our new, unique, phased EIA will take care of everything.'"[30]

Unsatisfied following those two meetings, community volunteers decided to find out for themselves the degree of concern. Over a 25-hour period on June 18 and 19 – Father's Day weekend – 15 volunteers went door-to-door to ask the 369 people on the official voters list to sign a petition that stated the people of Taymouth did not believe they had been adequately consulted in advance of shale gas exploration taking place in their area, and they wanted further seismic testing to stop. Of the 284 voters who were home, 267 signed the petition. Three people did not sign it because they supported shale gas development and the jobs it would bring.[31] A week later the Government announced new regulations requiring baseline testing of all water wells prior to seismic testing, full disclosure of hydraulic fracturing fluids and chemicals and companies to set up a security bond to protect property owners from potential accidents. This did not assuage residents' concerns and the anti-shale gas movement continued to grow.

By this point the members of the environmental committee had formed Taymouth Environmental Action (as a non-profit, the Taymouth Community Centre could not conduct political activity) and began to connect with like-minded people in other parts of the province who were also aligned against shale gas. When word went out one day in August that 'thumper' trucks were in Stanley doing seismic testing, people decided to take a stand and form a peaceful blockade.[32] "It was a little scary," said Susan Young, a Taymouth-area farmer who was in Stanley that day. "I'd never done something like this before but I felt I had to do something."[33]

Across the province in Hillsborough, the Mayor and Council were also trying to get answers regarding potential shale gas development in their area. Hillsborough is a community of 1,350 people, located about 30 kilometres south of Moncton on the road to New Brunswick's famed Hopewell Rocks and Fundy National Park. The village depends on groundwater wells in the Albert Mines area for its municipal drinking water, and so when the community heard there might be shale gas development nearby, they went looking for answers from municipal politicians. They were concerned about their groundwater, but some were also concerned about the impacts the oil and gas industry could have on their local tourism economy. As Phyllis Sutherland wrote in her submission, "Tourists come here to experience open, fresh and relatively pristine rural environments. Hydraulic fracturing will ruin that..." [34]

Hillsborough councillors heard the questions their constituents were asking and set out to get some answers and assurances from the Government of New Brunswick. However the answers they received did not alleviate their concerns. "We were simply not given the information we needed to make informed decisions," said Mayor Patrick Armstrong, when he met the Commission. As opposition to shale gas development began to grow, the Council and its small staff felt caught in the middle, unable to provide residents answers to their questions while at the same time blamed for that by opponents who saw it as another sign that all levels of government were ineffective in protecting the public interest.

This frustration that clear and credible information was not made available to residents reached its height in Kent County. The Commission spent a full day in Richibucto where it met with a broad spectrum of local people, including farmers, civil servants, teachers, the unemployed, nurses, retirees, and Indigenous people. As Marc Bernard of Richibucto wrote in his submission, "We the people have already spoken. We clearly said no, and many of us got intimidated, beat up, traumatized, abused, jailed, etc. Trust between people and colonial government has been broken, there is none at all." Their story has to date been overshadowed by the demonstrations on Routes 126 and 134 that grabbed national and international headlines in October 2013. However, the roots of their experience were similar in the beginning to that of the people in Taymouth and Hillsborough: a lack of information to start and then, when questions were asked, a strong denial that anything could go wrong. As the Groupe de développement durable du Pays de Cocagne (GDDPC) wrote in its submission, "The GDDPC steering committee has submitted questions and concerns about hydraulic fracturing practices several times to government, the industry, and civil organizations over the past few years. The little response we received to these requests was not detailed enough for us to accept shale gas exploration or production in New Brunswick."[35]

The story in Sussex and Penobsquis is different because it has experience with both hydraulic fracturing and over a decade of living and working alongside natural gas producer Corridor Resources. There is a mix of opinions ranging from highly supportive to cautious to highly frustrated, each informed by the direct impact Corridor Resources and/or its partner Potash Corporation of Saskatchewan (PCS) has had on people's lives and livelihoods. Like in other parts of the province, opposition to shale gas development is rooted in the safety of water supplies.

There is history here. In 2004 residents in and around Route 114 had their wells either run dry or produce unusable, dirty water. Most of the people affected suspected it had something to do with the nearby potash mine, owned and operated by PCS. The residents formed the group Concerned Citizens of Penobsquis and began years of negotiations with the Government of New Brunswick and PCS. Initially the Government and PCS provided residents with weekly supplies of bottled water. Eventually, in 2009, the Government installed a $10 million municipal water system, charging each household $360 annually. Residents whose wells had been damaged protested the fee and in 2012 PCS agreed to pay residents' water bills following lengthy hearings before the province's mining commissioner. When they began their fight for compensation, the Concerned Citizens of Penobsquis had legal representation but the lengthy process drained the group's funds and residents ended up representing themselves. In the midst of these negotiations, in 2008, Corridor Resources announced details of an independent consultant's report that estimated significant natural gas resources in Frederick Brook, near Elgin (detailed in the next section). For the people still tied up in negotiations with the Government, this was not good news.

As one of those residents, Christine Bell wrote of her experience to the Commission, "I spent six years without water to my home. My husband and I lived on 150 gallons of water per person for three days. Those 150 gallons were for showers, laundry, washroom facilities and other household necessities. I urge you to try that for a week. The fun soon goes out of it...I can only tell you my personal experience. That experience has left me with a very jaded opinion of industry, government, bureaucrats and commissioners. I understand the frustration, the anger, that deep sense of hopelessness, that no one cares, that you are totally alone in a fight that you can't possibly win...I have spent the last [few years] trying to release the anger, to put it in the past and not look back, I write this with mixed emotions. I fear all my hard work will have been in vain, but I cannot turn my back on this because I feel it is so important for the citizens of this province – to get it right."[36]

Other Sussex area residents have felt the positive impacts of Corridor Resources' presence. The Commission met with a group of small business owners who have been able to expand their businesses and the local workforce as suppliers and contractors to Corridor, including the following examples:

- Alantra Leasing, owned by Marcus deWinter, which began supplying Corridor Resources with mobile work trailers in 2005 and now employs over 50 people and has expanded to serve customers across Atlantic Canada;
- Kings County Mechanical, owned by Tony Bell, who had gone out west on rotational welding work but, wanting to raise his children in New Brunswick, opened a small welding shop in Sussex that today serves industries around New Brunswick; and,
- Timberland Motel and Restaurant, which is owned by the MacIntyre family, was threatened with closure following the construction of the TransCanada Highway because it bypassed the business. However local industrial development, including the McCully field in 2001, helped sustain the business.

John deWinter, manager of the Amsterdam Inn told the Commission, "For myself in the hotel industry, I've seen a bit of a swing. I did about 300 shuttles to the airport last year of people coming and going from industry here. We had over $300,000 in sales related to the gas business on three of our properties."[37] Area resident Ed Murray told the Commission, "When I was growing up it was farming and forestry. Now there's just [a few] farms and forestry is going down the tubes, I thank God every day that the industry is here."[38]

These community experiences are relevant because they are etched in the memory of many New Brunswickers. They are part of our collective history on shale gas development in this province. As Olivier Clarisse and Céline Surette of the Université du Moncton wrote in their submission, "Many communities targeted for the development of the shale gas industry raised serious concerns about the potential impacts of this industry on their quality of life and the quality of their environment. These concerns, whether valid or not, simply must be addressed before beginning any development of these resources."[39] These community experiences are important because they serve to illustrate the possibilities available when social license is achieved – and the consequences when it is not.

The Business Case for Shale Gas Development

Natural Gas Use in New Brunswick

To make the transition to a value-added resources and knowledge-based economy, New Brunswickers need access to affordable, secure and increasingly clean energy. Natural gas is going to be a part of that mix for the foreseeable future. It is generally accepted that natural gas is going to be used in large amounts by institutional, industrial and commercial users in New Brunswick well into the next decade and beyond. Most, if not all, of that natural gas will be produced via hydraulic fracturing from somewhere in North America.

New Brunswick's increased use of natural gas was facilitated by a single event: the arrival of natural gas from Nova Scotia's Sable Offshore Energy Project via the Maritimes and Northeast Pipeline (MNP) in January 2000. The table below illustrates that arrival and the growth of natural gas as an energy source for New Brunswick industrial, commercial and institutional users and the accompanying decrease in heavy and light fuel oil.[40]

New Brunswick's economy is now heavily linked to natural gas and will be for many years to come. The question New Brunswick residents must answer is how do we want to access hydraulically fractured natural gas? Do we want to produce it ourselves or purchase it from existing shale gas-producing regions in the United States and/or western Canada?

Both options carry with them significant impacts for our economy and for the lives of New Brunswickers. This is a difficult choice. For industries that are reliant on natural gas, the choice is clear – locally-produced natural gas should be available. As the submission from Enterprise Saint John states, "Of the 25 energy-related investment opportunities identified...15 are expected to be heavily reliant on natural gas as an energy source. With the current price, availability and volatility of the natural gas market, these opportunities are unlikely to be realized."[41]

Those who oppose shale gas see the choice differently. As the Anti-Shale Gas Alliance wrote, "Businesses that reap the benefits of gas, and that made decisions to be dependent on gas, did so voluntarily, by themselves, in full control of their destiny, often with the collusion or assistance of the government. Whether the decisions were based on good information, foresight or outside influences is irrelevant. We would argue that the decision to commit

	Industrial		Commercial/Institutional		Residential	
	1999	2013	1999	2013	1999	2013
Electricity	58 %	41 %	49 %	66%	50 %	56 %
Natural Gas	0	43 %	0	19 %	0	2 %
Light Fuel Oil	3 %	3 %	32 %	5 %	19 %	14 %
Heavy Fuel Oil	39 %	10 %	13 %	6 %	2 %	1 %
Other	0	3 %	6 %	4 %	29 %	27 %

Source: Statistics Canada. Report on Energy Supply and Demand in Canada, 2013 Preliminary. Catalogue no. 57-003-X completely to natural gas in a province that had a very small infrastructure and customer base for that gas was a risky choice."[42]

Right now New Brunswick's natural gas users are facing down a looming problem: offshore Nova Scotia natural gas production is slowing down. A 2014 report prepared by Jupia Consulting for the Atlantica Centre for Energy estimates demand for natural gas in the Maritimes will outstrip supply by the winter of 2017/18.[43] (Full disclosure: Jupia's founder became Chief Economist for the Government of New Brunswick in February 2015.)

In anticipation of this decline, MNP majority owner Spectra Energy has proposed the Atlantic Bridge Project, an expansion of the MNP and Algonquin Gas Transmission systems. It will supply natural gas to New England and Maritimes customers, with an in-service date of November 2017. Three regional users – Irving Oil and J.D. Irving in New Brunswick and Heritage Gas in Nova Scotia – have already entered into long-term service agreements.[44] The project will "provide New England and the Maritime provinces of Canada with greater access to traditional and new supply sources in the U.S."[45] In other words, U.S.-produced hydraulic fractured shale gas will arrive in New Brunswick by November 2017.

