CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

Nova Scotia Hydraulic Fracturing Review and Public Consultation

Amherst

22nd July 2014

Presentation

- Mandate, Process, Principles
- Preliminary Conclusions, Emerging Recommendations
- Natural Gas and Hydraulic Fracturing Globally
- More Detailed Analysis
- Development Pathway?

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

Mandate

- Independent review
- Creation of an expert panel
- Conducted within the context of the Environmental Goals and Sustainable Prosperity Act (EGSPA)
- Studying the environmental, health and socio-economic impacts of Hydraulic Fracturing
- Includes public engagement including online tools and in-person meetings
- Resulting in a report with recommendations to the government of Nova Scotia

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

Review Process (I)

VCSEE/CBU appointed August 2013

Confirmed brief with new Minister October 2013

Stakeholder engagement opportunities announced October 2013

Calls for nomination to the Panel November 2013

Technical Advisory Group announced December 2013 (amended April 2014)

Expert Panel announced February 2014 (amended April 2014)

Aboriginal outreach process announced April 2014

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

Review Process (II)

Public information sessions x 2 April 2014

Primer released April 2014

238 submissions received by deadline; Aboriginal submissions commencing

Nine discussion papers released May-July 2014

Public meetings July 16th – 29th 2014 and beyond (especially to Aboriginal communities)

Report and recommendations submitted to DoE August 2014

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

Review Process – From Discussion Papers to Report Chapters

- Primer (Introduction)
- The Potential Oil and Gas Resource
- Potential Economic Impacts
- The Protection of Public Health
- Socio-economic & Socio Ecological Impacts on Communities
- Impacts on Water
- Well Integrity
- Public Participatory Risk Assessment
- Regulatory Issues
- Aboriginal, Treaty and Statutory Rights of the Mi'kmaq
- Risks, Impacts, Research, Regulation, Mitigations and Controls
- Recommendations

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

Review Process – Prior Public Feedback

- June 2011 DoE report on public consultation: 21% of 279 respondents requested transparent public consultation (8th most important issue). 46% wanted ban or moratorium (3rd).
- Even with stringent government regulations, a slight majority (53%) of Nova Scotians still oppose the development of hydraulic fracturing in the province, with 39% supportive, and another 8% largely undecided (Corporate Research Associates, 2013).
- Other data also available eg NoFrac and CC polls

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

Review Process – Public Feedback Mechanisms

- Commenting on skill sets to be incorporated into the selection process for panelists to serve on the Panel
- Recommending candidate Panelists
- Bidding for technical advisory work commissioned by the Expert Panel
- Submitting written evidence
- Participating in on-line discussions and surveys
- Participating in public forums
- Commenting on discussion papers (draft chapters) and recommendations

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

Principles

- No Preconceptions
- Legitimacy of All Views
- Transparency
- Evidence Based
- Interdisciplinarity
- Precautionary Approach

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

The Precautionary Approach

Principle 15 of the final declaration of the UN Conference in Environment and Development states that "In order to protect the environment, the precautionary approach shall be widely applied by [UN Member]States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.“

Two tests applied where there is significant scientific uncertainty and potential significant risks to public and environmental health. One is the burden of proof and one is proportionality.

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

Preliminary Conclusions: Unknowns

i) the *proven* size of the resource;

ii) will industry be interested to explore for the resource;

iii) what are the comparative lifecycle impacts of natural gas and oil development and use versus those fuels it may replace *in a Nova Scotia context*;

iv) whether community support can be established for exploration and/or development; and

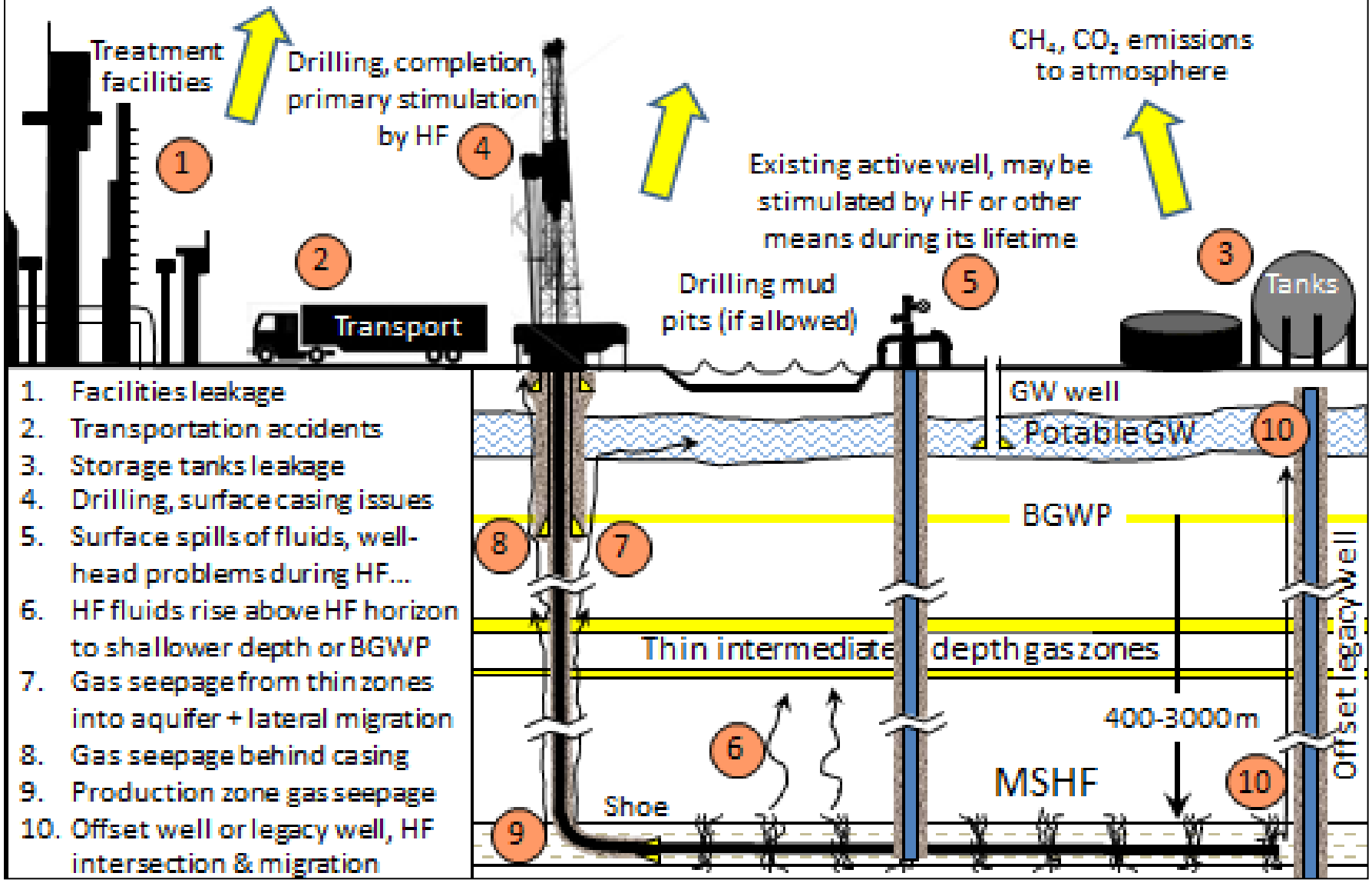
v) how risks, benefits and impacts (+ve/-ve) would be distributed

vi) Long term implications for climate change and wellbeing of future generations.

