# The Public Policy Implications of Shale Gas Extraction in Canada

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With recent developments in horizontal drilling and hydraulic fracturing of gas bearing sediments, previously marginal shale gas resources are being considered for development throughout Canada. The techniques and technologies used in extracting gas from shale formations are more aggressive than previously employed in conventional gas wells.

The goal of the paper is to look at the potential areas for shale gas extraction and analyze the impact that further development would have on water resources. A review of policy options available to control the shale gas extraction business will be considered as well as recommendations for regulating the industry to minimize its environmental impacts on water resources in Canada.

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## 1. Introduction

As conventional sources of hydrocarbons become more and more scarce, there is an inclination to try and use unconventional methods to exploit the more marginal resources. Instability in the energy market causes prices to rise and as does the scarcity of conventional deposits. This creates an economic imperative to examine previously overlooked deposits to see if there is an alternate way to coax the material from the ground. This has revolutionized the natural gas business in the past decade. According to US Energy Information Administrator, Richard Newell,: "Shale gas development drove an 11 percent increase in U.S. natural gas proven reserves last year, to their highest level since 1971, demonstrating the growing importance of shale gas in meeting both current and projected energy needs," (Department of Energy 2010). The gas industry has combined the traditional hydraulic fracture mechanism with breakthroughs in horizontal drilling to turn unprofitable deposits into lucrative ones. Two major players in Canada are Talisman Energy which acquired the mineral rights to one million acres in the St. Lawrence Lowlands in Quebec and Encana Corporation which has purchased the mineral rights to two million acres in British Columbia. One of the formations of interest in North America is the Marcellus shale which the US Geological Survey estimates to contain 84 trillion cubic feet of undiscovered, technically recoverable natural gas.(US Geological Survey, 2011) which is 3 per cent of the United States total natural gas deposits which is estimated at 2,500 trillion cubic feet ). While the Canadian production of shale gas is significantly less, studies show there is potentially (1,000 trillion cubic feet) of shale gas in Canada if not more.(National Energy Board 2009)

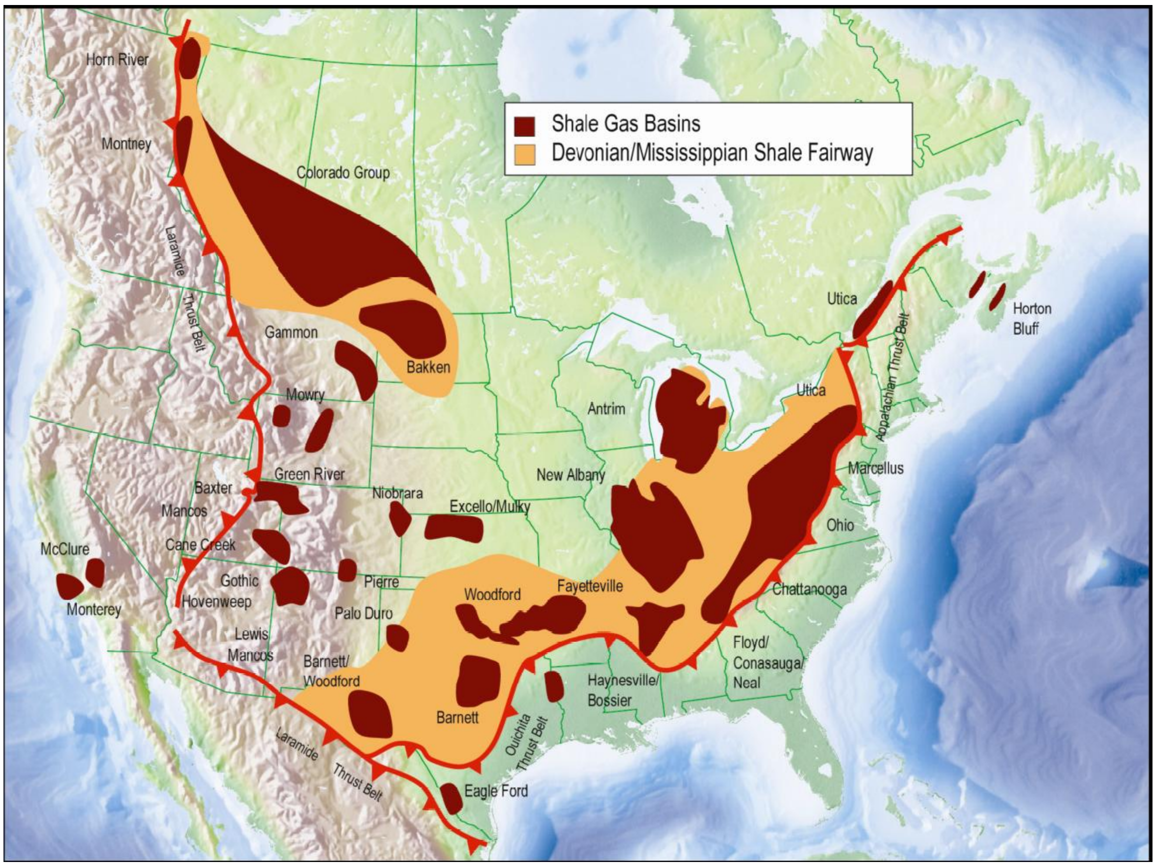
The potential of this once marginal, now profitable source of energy is encouraging a lot of activity in this field.