Natural gas producers and transporters have three possible ways to build market demand.

- First, there are existing customers for natural gas. In the near term, this group will likely maintain current natural gas volumes. This group includes large industrial customers Irving Oil, J.D. Irving and Bayside Power, as well as 12,000 customers served by Enbridge Gas New Brunswick in Fredericton, Moncton, Oromocto, St. George, St. Stephen and Saint John, such as: Greenarm Group of Companies, Acadian Construction, Commercial Properties, Université du Moncton, St. Thomas University, the University of New Brunswick, the New Brunswick Community College and the Legislative Assembly. Other gas customers are supplied by compressed natural gas (CNG) via trucking where consumption is high enough to justify the economics and there is no pipeline service. Such customers include McCain Foods in Florenceville.
- Second, there are potential new local customers, such as NB Power, which could increase the province's overall natural gas volumes.
- Third, there remains the possibility of attracting new, natural gas-dependent businesses if New Brunswick has a guaranteed long-term supply. The Atlantic Potash Corporation falls into this category. It has proposed two capital projects, a $3 billion potash mine at Millstream and a fertilizer plant in Saint John, estimated at just under $100 million.[46]

NB Power is one of the few local natural gas users likely to add to the province's overall natural gas volumes. According to the utility, every $1/MMbtu change in the price of natural gas has an $8.5 million impact on electricity costs. Seasonal variations in market price can range between $5/ and $10/MMbtu. As the utility stated in its submission, "NB Power views natural gas fuelled electrical generation as transitional [because it] strengthens NB Power's fuel diversity and reduces heavy fuel oil consumption, a domestic supply of natural gas provides commodity price stability (low and stable rates) and it provides opportunity for an economic transition to next-generation renewable and/or non-emitting energy."[47] NB Power predicts the money saved using natural gas rather than fuel oil will be passed on to all New Brunswick customers through lower rates.

Currently NB Power accesses natural gas-powered electricity via power purchase agreements with two Saint John-based generation stations: Bayside Power, which is owned by Emera; and Grandview Power, a joint venture between Irving Oil and TransCanada. These agreements commit the utility to purchase natural gas-produced power into the next decade. In addition, NB Power is examining whether to convert Coleson Cove to natural gas. Coleson Cove is the largest thermal generator in eastern Canada and NB Power's largest emitter of greenhouse gases. Converting Coleson Cove to natural gas could reduce NB Power's greenhouse gas emissions intensity by 28 per cent.[48]

As this table illustrates, NB Power has reduced its use of fuel oil and coal by just over 35 per cent over the past 16 years.

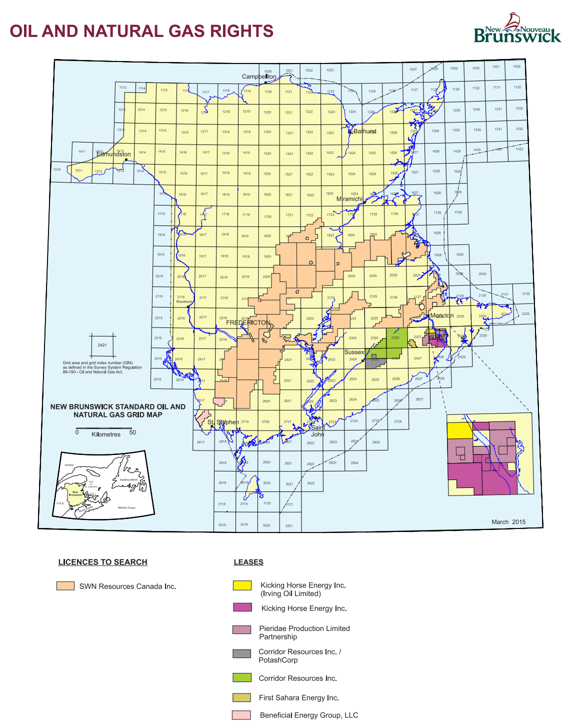
Electricity Generation by Fuel Type

Gigawatt hours	1999[i]	2015[ii]
Fuel oil and coal	55 %	19.3 %
Natural gas	0	11.7 %
Nuclear	22 %	34.4 %
Hydro	18 %	25 %
Biomass	5 %	3.8 %
Wind	0	5.5 %
Reduce and shift demand	0	0.3 %

Sources: i.) Statistics Canada. Report on Energy Supply and Demand in Canada, 2013 Preliminary. Catalogue no. 57-003-X ii.) New Brunswick Power Corporation, presentation to the NB Commission on Hydraulic Fracturing, November 10, 2015

Non-carbon sources now account for about 60 per cent of NB Power's generation capacity, the bulk of which comes from two sources, Point Lepreau nuclear generator and Mactaquac hydroelectric generator. NB Power recently completed a refurbishment of Point Lepreau and is now considering options for Mactaquac. NB Power is also moving forward with small-scale renewable energy projects in partnership with Indigenous-led groups and local cooperatives.

Determining whether New Brunswick industries, small businesses and institutions should be served by locally-produced, hydraulically-fractured natural gas is the choice before the Government of New Brunswick. Natural Resources Canada estimates horizontal drilling and hydraulic fracturing will account for over 90 per cent of Canada's natural gas production by 2035.[49] Here in New Brunswick, 50 oil and gas wells have been hydraulically fractured since 1990. There are currently three natural gas exploration and production companies operating in New Brunswick.



Corridor Resources Inc. arrived in 1999 and today holds three leases with a total area of 87,795 hectares in and around the Sussex area of Kings and Albert Counties. Two distinct natural gas plays occur on these lands: the Frederick Brook shale gas formation and the Hiram Brook sandstone formation. The vast majority of Corridor gas production has occurred in the McCully gas field, located in Penobsquis, Kings County. Since commercial production began in 2003, the field has produced 51 billion cubic feet (BCF) of natural gas. Corridor is partnered with Potash Corporation of Saskatchewan (PCS) in approximately one half of the wells at McCully. Prior to 2007, McCully gas was consumed at the PCS's Penobsquis potash operation, located adjacent to the field. In 2007 Corridor expanded the field and constructed the McCully gas plant. Corridor's plant and gathering system connects to both PCS' Penobsquis mine and the MNP system, enabling Corridor to reach other customers in the region. On January 19, 2016 PCS announced it was permanently shutting down its Penobsquis operations, including its new Picadilly mine. This decision is not likely to have an immediate impact on Corridor's and PCS's gas operations other than more of PCS's gas will be sold via the Maritimes and Northeast Pipeline. In public filings, the company indicates approximately a 12 per cent annual decline in its reserves and it requires more drilling and hydraulic fracturing to maintain its current reserves. This will only happen if the Government decides to proceed with hydraulic fracturing. To date Corridor has hydraulically fractured 39 wells.

The following timeline illustrates the development of New Brunswick's natural gas production industry, post-1999.

- 2003: Natural gas is discovered and begins at McCully. Producing reservoir is Hiram Brook formation sandstone.
- 2007: A 45-kilometre pipeline is constructed to connect the McCully gas field with the Maritimes and Northeast mainline and a gas processing plant is constructed in McCully area.
- 2007: Two natural gas gathering pipelines are constructed (450 metres and 2,000 metres in length) to tie in two existing well pads (F-28 and L-38) to the existing gathering system.
- 2007: Expansion of the McCully natural gas production including the construction of six new well pads and gathering pipelines.
- 2008: Further expansion of the McCully natural gas system including construction of a 3.4 kilometre pipeline to tie in well pad I-39.
- 2009: First hydraulic fracturing of a horizontally drilled well in New Brunswick in the McCully area.
- 2009: Start of exploratory drilling and hydraulic fracturing in the Elgin area, south of Petitcodiac.
- 2009-2010: The first shale-targeted wells are drilled in New Brunswick – four wells in the Elgin area, south of Petitcodiac. None are producing.
- 2014: The last hydraulic fracturing carried out in New Brunswick to date. Corridor Resources conducted hydraulic fracturing using liquid propane at five wells in the McCully and Elgin areas.

The Frederick Brook shale gas formation, which occurs over all three of the leases, requires further exploratory drilling to determine if production is technologically possible and economically feasible. Based on a preliminary study conducted by independent consultants, the Frederick Brook formation may contain approximately 67 trillion cubic feet (TCF) of natural gas in place. If the Government decides to proceed with hydraulic fracturing, Corridor will likely restart its efforts to raise capital investment for its Frederick Brook exploration and evaluation program.[50]

SWN Resources Canada was granted an exploration licence in 2010 for 1.019 million hectares covering much of central New Brunswick including parts of York, Sunbury, Queens, Northumberland and Kent Counties. The company's exploration program will allow it to categorize potential oil and natural gas resources and assess its commercial and technological feasibility. To date SWN has conducted geophysical (seismic gravity and magnetic) surveys, surface geochemical surveys and aerial photography, which enabled the company to identify areas for further exploration. In 2014 the company submitted four phased EIAs to the Government as it proposed to drill up to four exploratory stratigraphic wells. Those potential drill sites are near Lower Saint-Charles and Galloway in Kent County and in Queen's County in the areas of Bronson Settlement Road and Pangburn. If the Government decided to proceed with hydraulic fracturing, SWN would be required to seek further regulatory approval. In July 2015 the Government of New Brunswick extended SWN Resources Canada's exploration licences through 2021.

ORLEN Upstream Canada Ltd. (formerly Kicking Horse Energy Inc.) holds leases totalling 13,300 hectares in the Stoney Creek and Hillsborough areas of Albert County in southeastern New Brunswick. Its lease areas include both proven oil reserves and potential natural gas reserves. In January 2016 ORLEN Upstream Canada Ltd., a wholly owned subsidiary of Polish oil and gas producer PKN ORLEN S.A., acquired Kicking Horse Energy and all its assets, including its leases in New Brunswick. ORLEN is currently reviewing the former Kicking Horse Energy holdings, including its license in New Brunswick.

Right now, neither the Government of New Brunswick nor shale gas producers know definitively if shale gas and/or oil exist within these licenses or if it can be extracted commercially. Therefore neither the Government, producers nor the Commission can accurately predict either production levels or a timeline for shale gas activities in New Brunswick. Because of this lack of information, the Commission understands that any estimates regarding future government royalties and economic impacts are highly speculative. This lack of information regarding the actual size and potential value of natural gas and/or oil reserves makes it difficult to assess the full spectrum of risks and benefits. Recognizing that, the Commission notes that private sector investors may be reticent to participate in an exploration program without guarantees that commercial production will proceed if the viability of the reserve is established. In the event that the Government of New Brunswick wants to determine the extent of New Brunswick's reserves without committing to the possibility of commercial development, it could examine the possibility of a federal/provincial geological survey including exploratory drilling.