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

Potential Environmental Impact Pathways



1. Facilities leakage
2. Transportation accidents
3. Storage tanks leakage
4. Drilling, surface casing issues
5. Surface spills of fluids, well-head problems during HF…
6. HF fluids rise above HF horizon to shallower depth or BGWP
7. Gas seepage from thin zones into aquifer + lateral migration
8. Gas seepage behind casing
9. Production zone gas seepage
10. Offset well or legacy well, HF intersection & migration

Preliminary Conclusions: Knowns

i) **risks and impacts can be described in semi-quantitative or qualitative terms in most cases;**

ii) **outstanding global and specific local research needs are reasonably clear;**

iii) **regulatory frameworks exist or likely can be developed to address aspects of the most significant 100 year risks assuming the knowledge base continues to develop toward supporting this goal**

iv) **risk reduction mechanisms are available or with research likely can be developed to address aspects of-the most significant 100 year risks. Effective planning, monitoring, technology improvement and regulatory arrangements can all contribute to reducing risk levels**

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

Emerging Recommendations (I)

- The Panel is not saying this activity should proceed now in our Province, nor are we saying it should necessarily proceed in the future.
- We are saying:
  - A significant period of learning and dialogue is required as a first step – ideally based on the analysis in our report
  - Foundational research is required with communities re attitudes to risks and benefits
  - Foundational research is needed to model social, environmental and economic scenarios versus the fossil fuel alternatives (i.e. coal and oil) and renewables
  - The Province should keep an open mind on technological developments and unfolding experience eg NB

Emerging Recommendations (II)

- ***If we ever get that far***, and if communities welcome the prospect of exploring the potential benefits and costs of hydraulic fracturing eg by identifying where the resource may be and what it might be worth and what it might impact
  - Do seismic testing and exploration when full, prior and informed community consent is in place
- ***If we ever get that far***, and if communities welcome the prospect of developing hydraulic fracturing eg for regional economic development reasons and assuming the risks are negligible/manageable in their geographies
  - Design monitoring, regulatory & enforcement
  - Design highly rigorous HIAs and EIAs
  - Design specific risk reduction and benefit sharing systems by population
- Plus many more detailed specific recommendations….

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

Hydraulic Fracturing and Natural Gas

- As of 2010 world production of unconventional gas was about 472 billion cubic metres, 89% of which was produced in North America (US 76%, Canada 13%)
- The global demand for gas may grow by 45% to 50% by 2035, compared to 2010 figures.
- Between 2007 and 2013, approximately 35,000 horizontal wells were drilled in Canada, almost all of them stimulated with hydraulic fracturing.
- Canada consumes approx 3 TCF gas per annum (9 BCF per day)
- 0.5 BCF/d produced by Sable Island/Encana offshore NS

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

Technically Recoverable UG Resources

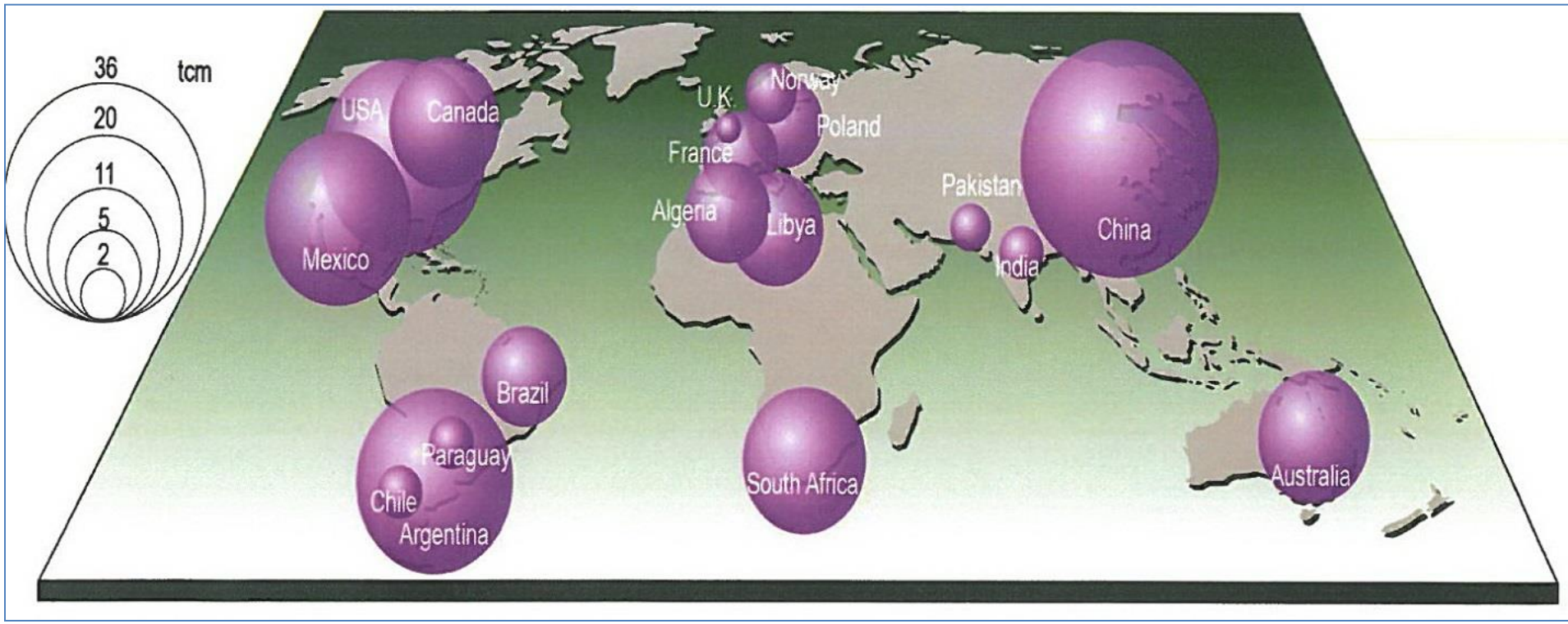
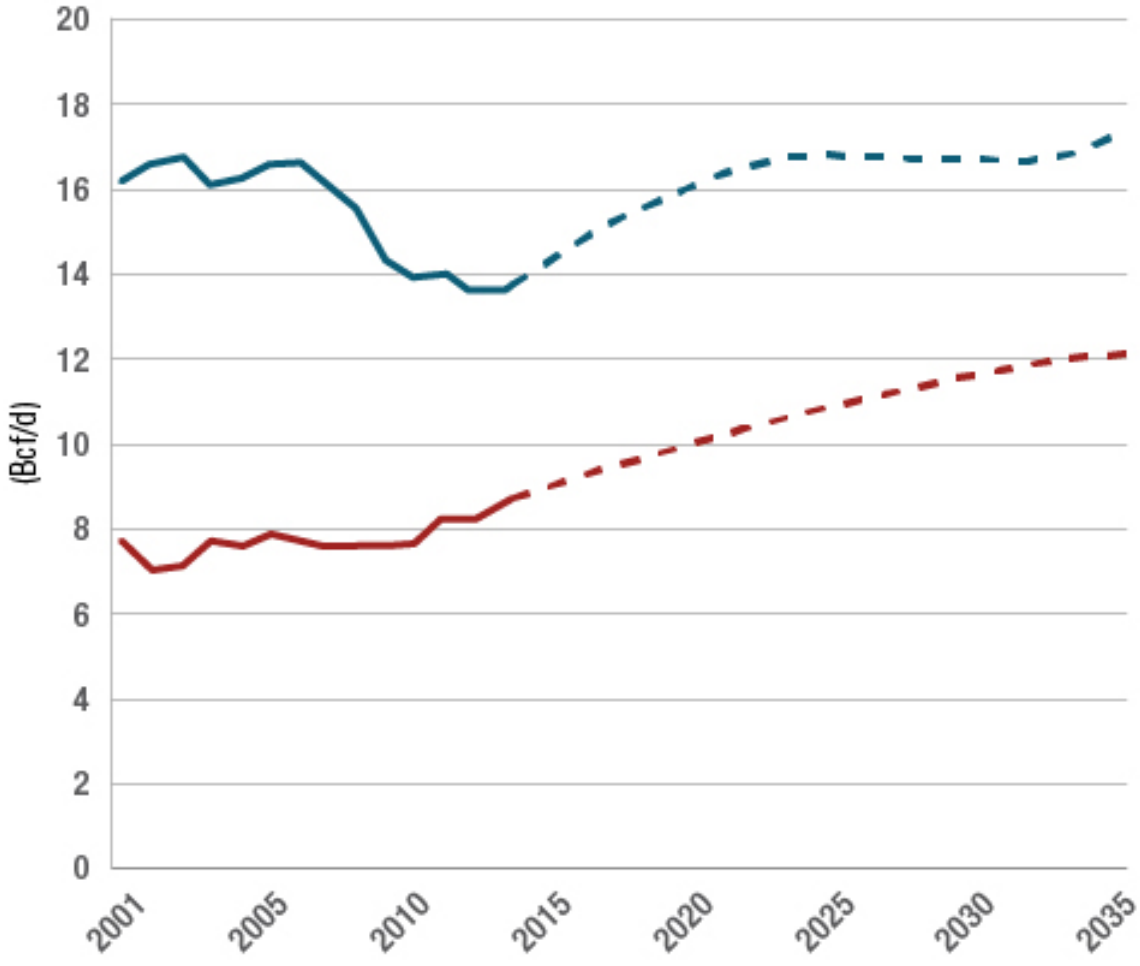