The “gold rush” in shale gas land claims has led to an equal backlash in calls for conservation of water use, regulation of groundwater and additional testing for water contamination.

## 2. Shale Gas Formations in Canada

The following map shows the location of major shale gas fields in North America :

Figure 1:




Source: National Energy Board, 2009

## British Columbia

The province has two major shale gas formations. The largest is the Montney Formation – The production of natural gas from horizontal shale gas wells in the Montney region of northeast B.C. began in 2005 and continues to grow yearly. In 2009 there were over

230 horizontal wells in the area (National Energy Board, 2009). The gas rights are owned by the BC governments who have sold drilling rights to private companies for more than $2 billion. . Horn River Basin - Wells in this basin in northeast British Columbia are prolific and produce an average initial flow rate of 230,000 cubic metres per day (8 million cubic feet per day) with the top wells ranking amongst the most productive drilled in Western Canada last year. Exploration companies such as Encana have spent over $2 billion to acquire resource rights in this basin. (National Energy Board, 2011).

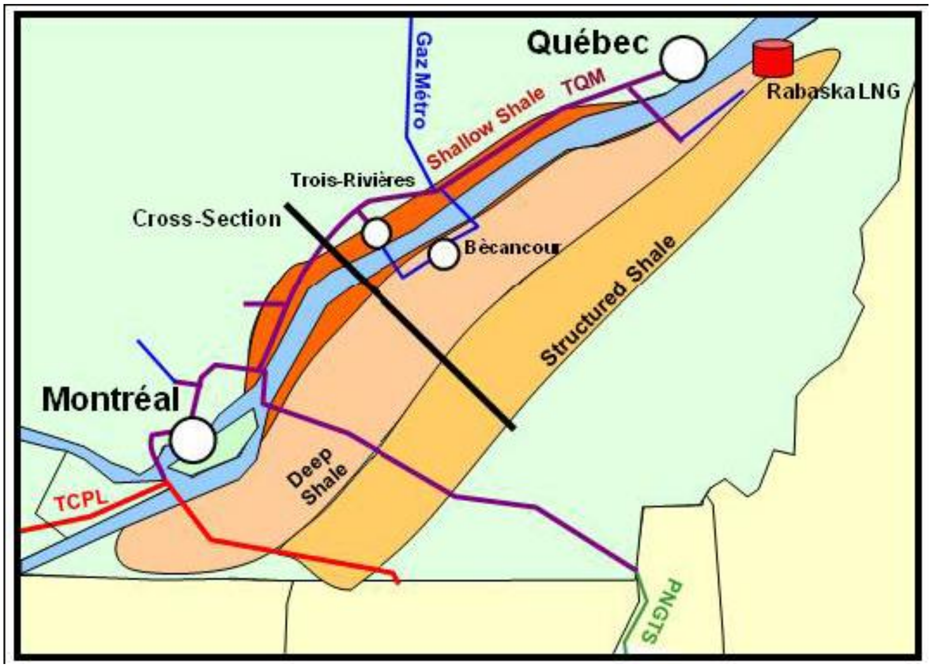
## Alberta and Saskatchewan

The formations of the Western sedimentary basin are referred to as the Colorado Group and are found in southern Alberta and Saskatchewan. These formations have been producing natural gas from shale for over 100 years, primarily through vertical, conventional drilling due to the fissile nature of the rock conditions and the risk of caving in the wellbore. (National Energy Board, 2009).

## Quebec

The shales of the Utica Group are located between Montréal and Quebec City in the St Lawrence Lowlands basin have a high potential for natural gas production. The development of shale gas from the Utica Group is still in the early evaluation stages with only 29 wells drilled to date (National Energy Board, 2009). The Quebec government has put a moratorium on further drilling as a result of a public inquiry held by BAPE, the environmental public-hearings board (Macpherson 2011).

Figure 2: Location of Shale Gas Formations in St. Lawrence Lowlands




Source: Ziff Energy Group, 2008.