Shale Gas: Its Origins and History of Development

Interest in New Brunswick's shale gas resources is part of a worldwide interest to explore and commercially develop unconventional oil and gas located deep underground in shale rock. Geologists and oil and gas producers call shale 'source rock' because it is the original resting place of ancient organic matter. North America's shale formations were formed millions of years ago, when dead plants, algae and other surface organisms sank to the bottom of massive saltwater seas and became trapped in sediments of sand, clay and silt. One of those seas covered most of what is now the Maritime provinces.

Over millions of years, the seas receded and a combination of heat and pressure 'cooked' the organic matter, while at the same time, significant layers of rocks and sediment accumulated over it providing immense pressure. The combination of this heat and pressure resulted in the decomposition of this matter into solid, liquid or gaseous hydrocarbons.

Raw natural gas is composed primarily of methane and may also contain varying amounts of ethane, propane, butane and pentane, commonly known as natural gas liquids (NGLs). Natural gas is contained in the pores and fractures of sedimentary rocks deep beneath the surface of the earth and ocean floors. The portion of this sedimentary rock layer (known as a formation) is often referred to as a reservoir, field or pool. The natural gas can be trapped in different types of sedimentary rock including sandstone, carbonate, coal seams and shale beds. How the pores within these rock types are connected is called permeability and gives rise to conventional and unconventional natural gas. The technology of hydraulic fracturing is generally used for unconventional natural gas where the permeability (pores interconnectivity)

The lifecycle of shale gas development can vary from a few years to decades and occurs in six major stages, as described by Natural Resources Canada, assuming all approvals from the various regulatory authorities have been obtained:

- **Stage One:** Exploration, which involves applying for the appropriate licenses and permits, leasing the mineral rights, Indigenous consultations, community consultations and geophysical study, including geological assessments and seismic surveys;
- **Stage Two:** Site preparation and well construction, which includes exploratory drilling to determine the physical and chemical characteristics of the rock and to assess the quality and quantity of the resource;
- **Stage Three:** Drilling, which includes horizontal drilling;
- **Stage Four:** Stimulation, which is the use of hydraulic fracturing to enable the hydrocarbons to flow to the wellbore;
- **Stage Five:** Well operation and production, which can operate for 10 to 30 years; and,
- **Stage Six:** End of production and reclamation, which requires the company to properly seal the well, clean and inspect the site. Reclamation occurs over several years as the company remediates any contamination, restores soil profiles, replants native vegetation and any other reclamation work required by local regulations.[51]

is low and needs to be enhanced through application of intense hydraulically induced fracturing.

While the oil and gas sector has long known about shale gas, it had no means to access it. That changed in the 1990s following decades of research and development by the U.S. government, university researchers and the oil and gas sector, which led to the commercial application of two technologies:

- Multi-stage hydraulic fracturing, a process where fluids, sand and chemicals are pumped underground to break away rock and release the natural gas locked within; and,
- Horizontal, or directional, drilling, which is a drilling process that turns the well horizontally so it can extend its contact with the shale formation at an extensive length in order to access and extract natural gas from shale rock formation.

The resulting use of both these technologies had a significant impact on world energy markets, disrupting established market patterns by quickly converting the United States from a net importer of natural gas and oil into a potential net exporter. This accelerated growth in the U.S. shale gas and oil industry also had a profound impact on the communities located near these new developments. Between 2002 and 2006 the U.S. experienced a boom in shale gas developments centred around the Barnett formation in Texas and the Marcellus formation in Pennsylvania. By 2009 shale gas had halted the States' long-term decline in energy production and the U.S. had become the world's largest producer of natural gas, eclipsing the previous leader, Russia. It also created great wealth for former small players. For instance, in 2012, Chesapeake Energy eclipsed Exxon Mobil as the largest U.S. natural gas supplier.

The first modern Canadian shale gas production occurred in northeastern British Columbia's Horn River Basin in 2006, while Canada's tight gas production is centred in the Montney Formation, which straddles the B.C.-Alberta border.[52] Canada has the fifth largest estimated recoverable shale gas reserves in the world, according to the United States Energy Information Administration[53] – but the majority of it, including all of New Brunswick, remains unproven.

According to National Energy Board 2014 estimates, shale gas accounted for about 4 per cent of total Canadian natural gas production. An additional 47 per cent comes from tight gas production. Tight gas refers to natural gas reservoirs trapped in impermeable, compacted sandstone or limestone. While both shale gas and tight gas require hydraulic fracturing, tight gas formations require less fracturing, and therefore less fluids, to enable the gas to flow. By 2035, these two processes are expected to account for over 90 per cent of Canada's natural gas production. [54]

However, the intense growth in the U.S. and western Canada came to a halt in 2015. The glut of natural gas supply, caused by the U.S. shale gas boom, has caused commodity prices to plummet, taking oil and gas producers' share prices with it. In January 2016, Pennsylvania, the heart of the Marcellus shale region, had 25 drilling rigs operating, down from 115 rigs in January 2012.[55] As of February 2016, oil and gas analysts were predicting further price volatility, which could lead to mergers and bankruptcies among both small and large oil and gas players. For example, Barclays Plc expects U.S. and Canadian oil and natural gas drillers to cut more than $35 billion US from exploration and production budgets in 2016, the deepest reduction of any region for the second consecutive year.[56]

New Brunswick's Future Energy Mix

In contrast to the oil and gas sector's market challenges, global clean energy investments in 2015 were up 4 per cent from 2014, to $328.9 billion US, a new record. Close to half were investments in utility-scale projects such as wind farms, solar parks, biomass and waste-to-energy plans and small hydroelectric projects.[57]

As New Brunswickers consider the role of natural gas in the province's energy mix, we should also examine the province's efforts to transition to clean energy, which is about a decade old. While the slowdown in the provincial economy did contribute to about a quarter of our carbon emissions reductions, the bulk of reductions were achieved through the following energy-related measures:

- high oil prices substantially reduced the run time of Coleson Cove Generating Station, which uses petroleum coke as its fuel source;
- the addition of 300 MW of wind power in New Brunswick, plus NB Power purchases of wind-generated electricity from PEI and northern Maine, which are both connected to the NB Power system;
- increased use of biomass by industry, particularly by the province's forestry mills which burn wood waste;
- energy efficiency measures undertaken by Energy Efficiency New Brunswick in all sectors of the provincial economy;
- the closing of the Grand Lake coal-fired power plant, which used NB-produced coal;
- the closing of the Dalhousie oil-burning power plant; and,
- the use of natural gas to displace heavy and light fuel oil, particularly in the industrial and commercial sectors.

In addition to these measures, the capping of municipal landfills to limit the migration of contaminants into the air and groundwater also contributed to reduced emissions.

Cumulatively these actions have done more to reduce New Brunswick's carbon footprint than any single action on its own. Moving forward, it is imperative that the province continues to accelerate projects and policies on multiple fronts. This is how systems change occurs: not with a single large action, but through the actions of many working towards a single goal.

There is also another important message from the above list. We did this. We – New Brunswick residents, businesses and public institutions – reduced our carbon footprint through our actions. This was not done to us by larger, outside forces beyond our control. We adopted new technologies and new behaviours while walking away from older, less advantageous processes. We believe this is an important story and one that often gets lost in our public angst and anger regarding our province's weak economy and chronic out-migration. All that negativity can drown out the smaller notes of optimism that, in all likelihood, can help guide us forward if we are willing to listen.

Despite the successes and major inroads to reduce the provincial hydrocarbon footprint from 1999 to 2013, we have more to do if New Brunswick is to meet the target of a 10 per cent reduction from 1990 levels by 2020, defined in the Climate Change Action Plan for 2014-2020.

Potential Economic Impact of Shale Gas on the New Brunswick Economy

New Brunswick's natural gas resource potential is projected to be in excess of 70 trillion cubic feet (TCF) and is expected to have a positive impact on the New Brunswick economy. This section reviews existing projections, with three caveats.

- First, the true size and commercial viability of New Brunswick's natural gas resource is currently unknown and will remain so until further exploration is completed;
- Second, because of that, existing studies on potential impacts are based on general assumptions about development costs, informed by experiences in other jurisdictions; and,
- Third, the natural gas market has changed considerably, which may affect the speed of shale gas development, if hydraulic fracturing proceeds in New Brunswick.

Based on these caveats, the Commission sees great value in including economic analyses in any future research program.

To date, two studies have analyzed the potential economic impact shale gas development could have in New Brunswick: a 2013 Deloitte LLC report, commissioned by the New Brunswick Business Council; and a 2014 report by Jupia Consultants Inc., commissioned by the Government of New Brunswick, entitled *Potential New Brunswick Infrastructure and Natural Resource Investment Review*.

The Deloitte study[58] estimated economic benefits over the lifecycle of the industry, which could be up to 45 years, as follows (all funds in Canadian dollars):

- $13 million in overall development cost per well;
- $4.5 million increase in gross domestic product (GDP) using the Statistics Canada input/output model;
- 21.2 full-time equivalent (FTE) jobs per well; and,
- $21 million in direct, indirect and induced investment.

It considered three development scenarios, allowing for some cost reductions for drilling and completions as the number of wells increased, with the projections listed in the chart below.

The report concluded, "The development of shale gas in New Brunswick presents strong economic benefits in a variety of services, many of which complement activities the province is already engaged in today."

The Jupia report[59] examined potential economic benefits of five potential large-scale resource developments: the Energy East Pipeline, the

Deloitte study projections

	Low 8 wells/year	Medium 25 wells/year	High 55 wells/year
Direct output impact	$105 million	$310 million	$650 million
GDP impact	$35 million	$110 million	$225 million
Employment impact	170 FTEs	500 FTEs	1,044 FTEs

Canaport Energy East Marine Terminal, the conversion of Canaport LNG to an export terminal, the Sisson Brook mine and shale gas development.

The report estimated potential impacts over a five-year period (2015-2020), assuming a gradual increase of wells from 15 in the first year to 75 wells in the fifth year. It included a $300 million natural gas processing facility in year one which could generate an estimated $122 million worth of direct and indirect GDP in the province rising to $141.8 million when induced effects are included. Jupia estimated the five-year cumulative economic impact from the growth of the shale gas industry in New Brunswick to be:

- $2.2 billion worth of new industry output;
- $1.6 billion worth of GDP;
- $427 million in new labour income; and,
- 720 FTE jobs per year over five years rising to 846 FTE jobs per year with induced effects.

As a point of comparison, the Commission also reviewed a 2013 Canadian Energy Research Institute (CERI)[60] report that studied potential economic impacts for the Province of Quebec. This study looked at two scenarios of drilling activity based on consumption, rather than production:

- a production level of 500 million cubic feet/ day (MMcfd), which would meet Quebec's current consumption; and,
- a production level of 1,500 MMcfd, which would include domestic and export markets.

Using a base case of 6 MMcfd, CERI calculated potential economic impacts over a 25-year period.