Figure courtesy of the Royal Society; cartography by UNEP/GRID-Geneva. See also http://www.eia.gov/analysis/studies/worldshalegas/ for more recent estimates.

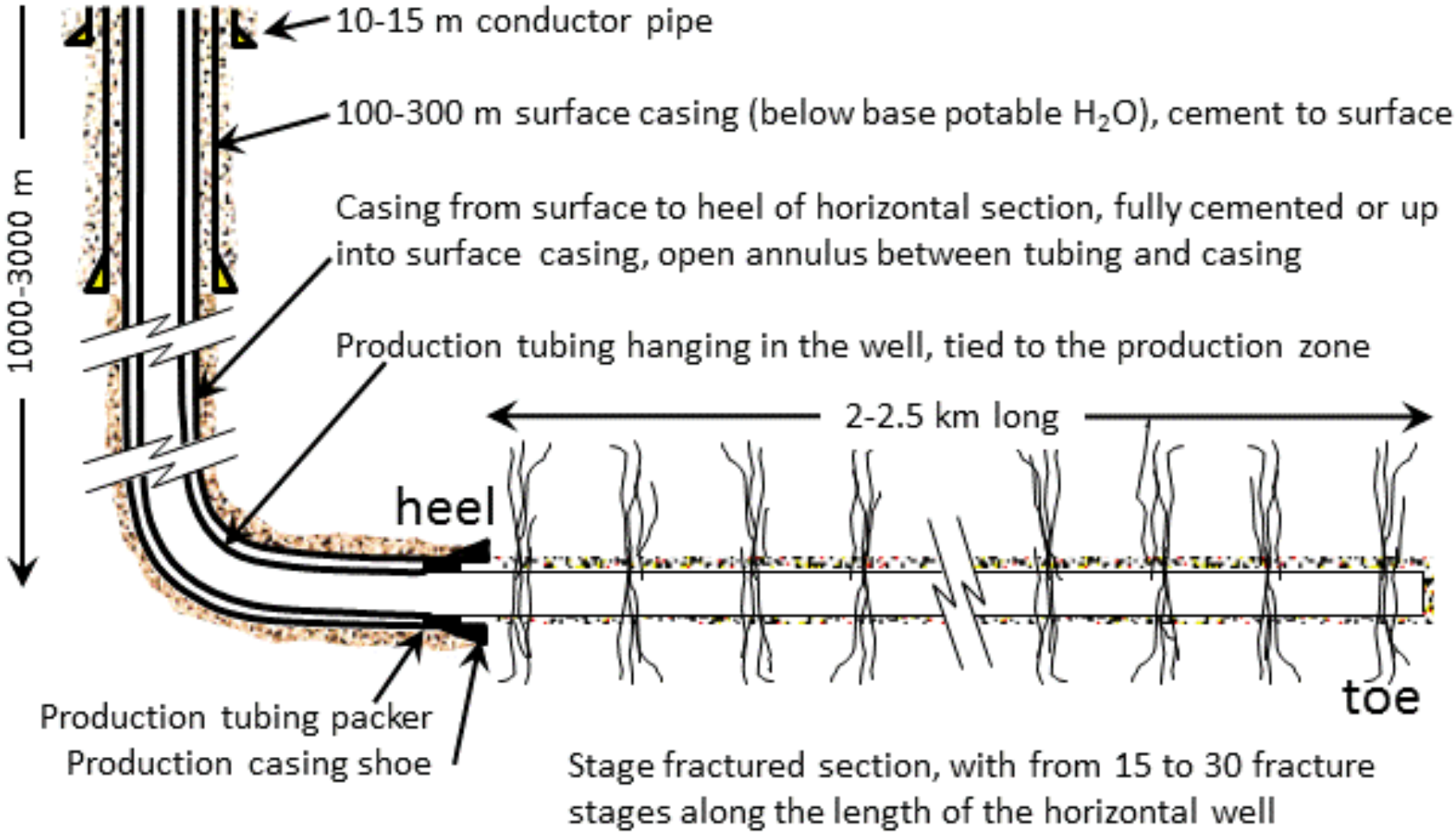


Source: World Energy Outlook© OECD/IEA, 2013, Goldman Sachs Global Investment Research, NEB

CANADA: NATURAL GAS MARKET

Canadian natural gas supply and demand are likely capable of moderate growth without a shift in domestic policy.