## New Brunswick and Nova Scotia

Horton Bluff Group - While still in the early evaluation stage, two vertical wells drilled in New Brunswick have flowed 4,200 cubic metres per day (0.15 million cubic feet per day) after undergoing small fractures. (National Energy Board, 2009)

**Figure 3: Comparison of Canadian Gas Shales**

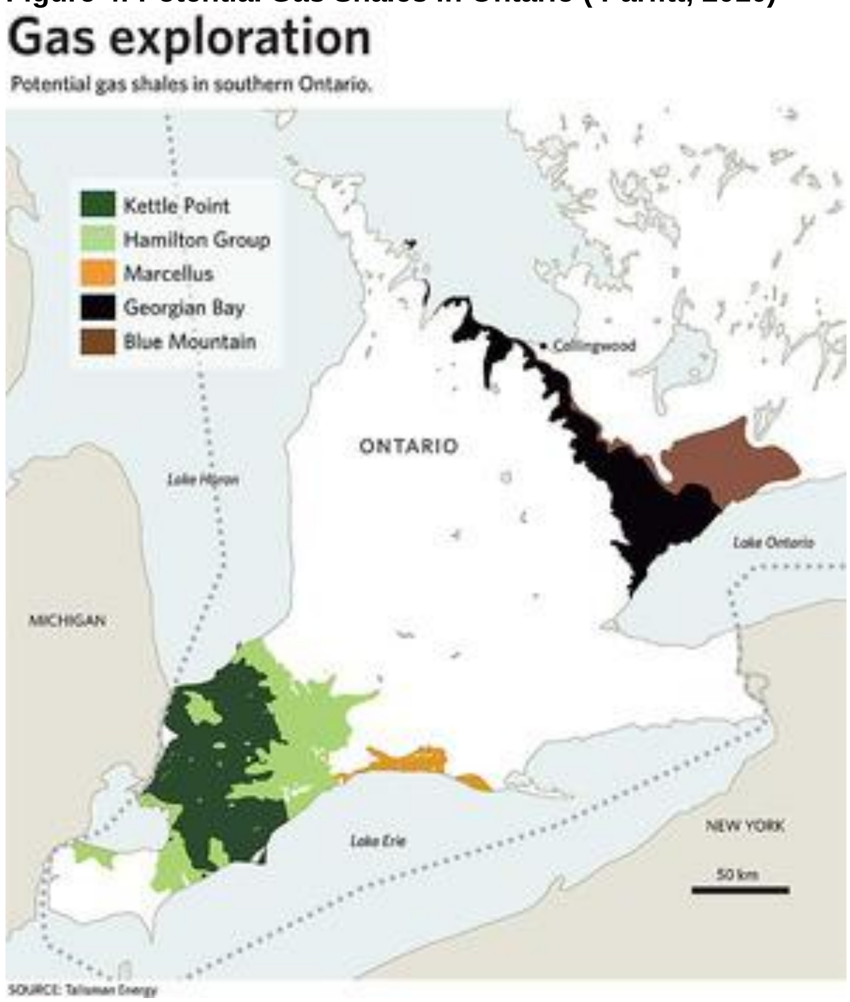
| | Horn River | Montney | Colorado | Utica | Horton Bluff |
|---|---|---|---|---|---|
| Depth (m) | 2,500-3,000 | 1,700 -4,000 | 300 | 500 -3,000 | 1,120-2,000 |
| Thickness (m) | 150 | Up to 300 | 17 - 350 | 90 - 300 | 150+ |
| Natural Gas Estimate * Trillion cubic feet | 144 – 600+ | 80-700 | > 100 | > 120 | >130 |
| Horizontal well cost (Million $ CDN) | 7-10 | 5-8 | 0.35 (vertical only) | 5-9 | unknown |

Source: National Energy Board, 2009

**Ontario**

The potential for shale gas extraction in Ontario does not seem as significant as it does for other provinces. There are five formations that could contain sufficient shale gas reserves to make them economically attractive to energy companies. The most likely to be developed are the Kettle Point/ Hamilton Group Formation of Lambton and Chatham-Kent counties (an extension of the Antrim Shale formation of central Michigan) and the Collingwood Shales of central Ontario (an extension of the overlying shales of Michigan (Hamblin, Carter and Lazorek, June 2008). The Marcellus Shale that has been so greatly exploited in Pennsylvania also may bear some potential gas in Elgin County.