CERI projections

	Domestic market	Domestic and export markets
Capital investment	$7.9 billion	$23.8 billion
GDP	$37.3 billion	$112 billion
Direct, indirect and induced employment	293,000 FTEs	880,000 FTEs

The potential economic impact on Canada's GDP could be $37.3 billion (domestic market) and $112 billion (domestic and export market). This impact would be roughly divided between Quebec at 54 per cent, Alberta at 40 per cent and the rest of Canada at 6 per cent. Roughly 69 per cent of jobs would be created in Quebec.[61]

Assessing the financial impact Corridor Resources has had on New Brunswick in just over a decade provides actual numbers to compare against projections. Since Corridor began production in 2003 it has spent:

- $510 million in capital;
- $20.6 million in royalty payments;
- $6.5 million in lease rentals and property taxes;
- $8 million in direct salaries; and,
- $500,000 in community sponsorships.[62]

While economic impact projections for New Brunswick are highly subjective, it is apparent from the Commission's review that shale gas development would have a notable impact on the provincial economy if the Government decides to proceed.

Review of Royalties

New Brunswick's current royalty system was developed following public consultations, conducted in 2012 by the New Brunswick Natural Gas Group. Its discussion paper outlined a basic royalty of 10 per cent and an economic profit royalty component of 40 per cent after recovery of all costs including a return to the investor. Following public consultations, the Government introduced *Regulation 2001-6 under the Oil and Natural Gas Act, RSNB O-2.1* in 2014. It calls for a basic royalty component and an economic rent component. Economic rent is the price the Government of New Brunswick charges companies for the right to produce an undeveloped resource. It reflects the cost of exploration and extraction, plus the price of the extracted resource when sold. The basic royalty consists of the greater of the following two options: 4 per cent of the wellhead price of natural gas or, 2 per cent of the gross revenue from all its wells. In addition, there is an economic rent of 25 per cent to be applied once the company has recovered all of its capital and operating costs. This new royalty regime replaced the former basic royalty of 10 per cent on natural gas sales based upon the selling price at the wellhead.

There are differing views on the effectiveness of the present royalty regime. Industry representatives consider it a deterrent to development because of the percentage required in the earlier stages of development, suggesting it could be lower because royalties are only one component of total Government revenues. In its submission to the Commission, Corridor Resources requested the 25 per cent economic rent royalty component be implemented on a step-by-step basis to enable companies to recover initial investments and operating costs. On royalties, Corridor wrote, "The Government must encourage investment in the oil and gas industry in order for there to be any investment. Investors require a reasonable expectation of a competitive return. For marginal projects, the Crown maximizes its overall value by keeping investment ongoing, which requires lower royalty rates."[63]

Opponents of the present system argue it does not improve on the previous 10 per cent regime and will result in lower royalties. They recommend against applying royalties on all wells, which they argue benefits the companies at the expense of government revenues. Rather, they recommend applying royalties on a well-by-well basis. Another option is to apply royalties to individual well fields.

Royalties should achieve the following outcomes:

- attract investment by lowering risk to developers in the early years;
- ensure that some form of royalty is always collected when natural gas is extracted, as it is a non-renewable resource;
- develop a structure that is competitive with other jurisdictions thereby ensuring access to development capital; and,
- maximize the potential return to New Brunswickers, the resource owners.

Striking a balance with these principles is the challenge that any policymaker faces. To date New Brunswick has only one natural gas producer, Corridor Resources, which has paid \$20.6 million in royalties over the past 12 years.[64] Most of these royalties were paid using the old system as the new system has only been in existence since April 2014.

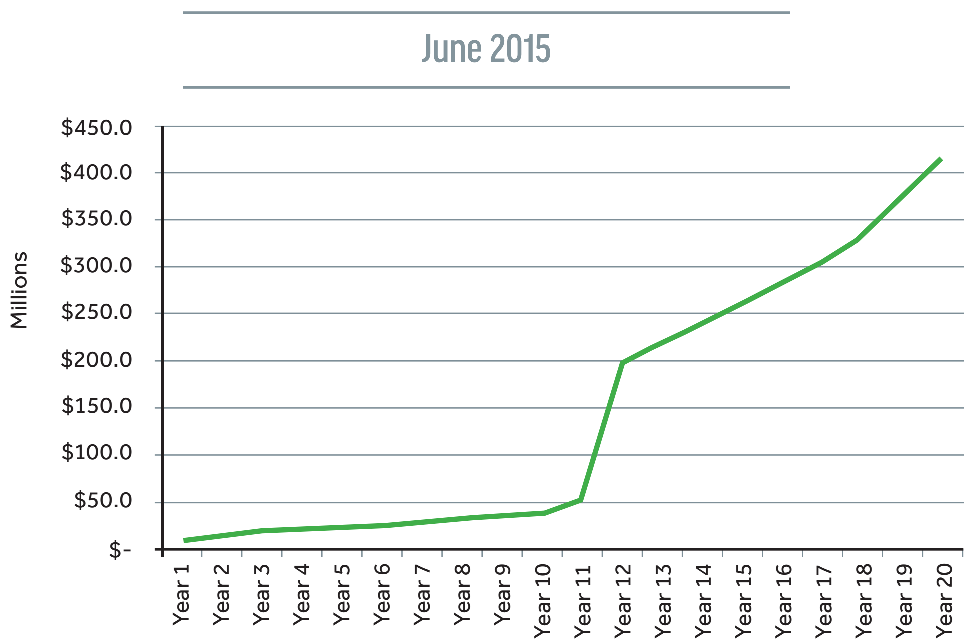
Royalty Projections

The Commission asked the Department of Finance to calculate the royalty potential assuming the following:

- a 20-year project life;
- 50 wells developed per year;
- initial production of 3 MMcf/day declining;
- Henry Hub price forecast by U.S. Energy Administration-adjusted for the Boston Market. Henry Hub is a distribution hub in Louisiana that is generally accepted as the place where the primary natural gas price is set for North American markets;
- MNP published tolls converted to Canadian dollars;
- Conference Board of Canada forecast of long term bond rate; and,
- the present royalty structure in New Brunswick.

The two graphs on page 28 illustrate the highly subjective nature of royalty projections. The first is based upon analysis dated June 2015 and the second is based upon analysis done in September 2015. These projections are highly sensitive to price changes and can vary by plus or minus 50 per cent with a 20 per cent price change. The importance of these two very different projections is not in the actual numbers, which will fluctuate due to a number of factors including currency exchange rates, but in understanding the overall trend line. In both scenarios New Brunswick is projected to experience a steady increase in royalty revenues from shale gas development.

The bottom line is this: while these findings are highly speculative, the long-term potential return to New Brunswick is significant and warrants attention.


June 2015
Millions
$450.0
$400.0
$350.0
$300.0
$250.0
$200.0
$150.0
$100.0
$50.0
$-
Year 1
Year 2
Year 3
Year 4
Year 5
Year 6
Year 7
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Year 9
Year 10
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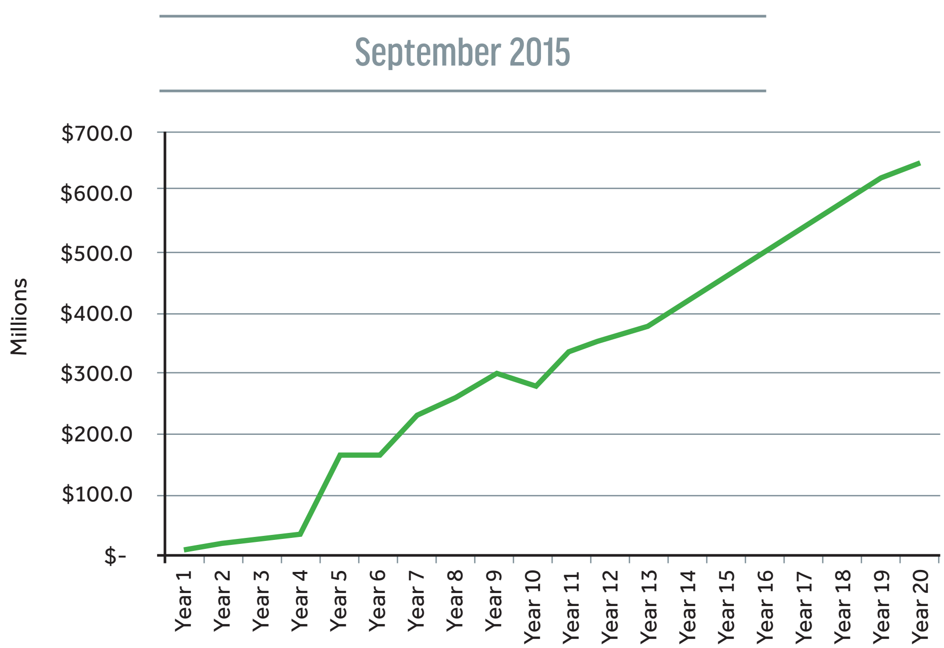
Year 12
Year 13
Year 14
Year 15
Year 16
Year 17
Year 18
Year 19
Year 20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Potential, Human Health and Environmental Impacts

Hydraulic fracturing, like all industrial developments, will have an impact on New Brunswick's economy, natural environment and the people who live here. What we don't know is the extent of those impacts. That will depend on a number of factors, most notably:

- the number of wells, well pads and related facilities, such as gas processing plants;
- the density of developments, which could be clustered in specific areas or spread out;
- the pace of development, which we noted in the previous section is expected to be slow over the next decade;
- the location of well pads in relation to water supplies and waste treatment facilities, and the extent to which water pipelines, waterless hydraulic fracturing technologies and onsite recycling systems are employed, all of which will impact the risk level to water resources as well as traffic patterns; and,
- the impacts of potential increases to individual communities' populations and the resultant economic spinoffs that could bring.

In order to effectively plan for potential shale gas development, the Government must articulate its goals for New Brunswick's overall quality of health, environmental protection, regional development and the province's role in a still-undefined national strategy to address climate change.

This section analyses major human and environmental health risks associated with shale gas and frames each in relation to the Government's capacity to address these risks, if it decides to allow hydraulic fracturing in New Brunswick. It is organized into the following four categories:

- risks in which Government practices need to be strengthened or updated to reflect the latest developments and/or new research that has emerged since the Government's current *Rules for Industry* was released;
- risks that will vary based on technology choices and the introduction of proactive Government practices to influence those choices;
- risks that can be mitigated using existing technologies but which are currently unavailable in New Brunswick; and,
- risks that can be mitigated with existing practices and/or small changes to reflect latest developments in the sector.