- CANADA NATURAL GAS DEMAND – STATUS QUO POLICY SCENARIO (BCF/D)
- --- SCENARIO PROJECTION
- CANADA NATURAL GAS SUPPLY – STATUS QUO POLICY SCENARIO (BCF/D)
- --- SCENARIO PROJECTION

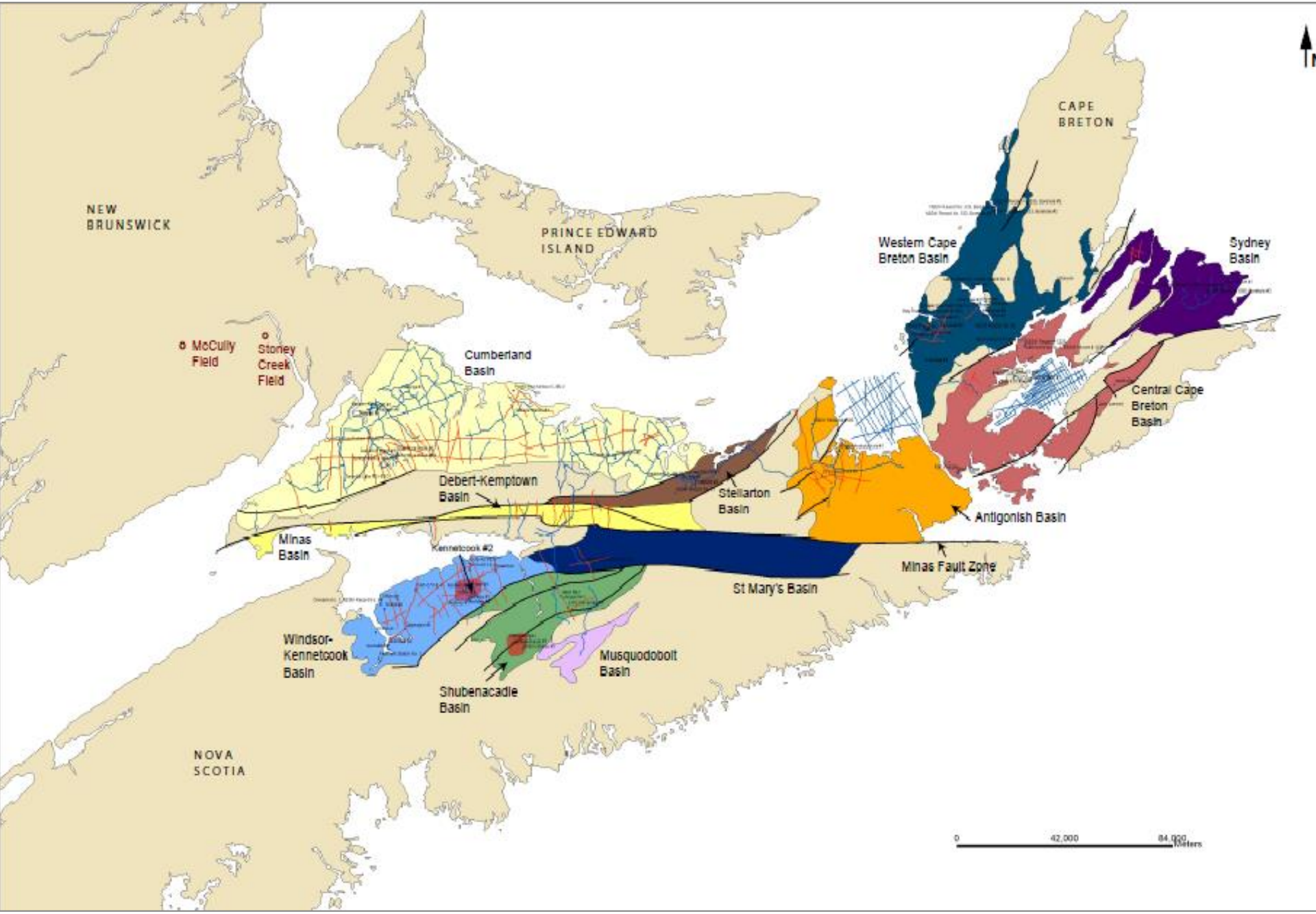


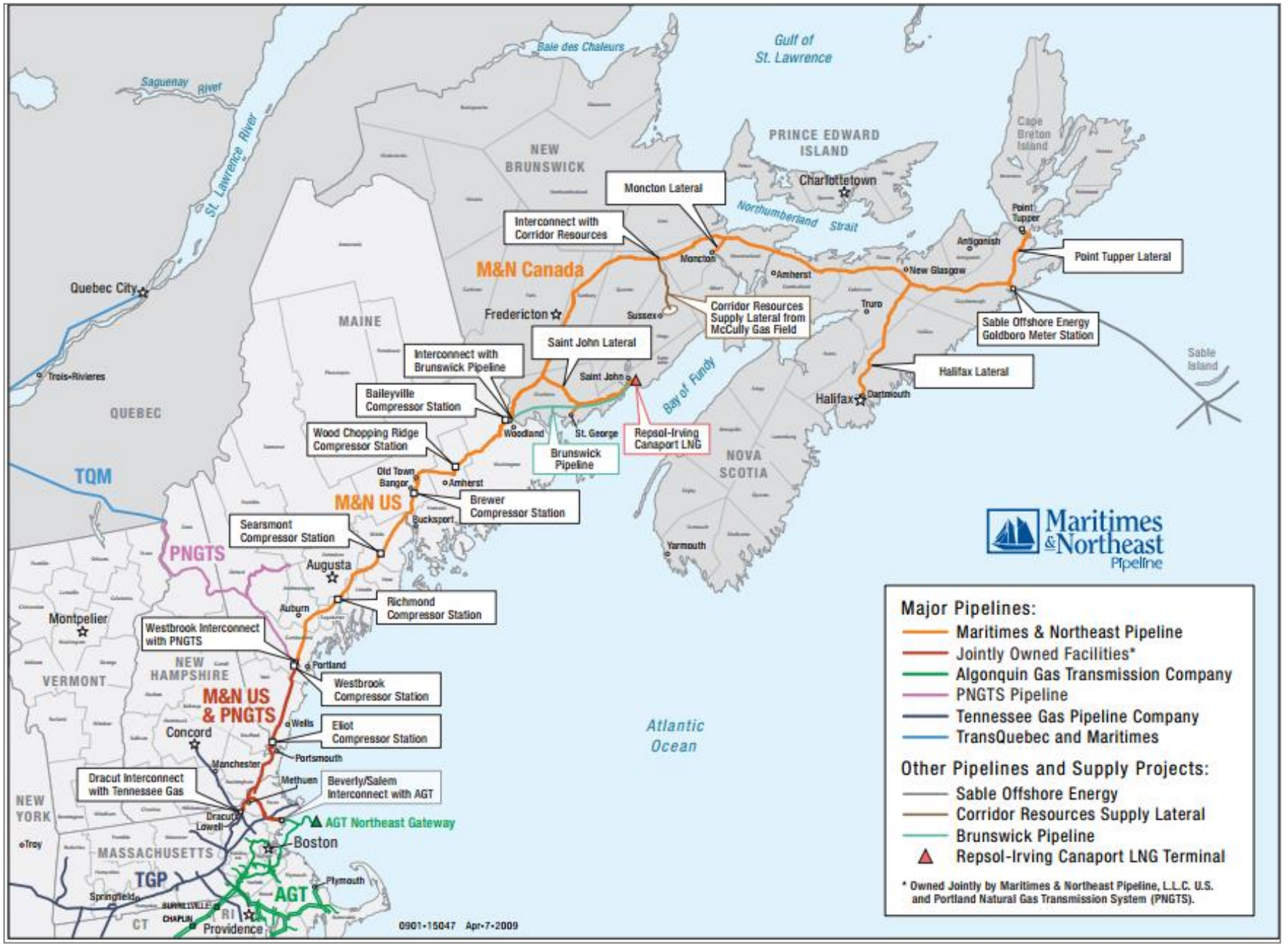
CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