**Figure 4: Potential Gas Shales in Ontario ( Parfitt, 2010)**

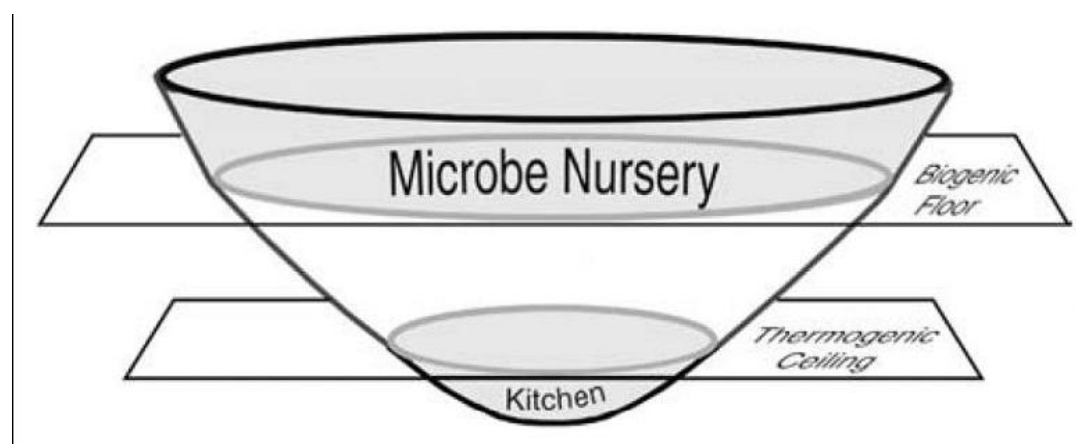


### 3. Shale Gas Generation

It is important to distinguish between the two ways that shale gas forms. One type is buried deep in the ground (several kilometers) and is known as “thermogenic” in that the methane generated is the result of heating and pressurizing of ancient organic matter, It tends to contain more carbon dioxide and is laterally distributed. For this reason horizontal drilling is usually required to extract it. The other way in which methane is formed is at shallow depths where live bacteria from glacial melt water metablolize the organic matter found in shale. This mechanism of formation is known as “ biogenic” or the microbe nursery. The methane from this process is considered geologically young (Shurr and Ridgley 2002). The pocket of shale gas from this mode of formation is relatively closely distributed and can be accessed by vertical drilling. The two types of shale gas generation are illustrated in Figure 5.

**Figure 5 Biogenic (Nursery) and Thermogenic (Kitchen) Methane Generation**

**100 of metres**




**several kilometers**

Source: Shurr and Ridgley, 2002

Regardless of the mode of formation, shale gas stays close to where it was formed, unlike oil and conventional natural gas which migrate to porous voids or pockets in the earth's crust. Shale gas stays in place because it is trapped in tiny pores; it as adsorbed to electrostically charged clay minerals, or it is dissolved in organic matter.

The in situ nature of shale gas means that it not concentrated within the formations and can extend laterally and vertically for several kilometers (Shurr and Ridgley 2002)

The pores by which shale gas would have to move if they were to be extracted by a well are 1000 times smaller than the pores of a sandstone oil reservoir rock (National Energy Board, 2009 .) Not only are the pores small but they are not lined up to flow gas or liquid efficiently through them. Shale gas formations have a low permeability compared to other sedimentary formations.

As a result of shale gas being trapped in formations of low porosity, low permeability and low concentrations, it has historically been left in the ground.

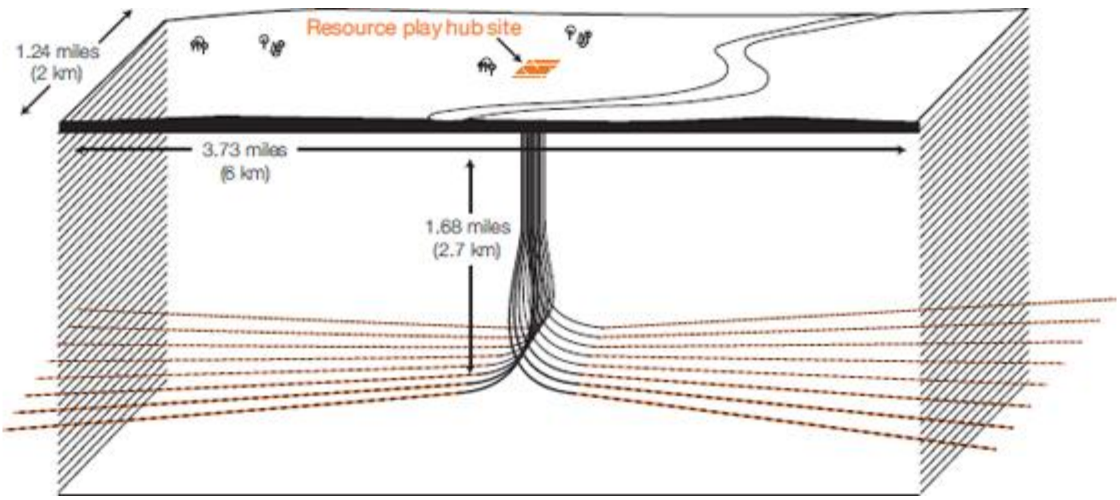
**4. A Description of the Hydraulic Fracturing Process**

The practice of injecting compressed water underground to liberate trapped hydrocarbons has been in existence for 65 years. (Parfitt, 2010). It was limited in its application and characterized by low volumes of water usage and minimal use of chemical additives.