Risks in which Government practices need to be strengthened or updated to reflect the latest developments and/or new research that has emerged since the Government's current Rules for Industry was released

Methane Emissions

Natural gas emits about 50 per cent less greenhouse gases per BTU than coal, however fugitive methane emissions erodes this greenhouse gas emissions advantage. Methane, the major element in natural gas, is a more potent greenhouse gas than CO² and fugitive emissions can reach the atmosphere by a number of pathways including seepage from abandoned wells, defects in well casing and cementing, and escape from production equipment such as compressors, pneumatic devices, valves and storage tank vents.[65]

Natural gas leaks are the largest anthropogenic (human-induced) source of methane (CH^4) in the United States.[66] In the U.S., oil and gas companies operating on federal and tribal lands lose enough natural gas each year through leaks and intentional venting and flaring to meet the heating and cooking needs of 1.6 million homes.[67] Globally, it is estimated that the oil and gas industry allows as much as 3.6 trillion cubic feet of natural gas to escape into the atmosphere each year. The leakage rate represents at least $30 billion in lost revenues.[68]

It is important to note that methane's lifetime in the atmosphere is much shorter than carbon dioxide (CO^2), but methane is more efficient at trapping heat than CO^2. The comparative impact of CH^4 on climate change is about 34 times greater than CO^2 over a 100-year period.[69] Numerous studies have been conducted on the potential impact of shale gas development on total greenhouse gas emissions, and the results have stimulated much debate but have yet to provide a generally accepted answer.

On the other hand, estimates of the total amount of fugitive methane expressed as a percentage of production are as high as 12 per cent within the full production cycle of natural gas, which is defined as the journey from well to consumers.[70] On the other hand, recent figures from the U.S. Environmental Protection Agency (EPA) indicate that fugitive methane emissions from hydraulically fractured natural gas wells in the U.S. have decreased by 73 per cent since 2011, which may be evidence that broadly targeted emission control requirements are starting to have an effect.[71]

Fugitive losses from natural gas distribution systems in the U.S. also appear to be declining due to upgrades at metering and regulating stations, the replacement of antiquated distribution lines with newer technology, stronger emissions control regulations and improvements in leak detection.[72] A recent field investigation using an airborne platform covering Texas, northwestern Louisiana, the Fayetteville shale region in Arkansas, and northeastern Pennsylvania identified methane loss rates of 0.18 to 2.8 per cent, which generally agree with the U.S. EPA estimates and are lower than those from previous studies.[73]

In Canada, it is estimated that methane emissions can be reduced by close to half with existing technologies.[74] Measures targeted at reducing methane emissions will also reduce emissions of other pollutants that can harm public health and the environment such as volatile organic compounds (VOCs) and hazardous air pollutants (HAPs).[75] Canadian federal greenhouse gas emission regulations for the oil and gas sector are forthcoming, but the release date is unknown. Once established, these will be applied to all oil and gas activities in Canada, including New Brunswick. Environment Canada is reportedly planning to match proposed U.S. regulations to target methane releases from drilling and hydraulic fracturing.[76] *The New Brunswick Oil and Natural Gas Blueprint* notes that the province may enhance its air quality monitoring network in the future, including new monitoring stations, new equipment to capture additional types of emissions, and upgrading of the existing air quality monitoring lab. The Blueprint notes that as of 2013, the Province had already begun to enhance its air quality monitoring capabilities to allow continuous monitoring of ambient methane levels.

New Brunswick does not currently have emission targets or emission restrictions specifically for greenhouse gas emissions, nor is there a specific requirement for periodic, comprehensive inspection of oil and gas production facilities to detect and repair leaks. In addition, capturing gas that would otherwise be vented or flared presents an opportunity for well operators to reduce the environmental impact as well as providing a possible economic opportunity to generate an additional revenue stream using technologies such as micro liquefied natural gas (LNG), and compressed natural gas (CNG).[77]

New Brunswick's *Rules for Industry* currently requires companies to submit a greenhouse gas reduction plan and report annually on greenhouse gas emissions. If the Government chooses to proceed with hydraulic fracturing, it could enhance its current policies and regulations to require companies to use:

- green completions to ensure methane associated with flowback water is not vented to the environment;
- equipment, such as non-pneumatic pumps, actuators, no-bleed pneumatic controllers, and dry seal systems that do not leak methane; and,
- develop an emissions monitoring program that includes periodic, comprehensive inspections of equipment and pipelines to prompt repair of any leaks.

Non-Greenhouse Gas Air Emissions

There is sufficient information available to conclude that with current practices and technologies the natural gas industry emits a variety of air pollutants. Substances emitted to the air during shale gas extraction may include: nitrogen oxides (NOx), volatile organic compounds (VOCs), such as alkanes, benzene, formaldehyde, xylene, ethane, toluene, propane, butane, pentane, and methylene chloride, polycyclic aromatic hydrocarbons (PAHs), ozone, hydrogen sulfide, and particulates including silica dust. There are both transitory and longer term sources such as drill rigs, hydraulic pump engines, vehicles, compressors, dust from sand used as a proppant, venting during flowback, flaring, fumes and flashing emissions tanks from condensate storage tanks.[78]

Some of the above substances have the potential to impact human health, for example as irritants, toxins, carcinogens and/or endocrine disruptors, the latter of which can, at certain doses, interfere with the human endocrine, or hormone, system. The actual degree of health impacts will depend on a variety of site-specific factors such as population vulnerability, proximity of people to emission sites, duration and intensity of exposure, and the potential synergistic effects of two of more substances.

Determining a cause-effect relationship between air emissions and health outcomes is complicated because a number of other factors besides air quality affect health, and some health effects are long term and may not be immediately apparent.[79] Air emissions are not unique to shale gas, however unconventional natural gas and oil extraction typically require a higher well density and more sustained drilling to maintain production levels as compared to conventional extraction, which means air emissions may have a greater intensity and duration.[80]

Monitoring has also highlighted the variability of air emissions from oil and gas facilities. Emissions of some substances, such as VOCs and fine particulates, are not encountered at all shale gas facilities,[81] and there is considerable hourly and daily variability in compressor station emission rates.[82]

New Brunswick's *Rules for Industry* contains the following provisions for addressing air quality impacts:

- emission limits under the *Clean Air Act;*
- required submissions of an air emissions inventory including predicted emission rates;
- requirements to monitor emissions at their source and at other locations; and,
- mandatory emissions management and reduction plans.

While the regulatory authority is in place, there is currently no explicit requirement for the design and implementation of enhanced monitoring protocols to assess impacts of air emissions on public health, because the current level of shale development hasn't warranted it. If the Government decides to proceed with shale gas development, it could enhance practices to require:

- companies to employ equipment powered by natural gas or electricity rather than diesel fuel;
- the application of state-of-the-art emission control technologies;
- continuous air quality monitoring that measures a variety of pollutants at various locations where people live and work; and,
- anything else that is appropriate given the size and speed of development.

Animals, Habitats and Farms

Species and habitats that are already sensitive to disturbances because of factors such as limited ranges, population size and specialized habitat requirements are most sensitive to impacts from all human activities, including shale gas.

Effective cumulative impacts monitoring would be of assistance in assessing the impact of development. In addition, proponents should gather the appropriate information regarding the impact of shale gas activities on local species and habitats.

For example, even seemingly minor changes in forest cover and forest edge density have been found to have significant effects on songbird abundance.[83] Research in Wyoming and Pennsylvania found that with intensification of natural gas development, the local activity of important nest predator species increased, thereby elevating songbird nest predation rates.[84]

There is evidence of impact of shale gas and related activities on large terrestrial mammals. Mule deer in Colorado were found to avoid well pads hosting active drilling to a distance of at least 800 metres. The deer avoided pads with active production and roads to a greater degree during the day than night. Taken together this behaviour alteration affected over 50 per cent of the animal's critical winter range in the study area during the day and over 25 per cent at night.[85]

Fish and aquatic organisms can be affected by shale gas development via three pathways:

- Hydrological, such as water withdrawals;
- Chemical, such as contamination by fracture fluid and wastewater; and,
- Physical, such as sedimentation and suspended solids.[86]

Increased stream water acidity and land disturbance near well pads where shale gas took place were observed to decrease biodiversity among fish and macroinvertebrates while increasing mercury concentrations across several trophic levels such as crayfish, and predatory macroinvertebrates.[87]

Invasive species are another potential threat. They can arrive in a number of ways, most notably via forest access roads that can act as corridors for invasive plants[88] and they can also hitchhike to a well site via equipment and/or water that is transported to the site.

As for farmland, shale gas development impacts can be measured by examining the cumulative loss of the local land base, due to activities such as the construction of well pads, roads and other facilities. Other potential threats to agriculture as a result of shale gas development include:

- surface water and groundwater contamination;
- soil contamination due to leaks and spills;
- fragmentation of farmland;
- loss of agricultural land;
- impacts on livestock health;
- impacts on soil fertility and soil structure, due to compaction of topsoil, alteration of drainage and mixing of soils;
- contamination of soil due to onsite waste disposal such as land spreading of contaminated drill cuttings; and,
- potential impacts on the marketability of organic or other speciality agricultural food products due to proximity of oil and gas activities.[89]

At present New Brunswick's *Rules for Industry* indirectly addresses potential impacts on vegetation, wildlife and/or agricultural lands/ operations in the following ways:

- an exclusion of national parks and protected natural areas (both existing and proposed) from lands that will be included in licences to search for oil and natural gas;
- opportunities for applicable Government departments to participate in the EIA process;
- a general provision that oil and gas facilities must, to the extent practicable, be located to avoid fragmentation or bisection of forested land;
- required setbacks between oil and gas facilities and watercourse and wetlands;
- a requirement to describe potentially affected components of the natural environment and proposed mitigative measures as part of the required environmental impact assessment;
- a requirement that proponents prepare a pre-construction assessment of soil, vegetation, drainage and topography;
- an ability for the regulator to impose site-specific setbacks from natural features via the required environmental impact assessment;
- use of tanks for flowback water instead of open pits; and,
- noise level limits.

To protect wildlife, habitat, agricultural lands, livestock and agricultural operations the Government and proponents should proactively emphasize these as priorities in future developments, and make appropriate changes based on industry's scale and speed.

Risks that will vary based on technology choices and the introduction of proactive Government practices to influence those choices

Each of the five risks described below will require the Government to:

- continue to incorporate requirements such as standards, construction and operational practices into the regulatory process;

- provide independent enforcement of these requirements;
- cooperate with contractors and operators to mitigate these risks;
- learn from incidents and accidents in New Brunswick and elsewhere, leading to the progressive adoption of the most effective equipment, well construction standards and operating procedures; and,
- continue to require proponents to establish active community environment liaison committees.

If the scale and pace of oil and gas development rapidly accelerates, the challenge for operators and contractors will be to maintain quality, and the challenge for the regulator will be to keep pace with appropriate levels of permitting, inspection, training and enforcement, and ensure that operators and contractors have appropriate training, expertise and equipment to respond appropriately to leaks, accidents, procedures and other non-routine events. To address this challenge, Penn State, the Colorado School of Mines and The University of Texas at Austin co-operate TOPCORP (Top Courses for Regulators and Policymakers), an international technical training initiative for oil and gas regulators with less than three years experience. To date, 21 states and the province of Alberta have participated in the training.