The Potential Resource in NS

- Knowledge of the subsurface, including sedimentary rocks and hydrocarbons, is extremely limited
- It is very difficult to quantify the potential or even rank the various basins in terms of overall prospectivity.
- Although our knowledge is limited by scarcity of data, shales and sandstones in New Brunswick, and American plays such as the Marcellus are a fair comparison
- Horton Group reservoirs have the largest assessed gas volumes
- Cumberland, Windsor-Kennetcook and Shubenacadie basins are relatively close to existing production in New Brunswick and have experienced exploratory activity already
  - If hydraulic fracturing moves forward, these basins would likely be the focus of unconventional exploration activity.
  - Most existing pipeline infrastructure is close to these basins


NEW BRUNSWICK
PRINCE EDWARD ISLAND
CAPE BRETON
NOVA SCOTIA
McCully Field
Stoney Creek Field
Cumberland Basin
Western Cape Breton Basin
Sydney Basin
Central Cape Breton Basin
Debert-Kemptown Basin
Stellarton Basin
Antigonish Basin
Minas Basin
Kennetcook #2
Minas Fault Zone
St Mary's Basin
Windsor-Kennetcook Basin
Musquodoboit Basin
Shubenacadie Basin
0
42,000
84,000
Meters



Maritimes and Northeast Pipeline website: http://www.mnpp.com/us/map

The Potential Resource in NS

- ZERO CASE: No commercial development established in any basin i.e. no production
- LOWER MEDIUM CASE: One basin - fully developed
  - 10 TCF recoverable resource, plus condensate
  - 4000 wells
  - All within one basin outline – most likely Windsor-Kennetcook or Cumberland
- UPPER MEDIUM CASE: Three basins fully developed
  - 30 TCF recoverable (plus condensate), 4000 wells in each (total 12,000 wells)
  - Cumberland, Windsor-Kennetcook, and Stellarton/Debert-Kemptown/Minas
- MAXIMUM CASE: Five basins successfully developed for gas, one for oil
  - 50 TCF recoverable, 4000 wells in the five gas-bearing basins (total 20,000 wells)
  - 50 MMBO recoverable, 250 wells in the oil-bearing basin

Potential Development Scenarios

	Scenario			
	Zero	Lower Medium	Upper Medium	Maximum
Basins developed	-	1	3	5
Total potential resources in place	-	100 TCF	300 TCF	500 TCF
Recovery factor	-	10%	10%	10%
Recoverable reserves/well	-	2.5 BCF	2.5 BCF	2.5 BCF
Recoverable reserves	-	10 TCF	30 TCF	50 TCF
Number of development wells	-	4,000	12,000	20,000
Development phase (years)	-	40	50	60

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

Regional Economic Benefits and Costs Lower Medium Case

- Development investments over 40 years could exceed $40bn (multiply by five for max case).
  - 35-40% could represent Nova Scotia content potentially >$300m per annum
  - Drilling forms a major component of this investment
  - Higher local content during development
  - Attributable to higher levels of participation in drilling development wells, and in construction activities related to the gas plant
  - Potentially 2500+ ongoing permanent full-time equivalent jobs
- Costs and externalities impossible to estimate at this point – would have to be done on a development case by case basis. Depending on geography, costs will include a wide range of direct impacts eg water use and treatment, infrastructural improvements (transportation infrastructure etc), possible pollution or health impact costs, in addition to regulatory costs, including the establishing baseline data, monitoring, and enforcement.

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

Lower Medium Case: 10+ pads (100+ wells) per annum for 40 years

Provincial Economic Benefits

Under the Lower Medium Case the Government of Nova Scotia could expect royalty revenues around $5.8 billion over the productive life of the development (multiply by five for max case).

NB This royalty estimate is *highly speculative* based on several key resource and market assumptions.

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

Protecting Public Health

- The development of unconventional gas and oil resources through the use of hydraulic fracturing, in common with other modern industrial technologies, has the potential to bring benefits and harms to individuals, communities, and populations.
- There should be a clear understanding of which groups benefit and which might be harmed
- The current state of knowledge does not identify issues with hydraulic fracturing which would pose a catastrophic risk to human health in the short or medium term.
- 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.

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

Socio-Economic and Social Ecological Impacts on Communities

- Community impacts of energy development may be both positive and negative, and occur in four key areas:
  - the local economy
  - social and physical infrastructure
  - the natural environment
  - social relations within communities
- The energy boomtown literature of the 1970s and 1980s focused on the negative impacts of the boom-bust-recovery cycle. Subsequent research has shown positive impacts in most categories.