Technological innovations such as the horizontal drilling (Parfitt, 2010), chemical additives and radial fracture patterns have greatly increased the amount of water consumed in the process and the possible contamination of ground and surface water as a result of this activity. The equipment used in the hydraulic fracturing process is summarized is very intensive. A typical hydraulic fracture could use a million cubic meters of water carried by 100 tanker trucks.

The process begins with a central vertical shaft being drilled into the overburden. When the drill bit enters the natural gas bearing shale layer, it begins to curve into a horizontal plane. This process is repeated several time times so that a radial pattern of drill holes is established Figure 6.

**Figure 6: Horizontal Drilling Patterns**




Source: Encana, 2011

At this point, either a small explosive charge is put in the drill holes, or a concentrated surge of high pressure water is injected into the shale formation to fracture the fissile layers of shale.

Once the rock fractured, tiny pathways are created which liberate the natural gas and allow it to flow to the surface. To ensure maximum flow rates, sand particles and chemical additives (to reduce the surface tension of the water) are added to the water slurry that is pumped into the gas well.

The combination of pressurized water (5000 -15,000 psi), sand and additives is designed to create a connective network of new and existing fractures. The pattern by which this fracturing happens has been described as non-linear or chaotic. The cracks not only propagate laterally but also potentially vertically (Ingraffea and Heuze 1980) . This can create a preferential pathway for hydrocarbons and fracturing fluids to migrate upwards to an aquifer or to surface water source.

**5. A Description of the Threat**.

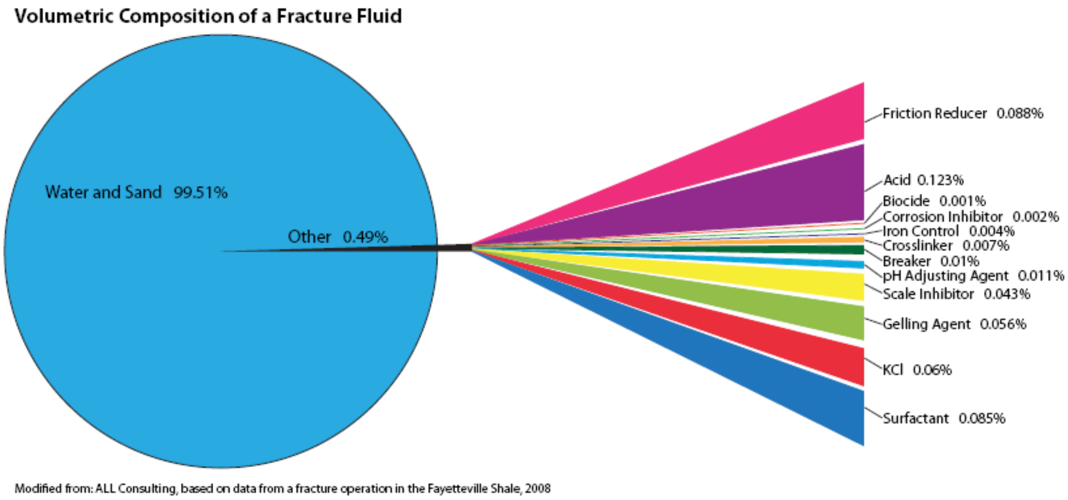
The threat that hydraulic fracturing poses to the environment occurs in multiple ways:

1. Large volumes of water are consumed.
2. Hazardous chemicals are released into the environment. (methane, fracturing fluids can contaminate the aquifer and surface water)
3. Large volumes of waste water are generated that either have to be treated or stored.
4. Carbon dioxide is emitted into the atmosphere during the extraction process

Drilling companies consider the composition of their drilling additives as proprietary.