Truck Traffic

Shale gas development generates a considerable amount of heavy truck traffic, especially during the hydraulic fracturing phase when water and wastewater is trucked to and from well sites. This is a problem because if shale gas development occurs, it will likely be in rural New Brunswick, where most roads are not built to handle the oversized and/or overweight vehicles used during the drilling and hydraulic fracturing phases. This increase in truck traffic can lead to increased road maintenance costs and increased rates of traffic accidents. A particular challenge for New Brunswick is the need to also identify and consider projected heavy truck traffic generated by other road users such as logging trucks and trucks associated with mining activities. The Government may want to consider regulations that distribute the costs of road maintenance and repair amongst all industries that employ large trucks on rural roads.

In the case of shale gas, elevated truck traffic tends to occur over a relatively short period of time because it is concentrated around well pads, the water source for hydraulic fracturing and the waste disposal site. Drilling typically takes place over several weeks, while hydraulic fracturing typically takes place over several days. Outside of that concentrated period of time there is minimal traffic caused by oversized and/or overweight vehicles.

Currently New Brunswick's *Rules for Industry* envisions a user pay model for road damage related to shale gas traffic. It requires proponents to:

- submit information on the volume, duration and proposed travel routes of heavy trucks;
- submit haul route (road use) plans for approval;
- provide financial securities to pay for future road damage; and,
- adhere to road use agreements that are based on road system integrity studies that inspect road condition prior to the start of shale gas.

If the Government decides to proceed with hydraulic fracturing, it should incorporate regulatory practices that identify roads or portions of roads that are off limits to oversize/overweight vehicles. This could be accomplished as part of the review of the proponent's haul route plan.

Wellbore Integrity

Over time a percentage of oil and gas wells will develop leaks and even the best practices applied to date cannot guarantee that there will be no casing or cement leakage in oil and gas wells.[90] Well barrier failure and loss of wellbore integrity are risk factors common to all oil and gas wells,[91] but the repeated, cyclical vibration, pressure changes, temperature fluctuations (e.g. between injected fluids and flowback water), and the use of non-vertical well bores typical of hydraulic fracturing add to the risk.[92] Research into wellbore integrity reveals that barrier leakage rates show considerable variability depending on factors such as geographical area, well operator, construction method, well type, well bore angle (deviation), regulatory regime, and abandonment method.[93]

For example, as of 2014 in New Brunswick's McCully gas field, 5 of 29 gas wells had trace amounts of methane flow from casing vents to the atmosphere – just less than 0.01 m3/day. One well had casing vent flow of 1.77 m3/day, which amounts to the equivalent of just over one-tenth of the gas in a BBQ propane tank. According to New Brunswick's *Rules for Industry*, immediate mitigation and/or intervention is not required unless the flow is greater than 300 m3/day – the equivalent of 30 BBQ propane tanks.

Reported rates of well integrity failure, resulting in escape (migration) of contaminants from the wellbore, are generally lower than the rate of well barrier leaks. This is because:

- wells typically have a series of overlapping barriers (casing and cement); and,
- there must be a pressure or buoyancy gradient in order for a contaminant to migrate from the well.[94]

The most common well integrity issue is slow leakage of methane around the external casing. The consequences of such leaks, although negative from a climate change perspective, are not a great threat to health because natural gas is not a toxic substance. Nonetheless, loss of well bore integrity represents potential risks to public safety and the environment. Specifically, wellbore leakage can:

- cause groundwater contamination such as brine and/or fracture fluid;
- cause a risk of explosion if leaking methane collects in a confined space;
- contribute to greenhouse gas emissions; and,
- represent an economic loss to government and industry due to loss of marketable gas and associated royalties.[95]

New Brunswick's *Rules for Industry* contains the following provisions for addressing wellbore integrity:

- monitoring of oil and gas wells for corrosion, leaks, and loss of pressure;
- standards for designing and installing well casing and cementing (minimum barrier protection concept);
- surface casing cannot be used as the production casing string and cannot be exposed to any hydraulic fracture stimulation pressures;

- prior notification and inspection of cementing operations;
- prescribed spacing of centralizers;
- cement testing and evaluation requirements;
- pressure testing of equipment and the well bore before hydraulic fracturing;
- pressure monitoring during hydraulic fracturing;
- operator must stop drilling and plug well if pressure is lost and deficiencies cannot be repaired; and,
- specified well plugging and abandonment requirements.

The *Rules for Industry* acknowledges the importance of continuous improvement based on environmental monitoring and experience with oil and gas development in New Brunswick and elsewhere. If the Government proceeds with shale gas development, well bore integrity monitoring requirements should be updated so that any applicable new monitoring technologies can be incorporated to detect and locate leaks.

Human-induced Earthquakes and Other Seismic Events

Earthquakes large enough to be felt by humans as a result of shale gas development are an area of increasing concern. Oklahoma had more than 5,700 earthquakes in 2015, a state record,[96] and there is a growing body of evidence that connects these events to hydraulic fracturing.[97] For example in Canada, the Alberta Energy Regulator concluded that a January 2016 magnitude 4.8 earthquake that month may have been related to a well completion operation.

In response, the Regulator shut down the Repsol Oil and Gas site indefinitely to conduct a full assessment and approve new mitigation plans from the company.[98] In December 2015 the B.C Oil and Gas Commission determined a 4.6 magnitude earthquake in northeast B.C. in August 2015 was caused by fluid injection during hydraulic fracturing.[99] A second B.C. Oil and Gas Commission report that examined seismic events in the Montney Region found that between August 2013 and October 2014 11 seismic events were felt at surface over the course of 7,500 hydraulic fracture stages. It was also noted that there was a higher occurrence of induced seismicity in certain areas due to the presence of pre-existing, stressed faults that are susceptible to reactivation.[100]

Subsurface disposal (injection) of wastewater is a proven source of induced seismicity and has been documented for nearly half a century.[101] An overall increase in seismic activity in the U.S. in recent years appears to be correlated to the increased use of injection for disposal of hydraulically fractured wastewater,[102] a process currently not permitted in New Brunswick.

New Brunswick is subject to occasional earthquakes from natural causes but they have been rare in southeastern New Brunswick where natural gas has been produced.[103] There is potential for hydraulic fracturing in New Brunswick to cause unintended earthquakes and/or tremors depends on a number of factors including:

- the geology of the parts of the province that have the potential to host unconventional oil and natural gas, including the location of hydraulic fracturing in relation to existing faults; and,
- operating practices including the volume and pressure of injected hydraulic fracturing fluid.

A baseline record of seismic activity developed in advance of the introduction of hydraulic fracturing to a new jurisdiction can be used to help identify changes in the seismic regime as a result of unconventional oil and gas development. Such a baseline was recently prepared in the U.K.[104] and similar work is underway in other locations such as the Northwest Territories[105] and Kentucky.[106] In addition the U.K. has adopted a 'traffic light' system that controls whether injection can proceed, based on local seismic activity. Operations stop is a tremor of magnitude 0.5 or greater is detected.[107]

New Brunswick's *Rules for Industry* contains a requirement for an assessment of the potential for hydraulic fracturing to induce seismic activity required before hydraulic fracturing takes place. The assessment must include a consideration of the location of existing faults. When potential for induced seismicity is found to exist, the operator of a high volume hydraulic fracturing program must:

- evaluate wellbore placement;
- prepare on-site personnel to recognize and respond to the induced seismicity;
- conduct qualitative or quantitative site-specific monitoring of seismic activity during hydraulic fracturing, and,
- take appropriate action if the magnitude of induced seismic activity exceeds pre-determined limits.

If the Government decides to proceed with hydraulic fracturing, it should implement practices that incorporate the latest science and regulatory development, including but not limited to B.C.'s and Alberta's independent regulators and the Geological Survey of Canada.

Groundwater Quality

As we have already stated, groundwater quality is of greatest concern to New Brunswick residents. Contamination of groundwater as a result of natural gas drilling and hydraulic fracturing is possible but not inevitable. Existing published data reveals mixed results. While some studies of specific incidents have revealed localized impacts, the results of other studies have shown no impacts or have been inconclusive. For instance, it is now well-established that the presence of methane in shallow groundwater, including water wells, is a widespread, natural phenomenon in both Canada and the U.S., and is not necessarily a result of oil and gas extraction.[108] This highlights the importance of collecting baseline water samples, the accuracy of which is strengthened when results from multiple water wells are combined to establish a regional baseline.[109]

There is also a need for a greater understanding of how methane migrates through underground formations. Understanding the transport of fugitive gas is critical because this transport ultimately dictates the subsurface impacts on water quality. This includes knowledge of site-specific hydrogeology, because the conditions that could lead to gas migration will vary with every site. A related challenge is a need to improve modeling tools, which predict the impact of shale gas activities on the underground migration of gas and fluids.[110]

Risks to water resources as a result of shale gas activities continue to evolve over time as practitioners and regulators adapt and respond to changing economic, technological, social, and political pressures. It is therefore difficult to say to what extent risks and impacts experienced in the past will continue in the future.[111]

The literature suggests that the impacts of shale gas production on groundwater quality can be reduced using measures such as:

- ensuring wellbore integrity including the use of "multi-barrier" well casing and cementing to minimize leaks that can affect groundwater;
- using air or a water-based drill fluid when drilling though potable groundwater;
- pre- and post-fracturing testing of groundwater quality to ensure early identification of any contamination;
- using surface casing vents so leaks will be directed to the surface where they can be detected and pressure does not force escaping gas into groundwater;
- using enclosed systems to collect flowback water, rather than pits;
- using impervious well pad liners to allow spills to be cleaned up before spills reach groundwater;
- leak detection and secondary containment for storage tanks;
- spill prevention and response plans to address surface spills;
- using non-toxic or less toxic additives for hydraulic fracturing and drill fluids; and,
- proper characterization and management of wastewater.

Aquifer vulnerability mapping can supplement the Government's current understanding of New Brunswick's groundwater regime. Known shale gas deposits in New Brunswick are at a depth of approximately two kilometres below ground surface. The maximum depth of freshwater aquifers in New Brunswick is approximately 200 metres. The intervening rock contains multiple layers of tight rock formations, which would help prevent the upward migration of fracturing fluid and methane to drinking water aquifers. In addition in the relatively soft clay-rich rocks of the Maritimes Basin, fractures are generally 'self-sealing' under the high loading pressure of the overlying rocks, so the upward migration of these fluids is considered unlikely.[112]

New Brunswick's *Rules for Industry* contains the following provisions for protecting groundwater:

- minimum setbacks from water wells for well pads and seismic testing;
- assessment of geological containment prior to hydraulic fracturing;
- ban on shallow hydraulic fracturing;
- use of "closed loop" drill fluid systems and tanks for flowback water (no pits);
- spill prevention reporting and response plans;
- water well monitoring, before and after seismic testing and drilling;
- monitoring of oil and gas wells for corrosion, leaks, and loss of pressure;
- provisions for emergency containment of hydraulic fracturing fluid;
- incorporation of surface casing vents to keep methane leaks out of groundwater;
- impervious well pad liners;
- leak detection and secondary containment for storage tanks;
- risk assessments and public disclosure for hydraulic fracture fluid additives; and,
- use of air or a water-based drill fluid when drilling though potable groundwater.