CAPE BRETON UNIVERSITY

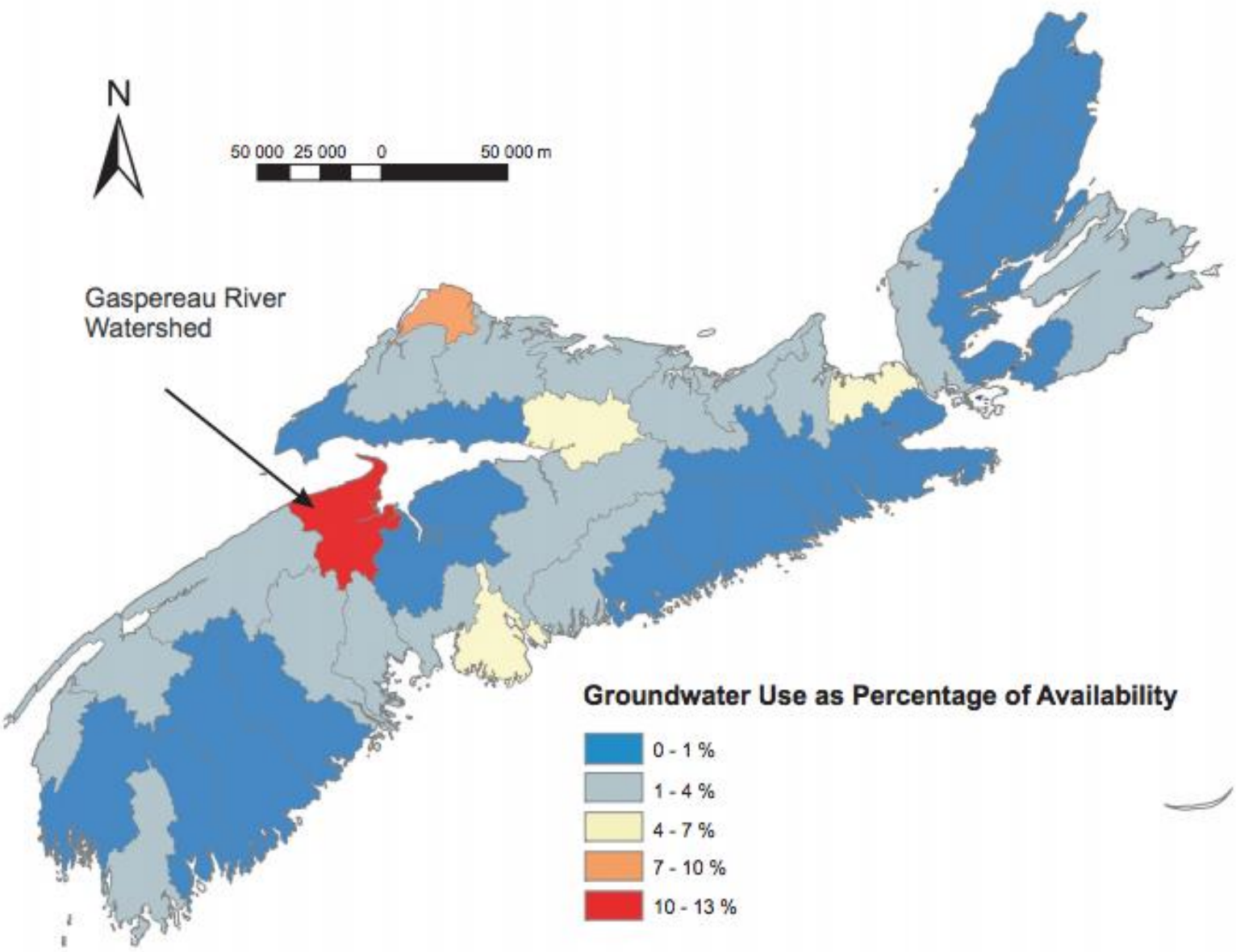
VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

Impacts on Water Resources

- Water use for hydraulic fracturing would likely not lead to issues of water demand for the majority of the province.
- Water withdrawals for shale gas, or any other industrial activity, would require approval from NS Environment and be subject to public scrutiny.
- Direct aquifer contamination from hydraulic fracturing fluids would appear unlikely.

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment


N
50 000 25 000 0 50 000 m
Gaspereau River
Watershed
Groundwater Use as Percentage of Availability
0 - 1 %
1 - 4 %
4 - 7 %
7 - 10 %
10 - 13 %

Water Usage Estimates for Lower Medium and Upper Medium Natural Gas Scenarios

		Water Usage per Well (ML)		Total Usage (ML)		
	No. of Wells	Low	High	Low	High	
Lower Medium Case	4000	5.9	6.8	23600	27200	
Upper Medium Case	12000	5.9	6.8	70800	81600	