A typical breakdown of the composition and concentration of fracturing fluid is given in Figure 7:

**Figure 7: Composition and Concentration of Fracture Fluid**




Source: Canadian Society for Unconventional Gas, 2011

As a result the composition of these additives is not well known, however two chemicals that have been identified are benzene and diesel . Both these chemicals have are considered threats to water supply. Other elements detected in wells proximal to shale gas operations in Pennsylvania include: gross alpha radiation, radium 226, radium 228, uranium 235 and uranium 238, barium and strontium (Urbina, 2011)

The other issue that the gas companies try to dodge is the volumes of the chemicals that they use. With no knowledge of the composition and the volumes, regulatory agencies are in the dark as to the concentrations of hazardous chemicals being introduced into the environment and therefore no meaningful toxicity studies can be carried out.

As the name implies, hydraulic fracturing produces cracks in the shale layer where the water is injected. The associated threat with this activity is that the underground fracturing will create preferential pathways for the natural gas and chemical additives to migrate upward into aquifers and surface water.

## 6. Review of Existing Controls

The following table (Parfitt, 2010) illustrates the aspects of hydraulic fracturing regulation in Canada:

### Figure 6. Current Controls across Canada

| Province | Water Allocating Authority | Publish Water Use? | Require Disclosure of Fracking Chemicals? | Require Groundwater Mapping before Fracking Approved? |
|---|---|---|---|---|
| British Columbia | Energy Regulator | NO | NO* | NO |
| Alberta | Environment | NO | NO | NO |
| Saskatchewan | Environment | NO | ? | NO |
| Ontario | Environment | NO | ? | NO |
| Quebec | Environment | NO | POSSIBLE** | NO |
| New Brunswick | Environment | NO | POSSIBLE*** | NO |

* British Columbia's Oil and Gas Commission has indicated that new regulations may require disclosure of fracking chemicals

** In Ontario there is no explicit requirement for disclosure of the chemicals. However, if any treatment is done on a well, a report must be submitted to the Ministry of Natural Resources providing information on the depth, type of treatment fluid and amount of proppant (sand, glass beads, etc.) used. Also, under Ontario's *Oil, Gas and Salt Resources Act*, an inspector has the authority to require a report, which could include such information.

** *New Brunswick's Department of Environment says that under its authority to grant Approvals to Construct, a company seeking to inject water and chemicals underground in fracking operations could be required to disclose chemical contents

Only in British Columbia, is an energy regulator, the provincially appointed Oil and Gas Commission, authorized to allocate water resources for the use of hydraulic fracturing. In all other provinces, it is an Environmental agency that grants permits to take water. No provinces publish water consumption statistics related to hydraulic fracturing. British Columbia and Alberta have no requirements for the disclosure of the composition of chemical additives used in hydraulic fracturing. In Quebec and New Brunswick, it is possible that in the permit granting process the formula may be requested. In Ontario and Saskatchewan, there is no requirement for disclosure unless in Ontario the substances are listed by the Toxic Reductions Act, 2009. No province requires that groundwater mapping has to be conducted prior to the approval of hydraulic fracturing. In Ontario, the activity of operating a natural gas well is governed by the Oil, Gas and Salt Resources Act, 1990, in conjunction with Section 40 of the Ontario Energy Board Act, with respect to granting of drilling permits by the Ministry of Natural Resources. It covers the establishment, alteration, enlargement or extension of sites or systems. In addition, the taking of water for the process of hydraulic fracturing would require a permit issued by the Ministry of the Environment under the Ontario Water Resources Act.1990. The provincial officer or agency inspector can suspend the permit if they deem impairment of the water resource.

The Ontario Mining Act 1990 covers the issuance of drilling permits and specifies mine reclamation activities once the well is abandoned. While the Ministry of Natural Resources regulates the leasing of Crown Land, it does not govern the leasing agreements established for private property drilling.

The extraction of natural gas by way of an underground pipeline is not a prescribed threat listed in the Clean Water Act, Ontario Regulation 287/07. However in Ontario, Source Protection Committees can apply to the Director of the Source Protection Program Branch to include hydraulic fracturing as this local threat given the toxicity and potential negative impact to a municipal drinking water system. This could be identified as a local threat by Lower Thames Valley and Chatham Source Protection Committees which have jurisdiction in Lambton and Chatham-Kent counties where gas companies have obtained the leases for gas exploration.

**7. Discussion:**

By looking generally at the existing legislation across the country and by looking specifically at legislation in Ontario, it is my conclusion that the existing regulatory framework governing hydraulic fracturing is inadequate to ensure the safety of drinking water and prevent degradation of the natural environment. For example, much of the terminology in the Oil, Gas and Salt Resources Act, is too general and would be difficult to apply to hydraulic fracturing. Other legislation such as Ontario Water Resources Act and the Mining Act are reactive in nature. Hydraulic fracturing technology has developed greatly in the past decade whereby the legislation that applies to it is at least twenty years old. It is also unclear who would have authority if a shale gas formation and/or aquifer straddles a provincial boundary.