While the regulatory authority is in place, there is currently no explicit requirement for enhanced groundwater mapping and monitoring due to the low level of hydraulic fracturing activity. If the Government decides to proceed with hydraulic fracturing it should enhance its program because it can help identify areas where enhanced spill and leak prevention should be required.

Surface Water Quality

The greatest risk to surface water in the past has been the release of inadequately treated shale gas wastewater,[113] Other potential pathways include:

- leaks and spills from well pads, storage tanks and wastewater holding ponds;
- erosion, sedimentation and increased run-off due to land clearing; and,
- creation of impervious surfaces for well pads and related infrastructure such as access roads.[114]

For instance, studies of North American shale gas zones indicate elevated levels of ammonium, benzene, barium, strontium, chloride, halides, bromide and radium in rivers downstream of treatment facilities.[115]

Baseline data is particularly important for determining shale gas development's potential impacts on surface water because study results are not always transferrable beyond the study area. The *Rules for Industry* acknowledges the importance of continuous improvement based on environmental monitoring and experience with oil and gas development in New Brunswick and elsewhere. The province's *Oil and Natural Gas Blueprint* calls for the preparation of a compliance and enforcement strategy, incorporating inspection and enforcement measures that are to be phased in as required according to the pace of development.

New Brunswick's *Rules for Industry* contains the following provisions for protecting surface water:

- minimum setbacks from watercourses and wetlands for well pads;
- use of "closed loop" drill fluid systems and tanks for flowback water (no pits);
- mandatory spill prevention reporting and response plans;
- surface water quality monitoring prior to well pad construction, and during and after hydraulic fracturing;
- provisions for emergency containment of hydraulic fracturing fluid;
- impervious well pad liners;
- leak detection and secondary containment for storage tanks;
- risk assessments and public disclosure for hydraulic fracture fluid additives;
- waste management plan to address flowback water and produced water;
- run-off management plans for well pads;
- well pads to be above flood elevations; and,
- use of municipal wastewater treatment facilities to treat wastewater is not permitted unless upgraded to be capable of treating the wastewater.

Risks that can be mitigated using existing technologies but which are currently unavailable in New Brunswick

Wastewater Management

Wastewater generated as a result of shale gas activities typically includes, but is not limited to, a mixture of:

- flowback water, which is injected hydraulic fracturing fluids that return to the surface after hydraulic fracturing; and,
- formation water, which contains naturally occurring salts, metals, hydrocarbons and radioactive material and comes to the surface along with the gas.

In practice, wastewater is a mixture of the two, and generally speaking it is the formation water that poses the greater challenge for wastewater treatment options. The quality and quantity of shale gas wastewater can vary across different geologies, shale gas plays, and different wells within the same play, and can also change with time within a single well bore.[116]

Estimates of the total volume of wastewater generated per well from major shale gas plays in the U.S., range from 4 to 12.4 million litres per well, spread over the first four years of gas production[117] plus additional amounts over the life of the well, which may extend over one or more decades. As a comparison, the average daily effluent volume discharged to the St. John River by Fredericton's Barker Point Sewage treatment plant is about 21 million litres.

Wastewater treatment that results in releasing the treated water to surface waters, such as municipal systems, is no longer the preferred method in established shale gas producing regions due to cost and the risk of surface water contamination. Pennsylvania has a moratorium on the disposal of produced water in municipal wastewater treatment plants[118] and the U.S. EPA has introduced a draft rule to ban shale gas wastewater from sewage treatment plants unless it is pre-treated. For these reasons, the U.S. oil and gas industry no longer disposes of wastewater at municipal sewage treatment plants,[119] although industrial wastewater treatment facilities continue to play a role in managing shale gas wastewater.

The two preferred wastewater options are deep well injection and wastewater recycling. Deep well injection pumps wastewater underground for permanent disposal and it often represents the cheapest management option if disposal wells are available. It requires suitable geology, and given the fact that the Maritimes Basin is mostly comprised of low permeability rocks, it's unlikely deep well injection would ever be used in New Brunswick and it is currently not permitted.[120] However, the industry did inform the Commission that it would like to revisit this issue through additional research. [121]

That leaves wastewater recycling as the most likely potential long-term solution, if the Government chooses to proceed with hydraulic fracturing. Recycling is the predominant wastewater management option in the Marcellus Shale[122] because of technological advances in water treatment technology plus the creation of salt-tolerant hydraulic fracture additives.[123] Experts predict that almost all produced brines will be treated and reused within the next five years.[124] The use of leading edge recycling facilities can theoretically result in zero wastewater discharge to the environment.[125] However the practicality of recycling depends on economies of scale, specifically:

- the presence of multi-well pads (many wells located in close proximity);
- a sufficient recovery rate of injected fracturing fluid and formation water;
- the presence of enough gas wells under development in the same region and under the management of the same company to utilize the recycled water;[126] and,
- ensuring the right amount of water is available at the right time represents a significant logistical challenge involving well-planned wastewater storage and transportation infrastructure.[127]

A final concern is demand for recycled water will slow once well construction slows and the remaining wastewater will ultimately have to be dealt with in another way.[128]

A preliminary study by Atlantica Centre for Energy based on production from the McCully gas field to date, estimates 9 million litres of flowback water and 25,000 litres per day of produced water based on an assumption of 100,000 MMcfd of gas production.[129] Based on these assumptions, wastewater treatment will likely be accomplished either with portable wastewater facilities at the well pad or by shipping wastewater to out-of-province treatment facilities. The latter option has been the only option available in New Brunswick to date, with wastewater shipped to treatment facilities in Nova Scotia and Quebec. However out-of-province shipment of wastewater is not a viable long-term solution especially if volumes of wastewater were to significantly increase in future. If the scale of development were to increase, economies of scale would likely lead to the construction of one or more centralized treatment facilities. Another option, discharging into salt water, raises another set of challenges that will need to be explored.

New Brunswick's current *Rules for Industry* contains the following provisions for addressing wastewater treatment:

- a wastewater management plan is required before shale gas activities begin that describes how and where wastewater will be managed, transported, treated or disposed of;
- the plan must consider recycling and re-use, and if these options are not used, the operator must justify this decision;
- wastewater must be characterized (sampled) and results reported to regulator;
- flowback water must be conveyed by piping to a covered, water-tight tank (no pits);
- flowback water must be removed from the site within 90 days; and,
- use of municipal wastewater treatment facilities to treat wastewater is not permitted unless upgraded to be capable of treating the wastewater.

If the Government decides to proceed with hydraulic fracturing, it should develop regulatory practices for wastewater disposal options, supported by estimates of volumes and characteristics of wastewater based on various development scenarios. Development of an effective homegrown wastewater treatment option for shale gas activities will depend in part on detailed sampling and characterization of the wastewater and the subsequent tailoring of a combination of available water treatment technologies. Any new wastewater treatment facility would likely trigger an EIA under the *Environmental Impact Assessment Regulation, Clean Environment Act*.

Risks that can be mitigated with existing practices and/or small changes to reflect latest developments in the sector.

Water Volumes

The amount of water required to hydraulically fracture a well depends on the length and orientation of the well bore, the well depth and the geological setting.[130] On average, shale gas is more water-intensive than conventional gas but less-water intensive than conventional oil production.[131] However if re-fracturing of wells to extend production life becomes more common, the overall water intensity of shale gas production is likely to increase in the future.[132]

Despite the shale gas industry's reputation for being water-intensive, the total amount of water needed for shale gas activities is generally small in the Canadian hydrological context.[133] Therefore, in areas with ample freshwater resources, such as New Brunswick, it is possible that shale gas activities can proceed without significant impact on water resources.[134] However, the potential for localized impacts of large volumes of surface or groundwater extraction over a short period of time should not be ignored, especially if it takes place during periods of low flow.[135]

Of greater concern is the cumulative effect if a large number of wells are concentrated in just a few watersheds and the potential effect of surface water removal during low-flow summer conditions. Greater impacts might also be seen if currently known groundwater resources are used unsustainably. In light of the limited level of development to date, Government does not know how much water on average a shale gas well in New Brunswick will require in the long run. The hydraulically fractured wells completed in the McCully area have required about 300,000 to 700,000 litres each and two horizontal, hydraulically fractured wells completed east of McCully in 2010 required about 20 million litres each.

It is likely that water use associated with future wells would increase if longer well bores are used. One estimate of future water demand for wells in New Brunswick is 20 to 60 million litres per well, which means that 1,000 wells would require a water supply providing a continuous flow of about 0.6 to 2 m^3/second. This assumes no recycling and no use of waterless hydraulic fracturing technologies. By comparison, mean summer low flow of St. John River at Fredericton is about 400 m^3 per second.[136] Corridor Resources estimates that water use for future wells tapping the Fredrick Brook shale would be 10 to 20 million litres per well.[137]

New Brunswick's *Rules for Industry* contains the following provisions for addressing water use:

- water management plans are required;
- recycling is identified as the preferred method for dealing with wastewater;
- assessment of proposed water sources to ensure no impact on other users and aquatic environment;
- hierarchy of acceptable water supplies (use of potable groundwater not allowed unless operator proves that no other sources are available); and,
- water use reporting by industry.

If the Government decides to proceed with hydraulic fracturing it should continue with, and where appropriate, enhance its practices to ensure New Brunswick's water resources are properly managed.

A Comprehensive Research and Monitoring Program

A common theme that runs through all the reports the Commission reviewed is the need for increased research and monitoring of the impacts shale gas development may have on human health and the environment. Large-scale shale gas development is about a decade old, and comprehensive research regarding its impacts is incomplete. For this reason, we support expanding existing research and monitoring programs, details of which are well-documented in the Chief Medical Officer of Health's 2012 report, the Council of Canadian Academies 2014 report, the 2014 Report of the Nova Scotia Independent Review Panel on Hydraulic Fracturing, and the New Brunswick Energy Institute's body of work.

Our summary below is influenced by these reports as well as our conversations with John Cherry chair of the Council of Canadian Academies' report; David Wheeler, chair of the Nova Scotia Independent Review Panel on Hydraulic Fracturing; David Besner, chair of the New Brunswick Energy Institute's scientific advisory panel; and Maurice Dusseault who has served as a member and/or advisor to both panels and the Energy Institute.

Indigenous-led research: Future shale gas developments will need to involve Indigenous people in a far more substantive way and an Indigenous-led research agenda is key to this. The Government of New Brunswick, in partnership with the Government of Canada, should support the building of capacity within New Brunswick's small but growing Indigenous research community, which includes a combination of academic researchers and elders. As described by the Mi'gmaq Sagamaq Mawiomi in its submission to the Commission "When Mi'gmaq knowledge is researched by the Mi'gmaq in a fulsome manner, it will provide precise and accurate evidence of Mi'gmaq use and occupancy of the land." This statement is echoed in the correspondence we received from Maliseet (Wolastoqiyik) communities.