Based on CCA estimates

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

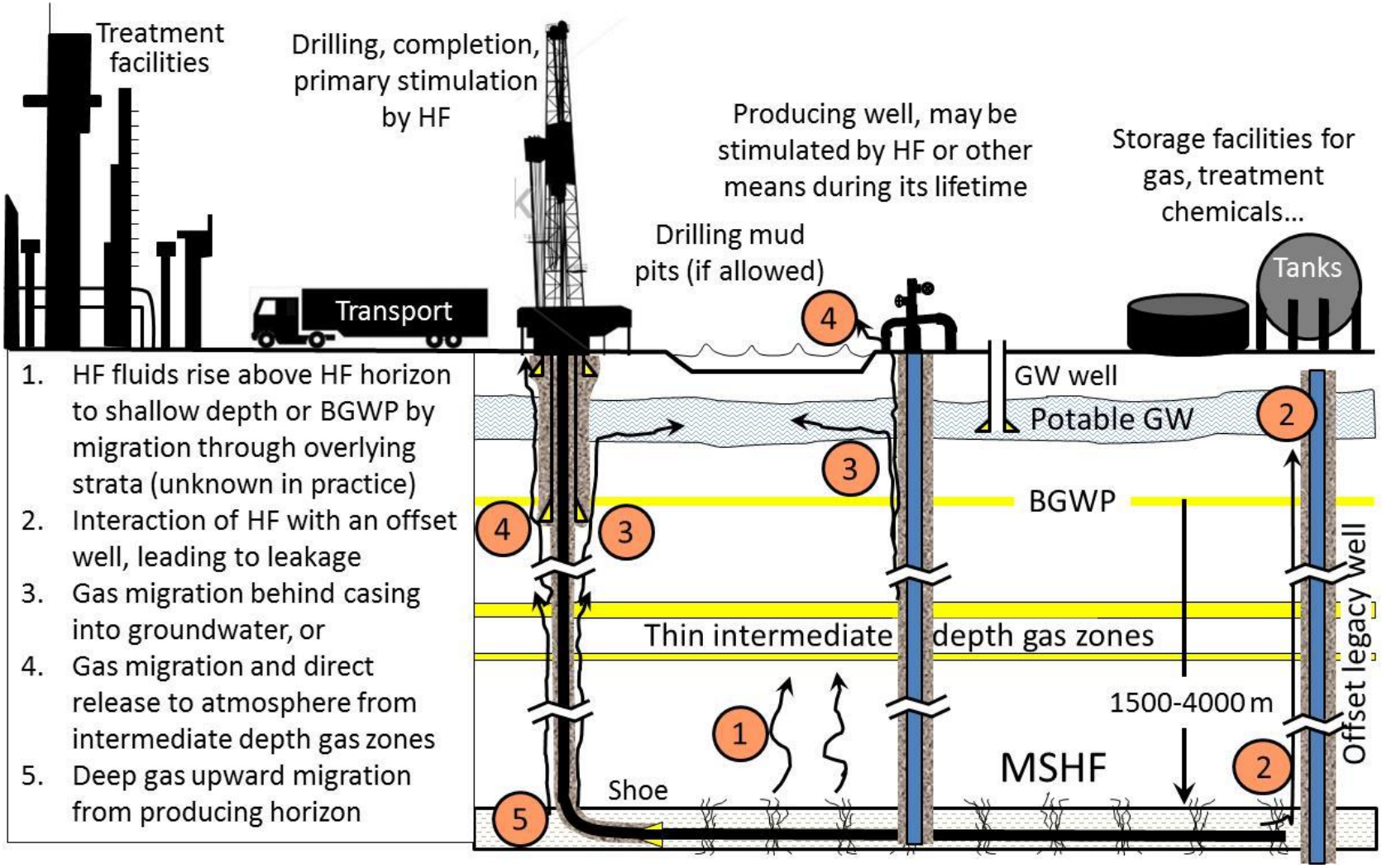
Impacts on Water Quality

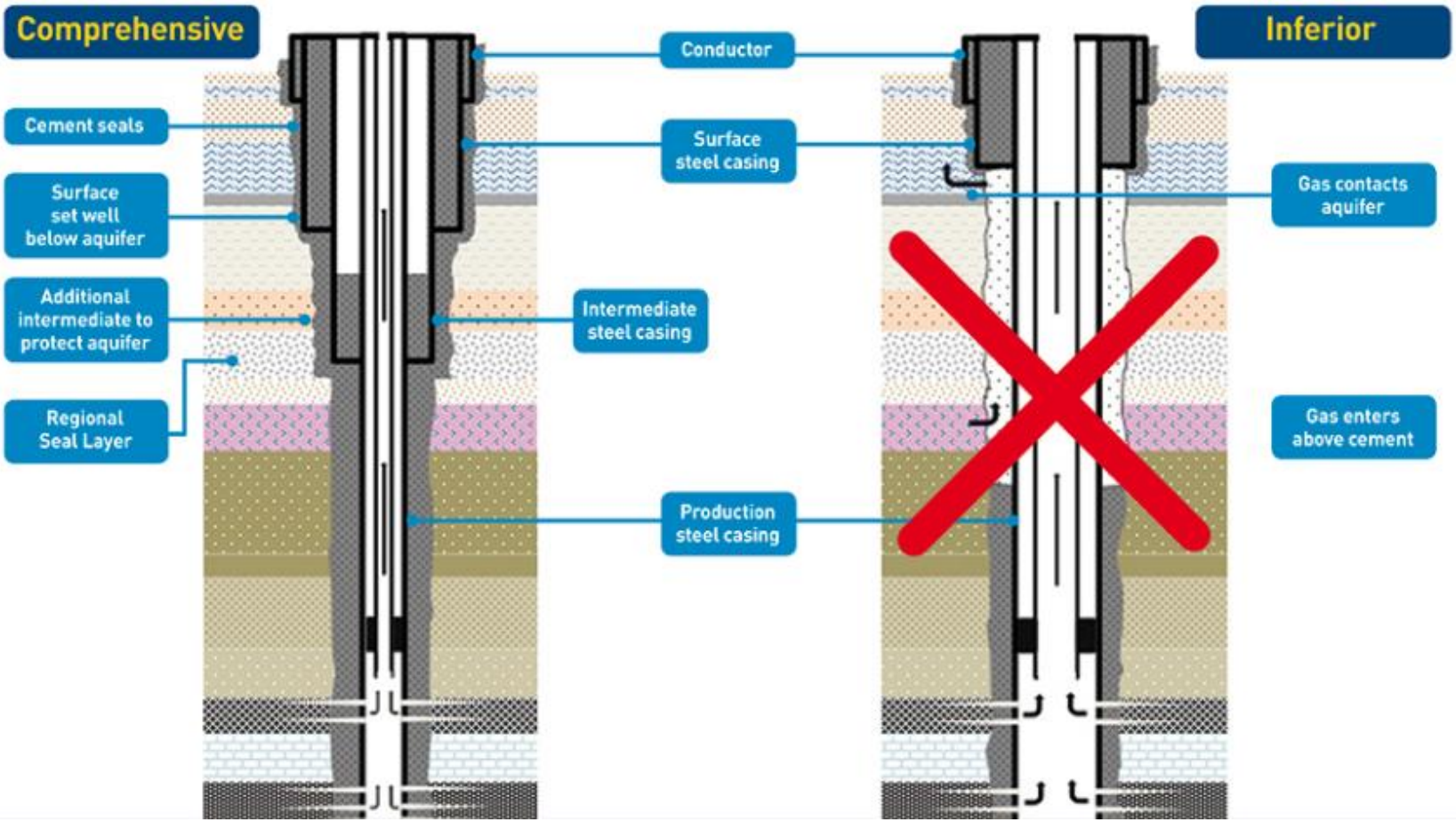
- Risks to water quality from shale gas operations is more related to operational practices (e.g., chemical handling; waste management) rather than the fracturing and extraction process.
- The Council of Canadian Academies (2014) reported that the risks that shale gas infrastructure and related operations pose to surface water and groundwater stem from:
  - accidental spills of chemicals, oils, drilling muds, and fracture fluids during transportation, storage, or use;
  - spills of condensates (where these are present) or flowback water from the producing well; and
  - inadequate storage, treatment, or disposal of flowback water, which includes both fracturing fluids and saline formation water, and leaks from surface storage ponds or other storage facilities

Well Integrity

- Because possible future unconventional resource development in Nova Scotia would take place using modern technology with multiple wellbores installed at each drilling site, it is a relatively straightforward task to establish good regulatory practices (guidelines and enforcement), quality control, and monitoring to ensure that the site is geologically understood, that wells are properly installed, and that well abandonment is done according to best practice guidelines.
- The establishment of an appropriate monitoring and regulatory system for onshore Nova Scotia will clearly be needed if unconventional oil and gas resource development ever takes place, regardless of scale.

Potential Subsurface Contamination Pathways





Source: Cuadrilla

Well Integrity

- Nova Scotia geological conditions are reasonably stable; this should lead to a low incidence of poor wellbore integrity for the following reasons:
  - Moderate tectonic stresses and dense competent rock in the subsurface mean that wellbore quality will be excellent (good stability, little drill-hole sloughing), facilitating the installation of high quality well casings, and therefore resulting in fewer cases of leaking wells in the long-term.
  - Except in Nova Scotia's coalbed areas, there appear to be few gas sands at shallow to intermediate depth that might lead to problems with long-term gas migration behind the casing.
  - Oil and gas in Nova Scotia are likely to be sweet (little or no associated hydrogen sulphide gas), making all operations easier and casing life longer, compared to some other jurisdictions.

Well Integrity Risks

- The risks, including probability and consequences associated with inadequate well integrity are not great, as shown by years of experience with hundreds of thousands of wells in the western provinces.
- The three main methane related risks are:
  - contamination of groundwater, by turning it unpalatable
  - escape of natural gas to the atmosphere, where it has a greenhouse gas effect
  - direct safety risk associated with potential explosion of an accumulation of gas in a confined space
- Water related risks can be baseline monitored and regulated

Public Participatory Risk Assessment

- Challenging to assess the potential benefits and costs of hydraulic fracturing for shale gas and its environmental impacts.
- A holistic and inter-disciplinary approach exploring potential benefits and risks within the geography, ecology, culture, policy frameworks and public perspectives in Nova Scotia is therefore required.