There are a great number of unknowns surrounding the activity of shale gas extraction based on the newness of the technology and lack of knowledge about the volume and movement of groundwater in Canada's aquifers. No comprehensive mapping of Canada' s groundwater resources has been conducted since 1967 even though there has been a commitment to map Canada's regional and national aquifers as expressed by the Canadian Groundwater Strategy. **(**Geological Survey of Canada, 2009). Without detailed knowledge of groundwater quality, quantity and the dynamics of its movement, it is very difficult to scientifically evaluate the impact of human activities on our aquifers. For technologies such as hydraualic fracturing, it is paramount to determine whether contamination and over usage will take place, prior to the granting of approvals to drill. The understanding of what happens to a shale formation and the layers of rock above after hydraulic fracturing clearly need to be better understood. Gas companies say that all the fracturing is horizontal and lateral to the formation while opponents of the process say there is a vertical component to fracturing which will endanger aquifers and surface water. The truth may be somewhere in between and it will only be ascertained by more research in this field.

The industry has been slow in revealing the composition of their fracturing fluids, stating that it is propietary information. This position will be difficult to defend in the future as most jurisdictions are aware of the impacts of these substances and are at least thinking about imposing some disclosure requirement for fracturing fluids. There is a wealth of anecdotal evidence coming from the United States of water taps on fire and skin rashes caused by showering in well water, chronicled in such documentaries as Gasland. As public opinion turns, gas company executives are softening their stance on disclosure.

## 8. A Framework for Policy Formulation

The Ontario Ministry of the Environment provides a useful tool to formulate policies (see Appendix Table1). The first tool in this framework is prohibition, which is exactly what the state of New York did by imposing a moratorium on hydraulic fracturing in the Utica Shale formation. They did this based on the proximity of the drilling to the Catskills and Skaneateles watershed and the fact that 8.2 million New Yorkers received their drinking water untreated from those watersheds. A similar ban is being considered by the province of Quebec, due to the shallow nature and the large number of people who receive their drinking water from the St. Lawrence River watershed between Montreal and Quebec.

The second tool is regulation which could require a gas company to provide a risk management plan to deal with leaks and spills in the drilling process, the containment and disposal of waste water, storage of chemical etc. This is widely applied to industry and provides some prevention measures but generally is reactive in nature.

The third tool is restricted land uses which are effective to curtail activities if they are close to areas that are considered off limits (aboriginal lands, wildlife migratory routes, etc).

The fourth tool is prescribed instruments which are commonly used by provincial governments in their issuance of drilling permits, permits to take water, mineral rights and land leases. Generally most of the activity occurs as part of the application process with little control being exercised during the term of the agreement due to a lack of enforcement resources.

The fifth tool of land use planning (considering future threats) is effective to direct future growth and exploration to areas of low risk while preventing expansion into areas of high risk.  Probably most useful in populated areas like the St. Lawrence Lowlands/ Southern Ontario regions.

The sixth tool is education, outreach/ incentive programs which could be applied to gas companies and their suppliers to investigate the least toxic formulations of fracturing fluids while achieving their production results.

The seventh tool is a catchall which includes best practices, knowledge and basic research which is a huge component of the fracturing issue.  Given the unknown parameters that relate to groundwater in Canada, this is a most important to include in any policy decision.

**9. Recommendations**:

1. Establish a commission to review existing federal and provincial legislation, as it would apply to the hydraulic fracturing and determine the extent of centralized and decentralized controls necessary to adequately govern current and future activities. Part of this mandate should be to ensure that the approval authority for drilling rights is overseen by an environmental authority rather than energy authority. **Best practices, knowledge and basic research tool**

2. Require the disclosure of all chemical additives and formulations used in the hydraulic fracturing process in terms of their composition and concentration as part of the permitting process. **Prescribed instrument tool**

3. For large scale projects, a full scale environmental assessment should be conducted. This would ensure that greenhouse gas emissions, energy intensity, water resource availability and utilization impacts are all considered as part of the approval process. **Land use planning + best practices, knowledge and basic research tool**

4. Enter into a public/private partnership of federal/provincial ministries and gas companies to map groundwater resources in areas where potential shale gas extraction exists. This would hasten the characterization of aquifers throughout Canada, in order to provide the regulators with a scientific basis to grant or deny drilling permits. **Best practices, knowledge and basic research tool**

5. As part of the water permitting process, gas companies should prepare a comprehensive water profile indicating the amounts of ground and/or surface water that will be taken by the hydraulic fracturing process. **Prescribed instrument tool**

6. Prior to approval, gas companies should submit a waste water treatment plan that includes the volumes and composition of wastewater that will be stored on site, disposed of underground and/or sent to wastewater treatment plants. **Prescribed instrument tool**