Baseline monitoring: Before exploration begins, the Government should establish a baseline program to assess relevant local health and environmental indicators pre-development, including a strong population health surveillance system. This will enable government, Indigenous people, industry and residents to be alerted to changes once development begins and determine how best to mitigate negative impacts. Ongoing monitoring should assess both short-term and long-term effects, as noted by the Nova Scotia panel in its final report: "Uncertainties around long-term environmental effects, particularly those related to climate change and its impact on the health of both current and future generations, are considerable and should inform government decision-making."[138]

New Brunswick Energy Institute

While it is true there remain gaps in our knowledge about the effects of shale gas on human and environment health, work to expand our knowledge base is ongoing. The New Brunswick Energy Institute was created in 2013, led by a team of independent researchers, "to provide objective science-based information to help New Brunswickers evaluate possible impacts from the potential development of energy resources and infrastructure in New Brunswick."[139] It has been quietly going about its work ever since.

To date it has completed the following activities:

- an examination, in partnership with the Canadian Rivers Institute (CRI), of environmental water flows in New Brunswick that recommends New Brunswick begin the process of adopting the globally accepted Holistic Framework for Environmental Flows as the standard for all surface water withdrawals in all sectors;[140]
- meetings with Elders on research needs for an Indigenous-led examination of unconventional gas resources and development;
- public presentations on technology and potential impacts of energy development on the environment and human health; and,
- expert presentations on a wide range of energy topics and discussions about future research needs for New Brunswick.

Ongoing work includes:

- a baseline groundwater study on approximately 500 domestic wells in two regions with the greatest potential for unconventional natural gas production;
- a baseline study on stream water quality in areas with the greatest potential for unconventional natural gas production; and,
- a monitoring system that is collecting baseline information on seismic activity in southeastern New Brunswick in partnership with the Geological Survey of Canada.

Public Issues Requiring Further Research and Monitoring

The following proposed areas of interest reflect what the Commission heard were of primary concern to New Brunswick residents, many of which have also been highlighted by other reports as issues requiring further study. The research described below emphasizes the need for an independent and trusted entity to provide timely, transparent and objective information to the public about shale gas exploration and development. An expanded research agenda, led by an independent entity, should be a required element should the Government proceed with hydraulic fracturing because it will help to build community trust.

To accomplish this, the Government should build upon the work already begun by New Brunswick's research community and support the expansion of this homegrown network's research capabilities and impact. This could include seeking funding support from the Government of Canada and/or creating an Atlantic Canada Energy and Environment Research Network with the governments of Nova Scotia, Newfoundland and Labrador and Prince Edward Island in support of a regional approach to climate change and future energy developments.

Air Quality

Air quality impacts of shale gas activities have been largely under-explored to date due to:

- the short time shale gas technologies have been in extensive use;
- a prior research focus on water quality issues;
- an evolving understanding of contributions of certain oil and gas production processes to air quality;
- limited air quality monitoring networks directed toward oil and gas production, making it difficult to quantify air quality impacts in shale gas regions;
- lack of air monitoring equipment;

- significant variability in air emissions and concentrations; and,
- air quality research that does not capture impacts important to residents.[141]

Ongoing research is focusing on a number of key areas including:

- improving future emission projections based on the lifecycle of individual wells and well fields and future regulatory changes;[142]
- improving estimates of emission factors from various oil and gas activities and equipment;[143]
- comparing predicted emissions (based on emission inventories) with actual field measurements;[144] and,
- identifying key air quality indicators that can be used to trace the impacts of specific oil and gas activities.[145]

In the fall of 2012, a Memorandum of Agreement for Services between Health Canada and the New Brunswick Department of Environment and Local Government was established to conduct an air monitoring study of shale gas activities in New Brunswick. The final report is pending. Preliminary analyses of the baseline data (Part I of the study) and comparisons with historical air quality trends across the southern part of the province of New Brunswick, including Fredericton, Saint John and Moncton, show the concentrations of air pollutants at the baseline site are similar to or lower than those at other provincial monitoring sites (rural and/or urban). The wind data also indicated that no significant sources of pollution, especially oil and gas activities, were located upwind of the site. As such, it appears that the baseline data will provide an appropriate data set against which to compare air quality data collected during other phases of the study.

Animals and Habitats

Impacts of shale gas production on animals and habitats are typically species-specific and system-specific. In addition, the degree of impact will depend on the presence of other stressors in the environment and whether the impact is natural or human induced.[146] This suggests that customized (site-specific) predevelopment investigations are required for different oil and gas project locations to help identify potential for impacts. Such an approach is especially important in remote areas where there may be little biological information available.[147] These site-specific investigations would also allow ecologically sensitive site locations to be identified and avoided.[148]

Researchers have suggested several general areas of research and monitoring that will aid in development of effective guidelines and policies to minimize negative impacts and protect vulnerable species and ecosystems including:

- cumulative effects assessments;
- spatial analyses;
- species-based modeling;
- vulnerability assessments;
- ecoregional assessments; and,
- threshold and toxicity evaluations.

Various scenarios for future shale gas development can be modelled to help gain an appreciation of the potential landscape and land use impacts and develop strategies, policies and regulations to address them.[149]

Groundwater

It is essential that New Brunswick have a robust groundwater research and monitoring program because groundwater study results from other jurisdictions may not be transferrable to New Brunswick due to geology, water well construction standards, oil and gas regulations and operating practices.

Groundwater studies are underway in New Brunswick, including the list below.

- In 2012-2013, the Department of Earth Sciences at the University of New Brunswick in cooperation with the Geological Survey of Canada carried out a sampling program of 26 water wells from the area around the McCully gas field near Sussex. The research found no evidence that natural gas development and production at the McCully had affected groundwater quality in the water wells that were sampled.[150]
- In 2011, the Geological Survey of Canada undertook a four-year evaluation of cap rock integrity in New Brunswick's McCully gas field, including the development of a 3D geological model. This study should shed further light on the question of whether or not fracture fluid can migrate vertically through geological formations.
- The New Brunswick Energy Institute has undertaken a large-scale examination of natural methane gas occurrences in private water wells in New Brunswick, with the objective of collecting and reporting on baseline domestic water quality data in selected regions of New Brunswick. The focus is on groundwater quality parameters that are most relevant to the potential impact on shallow groundwater from unconventional shale gas production. This two-year study began in April 2014 with a final technical report due in 2016. An interim report released in May, 2015 indicated that naturally-occurring methane is common in water wells in Kent County and the Sussex area.[151]
- The Canadian Rivers Institute is leading a baseline water quality research project that will provide the background for evaluating possible impacts of shale gas development on surface water by mapping inflows of groundwater to adjacent streams and characterizing current baseline water quality and aquatic species in areas of the province most likely to be of interest to shale gas developers. The CRI research team will also develop and test methods to monitor potential contaminants from shale gas development, such as methane levels in streams. Published results are expected in 2016.

Earthquakes

An accurate determination of the potential for shale gas activities to induce seismic activity requires the collection of quantitative information on the properties of the specific geological formations that would be subjected to shale gas activities, or of analogous formations elsewhere.[152] This includes accurately mapping faults, stress fields, and historical seismicity.[153]

Recent research has focused on a number of issues including:

- numerical models to simulate changes in the stress distribution and response of faults to hydraulic fracturing;[154]
- determining the largest potential magnitude of induced seismic events;[155]
- ways to predict induced seismicity;[156] and,
- ways to distinguish between natural and induced seismic events.[157]

In the fall of 2012, the Geological Survey of Canada installed a seismic monitoring station in southeastern New Brunswick as part of an ongoing investigation of the seismic impacts of shale gas activities.[158] The station complemented the National Canadian Seismograph Network and is part of a project to record the seismicity potentially-induced by hydraulic fracturing. Four additional stations were deployed in the fall of 2013 to improve the detection threshold and the ability to determine the location of earthquakes in southeastern New Brunswick; subsequent research[159] found that hydraulic fracturing conducted during 2014 in the McCully field near Sussex did not induce any seismic activity detectable at the surface.

Provided that sufficient baseline (pre-activity) data has been collected, changes in the frequency, magnitude and other characteristics of seismic activity following the onset of oil and gas activities can serve as indicators of increased risk of earthquakes.

Wastewater Disposal

The greatest challenges associated with wastewater treatment include its variability and the variety of potential substances it may contain. This means that characterizing wastewater and designing an appropriate treatment system can be time-consuming and expensive because it must be tailored to a specific wastewater source. The University of Alberta, with funding from the Canadian Water Network, is currently leading a review aimed at summarizing and assessing current knowledge regarding wastewater management and identifying critical gaps to be addressed by future research.[160]

In its submission to the Commission, Saint John-based Fundy Engineering stated that it has completed the first phase of a National Research Council Industrial Research Assistance Program-funded project to examine potential wastewater recycling processes. It is ready to move into Phase II of its project, which would be the creation of a mobile treatment plant,[161] if the Government decides to proceed with hydraulic fracturing.

Mental Health

Of particular note for the Commission is the issue of mental health, specifically depression, anxiety and stress felt by some New Brunswick residents. We met and heard from people who truly fear the arrival of shale gas development in their communities and they should not be dismissed. Nor should we ignore the deep mental anguish of New Brunswick residents who cannot find work to support themselves and their families in the places where they live. This is illustrative of an emerging issue within the mental health sector that requires further study. The Canadian Academies noted that, "lack of transparency, conflicting messages, and the perception that industry or authorities are not telling the truth can create or augment concerns about one's quality of life or well-being, and contribute to feelings of anxiety about the potential health, environmental, or community impacts."[162] The Commission recognizes this is a serious concern in New Brunswick and should be addressed in any Government strategy moving forward.

We also recognize this issue transcends shale gas. Examples of this type of stress and anxiety can be seen in online comments regarding a variety of issues, some of which embrace junk science as truth because it reinforces a personal belief system and/or a deep distrust of public institutions.[163] This is a significant societal challenge, and is a topic the Government should review to identify research gaps and recommend next steps.

Final Thoughts

We complete our work on the Commission by turning our attention to the future. While we remain concerned for our province's serious challenges, we believe a significant number of New Brunswickers share our desire to begin the transition to a new economic and environmental reality.

As was stated earlier, all developments carry a degree of risk. Our goal must be to manage and mitigate those risks that have the greatest potential to disrupt community life. The shale gas industry could generate about $200 million in royalties for the people of New Brunswick but there are risks and while many can be mitigated, some cannot. This volume, which contains a detailed review of the potential risks and benefits of shale gas development, is meant to be a guide for policy makers as they consider whether to proceed.

Understanding the full picture of the impact shale gas activities, and in particular hydraulic fracturing, may have on the lives of New Brunswickers is an important step in the direction we must all travel to rebuild trust in our institutions and in each other.

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