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

Public Submissions

Table 2: Type of Unique Submissions to the Expert Panel on Hydraulic Fracturing (n=238)

Group Type	**Number**
Citizen	215
Professional Organization	10
Environmental organization	6
Industry	3
Municipal	2
Community Group	2
Total	**238**

Table 4: Ranking of Public Issues and Concerns Mentioned in Unique Submissions (n=238) to the Expert Panel on Hydraulic Fracturing

Rank	Main Themes	Coded Sub-Themes ranked by the number of comments (in brackets)	Total Number of Comments
1	Water	Contamination (79), Massive usage (36), General (29), through well failure (7), fluid migration (4), access (3).	158
2	Community and Infrastructure	Damage to roads and other infrastructure (33), social impacts (32), urban and rural industrialization (17), noise pollution (13), First Nation consultation (13), increased traffic hazards (10), fear of becoming locked into industry (8).	126
3	Economy	Impact on: Agriculture (30), tourism (20), forestry (2), fisheries (1), distillery (1); property value decrease (21), overall negative impact on economy (9), questions abundance of resource (8), job creation overblown (5), vacancy rate decrease (2), self sufficiency + (1)	100
4	Waste and Cleanup	Wastewater disposal/storage (66), spills (7), NORM (6), Contamination (5), tailing leakage (3), concern for what is left behind (2).	89
5	Human health	Air quality (36), General (20), effect of close proximity (10), NORM effect (8), effects from fluids (6), mental health (4), impact on marginalized (2), Birth defect and fertility (2)	88
6	Climate change	Methane leaks/GHG contribution (31), Bridge fuel (18), climate impact (14), fossil fuel dependence (12), ozone (6), machine emissions (3).	84
7	Policy and regulation	Enforcement/monitoring (24), Precautionary principle (13), Enhance/update regulation (13), Impact/spill insurance (8), consultation between parties (8), balanced approach (3), best practices policy (3), education (2), need for chemical content disclosure (1).	75
8	Other Environmental Issues	General impact (19), Earthquake concerns (15), Habitat fragmentation (10), soil contamination (8), chemical composition of fluid/waste and effects (8), Animal Health/SARA (6), industrialization (3), risk to geology (1), sand usage (1)	71
9	Industry deception	Perceived dishonesty (28), Profit motives (9), Chemical composition disclosure (8), non-disclosure agreements (8), Disregard for Community and worker safety (8)	62
10	Inadequacy of Science	Inadequate data (13), long term unknown (12), casing failure (9), no evidence for concern + (6), new technique (3), hydrology of NS unknown (2), geology (1)	46

Notes: For each submission, discrete topics were coded, and totals for the themes and sub-themes represent the number of times unique issues were raised within all 238 public comments. Numbers in brackets indicate how many times sub-themes were mentioned and add up to the total for that theme.

Assembly of Nova Scotia Mi'kmaq Chiefs

The Mi'kmaq are opposed to all activities associated with hydraulic fracturing taking place on their traditional lands, and their priority is to protect the lands and the waters.

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

Native Council of Nova Scotia

The community of Mi'kmaq/Aboriginal peoples continuing on traditional ancestral homelands organized as the Native Council of Nova Scotia, oppose the practice of hydraulic fracturing for oil and gas in Nova Scotia.

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment


PRINCE
EDWARD ISLAND
NEW
BRUNSWICK
Wagmatcook
Membertou
We'koqma'q
Eskasoni
Pictou
Landing
Chapel Island
Paq'tnkek
Glooscap
Annapolis
Valley
Millbrook
Indian Brook
Bear River
NOVA
SCOTIA
Acadia
Nova Scotia
Mi'kmaq First Nations

Aboriginal, Treaty and Statutory Rights of the Mi'kmaq

- The Mi'kmaq people possess robust Treaty rights as well as Aboriginal rights in Nova Scotia.
- These rights have considerable consequences for provincial deliberations over hydraulic fracturing, as the province is constitutionally obliged to honour these rights

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

Aboriginal, Treaty and Statutory Rights of the Mi'kmaq

- The term 'Aboriginal rights' refers to the inherent rights of Aboriginal peoples. These rights have been held by Aboriginal people since before European contact and persist to this day. They were not bestowed upon Aboriginal peoples by the British or Canadian government.
- The term 'treaty rights' usually refers to historic promises and obligations that Aboriginal peoples and Britain or Canada formally enshrined in treaties prior to 1930.

Treaty Rights of the Mi'kmaq

- The treaty situation in Nova Scotia is unique. It is marked by a series of Peace and Friendship Treaties that were entered into during the 1700s.
- The enforceability of two of the historic Peace and Friendship Treaties has been litigated: they were found to be enforceable agreements.
- These treaties were motivated by mutual interests in cooperation and the Mi'kmaq continuing to have self-sufficient communities, as well as Britian's interest in securing a military and political alliance.
- They do not give up any Mi'kmaq land rights, and shield and preserve Mi'kmaq Aboriginal rights to hunt, trap and fish.

Aboriginal and Statutory Rights of the Mi'kmaq

- Mi'kmaq have inherent rights to hunt and fish
- Absent evidence of analogous historic activities, it is unlikely that the Mi'kmaq have an Aboriginal right to subsurface gas on traditional territory
- However, the situation changes if Mi'kmaq people have Aboriginal title rights

Recent Supreme Court Decision

The court was explicit that the rights of Aboriginal title holders include:

- The right to decide how the land will be used
- The right of enjoyment and occupancy of the land
- The right to possess the land
- The right to pro-actively use and manage the land, and
- The right to “profit from its economic benefits”

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

Reserve Land

- Regardless of [forthcoming] legislation not yet being in place, it seems extremely unlikely that hydraulic fracturing could take place on reserve land without the explicit consent of the affected First Nation.
- Mi'kmaq reserve residents benefit from protections in the face of hydraulic fracturing proposals that are not currently guaranteed to other communities in Nova Scotia, such as a clearly legislated right to an environmental assessment.

General Regulatory Issues

- Roles for all levels of government in regulating HF, including municipalities
- Principles of effective regulation need to be understood and followed
- Need a comprehensive, publicly trusted and fully resourced regime that includes independent systems for risk management, including monitoring, inspection and enforcement
- Need mechanisms to directly empower citizens and communities at key decision-making stages

More Information

Email: hfreview@cbu.ca

Website: www.cbu.ca/hfstudy

Discussion Papers: www.cbu.ca/hfstudy/resources/project-documents

This Presentation: www.cbu.ca/hfstudy/resources/project-documents

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment

How Would Unconventional Exploration and Development Unfold in Nova Scotia? (if we ever got that far)

- Basins are lightly explored
  - Exploration would require a systematic approach over several years
  - Build on existing knowledge – we have the most in basins with existing wells and seismic, and those closest to existing oil and gas production in NB
- Stage 1 – Basin Assessment
  - Regional mapping, acquire new seismic, identify target areas
- Stage 2 – Stratigraphic Testing
  - Drill vertical wells to gather data on unconventional reservoir characteristics
  - Take cores from prospective intervals; run laboratory tests to assess reservoir parameters (mineralogy, porosity, organic content, thermal maturity)

How Would Unconventional Exploration and Development Unfold in Nova Scotia? (if we ever got that far)

- Stage 3 – Initial Appraisal / Development Testing
  - Drill horizontal wells; experiment with drilling and completion parameters
  - Length of horizontal section; number, size and spacing of fracs
- Stage 4 – Full Scale Development
  - Economic analysis must support development expenditures
  - Continue to optimize drilling and completion techniques
  - Build infrastructure – gas processing, oil batteries, pipelines

How Would Unconventional Exploration and Development Unfold in Nova Scotia? (if we ever got that far)

- Each unconventional reservoir is different
  - Lessons learned in one reservoir unit are useful, but each reservoir in each basin must be assessed, developed, and optimized individually
- Several years and tens to hundreds of millions of dollars must be spent to delineate and appraise unconventional reservoirs
- Once economic value (sufficient oil and gas reserves) has been demonstrated, then larger-scale, long-term (likely decades) development can be undertaken

CAPE BRETON UNIVERSITY

VERSCHUREN CENTRE
For Sustainability in Energy and the Environment