7. For any approval of drilling, the vertical distance from the upper boundary of hydraulic fracturing to the bottom boundary of the closest aquifer must be determined. Establish criteria for the minimum allowable separation between the aquifer and the shale bed which should take into account the nature of the inter-lying rock strata. My recommendation is that this separation should be in the order of kilometres and not metres. **Best practices, knowledge and basic research tool**

8. Establish pre and post groundwater contaminant monitoring programs in areas where hydraulic fracturing is going to occur. This would help establish baseline levels for methane and other potential contaminants in ground water. The monitoring program should be continued beyond the initial fracturing into the mid-term to provide an accurate assessment of whether or not undesirable contaminants have migrated to the aquifer.

**Best practices, knowledge and basic research tool**

9. For shale gas that is thermogenic in nature, ensure that carbon sequestration is included in the permitting process to contend with carbon dioxide releases. **Prescribed instrument tool**

**10. Conclusion:**

Is there a safe way to extract natural gas from shale beds in an economical manner? We as a society do not know. The answer will probably have to be determined on a case by case basis and through a consistently applied regulatory framework which we do not currently have either federally of provincially in Canada. What we do know is that the past ten years has been characterized by a "Gold Rush" mentality whereby large profits have been made in the absence of regulation and public input. Many jurisdictions in the United States are now finding that the cost of remediation is great – had the money been spent on planning and prevention based activities they probably would be in a much better place today. Canada is in a more favourable position to study and regulate the shale gas industry than our neighbour to the south mostly because the number of shale gas operations are, so far, small in number and scale. We still have time to employ the precautionary principle in our regulatory and legislative processes. This paper has provided recommendations for moving forward, however there are large gaps in the knowledge base. Only through comprehensive planning, data collection and analysis can any rational decisions be made. In the meantime, both federal and provincial jurisdictions need to set up robust frameworks that can adequately assess the environmental and public safety concerns brought on by the practice of hydraulic fracturing of shale beds.

## 11. Appendix

**Table 1: Summary of Policy Tools** (Government of Ontario, 2006)

| **Policy Tool** | **General Example** |
|---|---|
| Part IV Tool: Prohibition | Prohibit the activity using Section 57 of the *Clean Water Act*. This tool should only be used as a last resort and can only be implemented if there is no other feasible option. *Prohibition* is used to eliminate or prohibit the activity from occurring. |
| Part IV Tool: Regulation (Risk Management Plans) | Regulation of the activity using a Risk Management Plan under Section 58 of the *Clean Water Act* (i.e., the activity can only occur if an approved plan is in place to manage the risk to the raw water supply from that activity). *Risk Management Plans* are site specific, locally negotiated plans developed between the municipal official and the person engaged in the threat after the SPP has been approved. |
| Part IV Tool: Restricted Land Uses | Under Section 59 of the *Clean Water Act*. Some development applications under the *Planning Act* of the *Building Code Act* related to activities that would be a significant drinking water threat would be subject to certain conditions. Acts as a “pause”/ screening tool/ early warning system by providing municipalities with an administrative procedure to avoid inadvertently approving applications/building permits for activities that would conflict with Part IV policies. This tool can only be used in conjunction with Part IV Prohibition or Part IV Risk Management Plans. This is not a stand alone tool. |
| Prescribed Instruments | Policies that affect decisions to issue or otherwise create, amend, or revoke a prescribed instrument. |
| Land Use Planning (Future Threats) | Policies that affect land use planning decisions under the *Planning Act* and *Condominium Act*. In some cases it may be appropriate to manage or eliminate the threat through land use policy planning decisions (Official Plans, zoning by-laws, development agreements and site plan controls). |
| Education, Outreach/ Incentive Programs | Policies to inform and/ or elicit positive responses. *Education and outreach* can be used to inform the identified residents/ owners of the significant threat associated with their property. *Incentives* are used to encourage an action by means of support, usually financial. |
| Other: Specify Actions | *Specify the actions* to be taken to implement the source protection plan or to achieve the plan’s objectives (i.e., includes policies that rely upon other municipal authorities such as the *Municipal Act*). |

| | |
|---|---|
| Other: Stewardship programs, Best Management Practices, Pilot Programs and Government Research | *Stewardship programs* partner the landowner and the regulating authority which usually provides financial assistance to mitigate risks.<br>*Best Management Practices* are methods or techniques found to be the most effective and practice means of achieving an objective while making the optimum use of the resources available.<br>*Pilot Programs* are implemented to determine best practices.<br>*Research* is the process of gathering information for the purpose of initiating, modifying or terminating a particular project. |

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