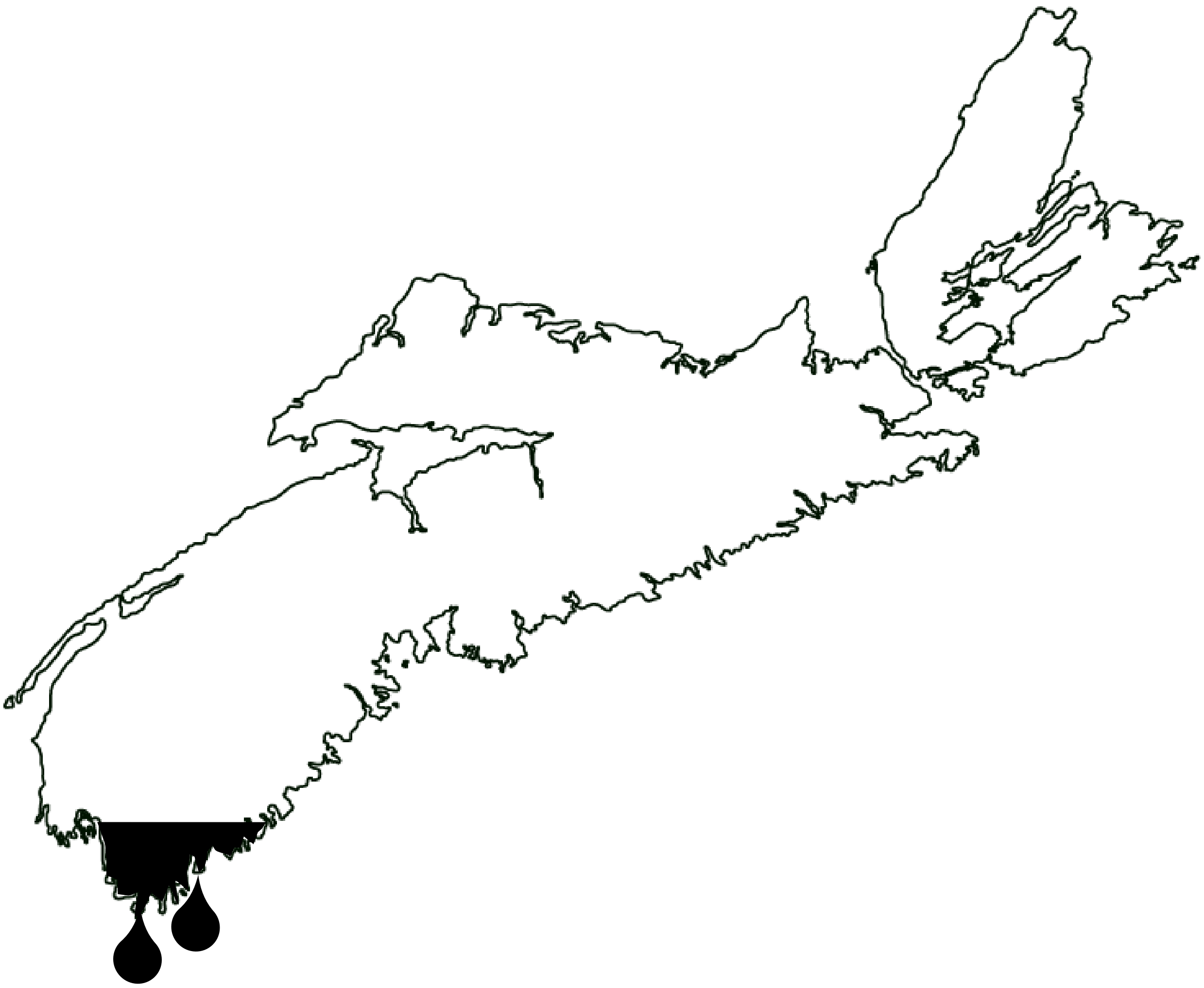
KEEP IT IN THE GROUND

THE IMPACTS OF FRACKING IN NOVA SCOTIA

Energy & Economics • Groundwater • Transportation
Food • Wilderness



Ecology Action Centre

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In Short

Hydraulic fracturing (fracking) is a relatively new technology in the oil and gas industry, with directional drilling technologies and proprietary slickwater mixtures only having been incorporated into older techniques in the past 15 years. Experience from other jurisdictions shows that fracking can have a range of environmental and socio-economic impacts.

- **Energy produced from shale is not a silver bullet for energy or jobs.** There is growing evidence that any economic benefits of fracking are greatly outweighed by the costs of environmental degradation, which is often borne by municipalities and communities. The energy produced by shale gas through fracking is expensive, adds to global warming, does not correlate with jobs, and will not create energy independence.
- **Fracking contaminates our drinking water.** Fracking uses large volumes of surface water, and is known to be associated with chemical and methane leaks that can impact drinking water resources. Since there is a widespread lack of baseline information about the quality and quantity of groundwater in Nova Scotia, it is unwise to commit to an industry that directly impacts our drinking water resources.
- **Fracking traffic damages rural roads.** The large numbers of trucks for the large numbers of wells have a wide variety of impacts to local areas. Most significantly, industrial traffic associated with fracking would reduce public health and safety, tourism and property value, and increase municipal costs for road maintenance and repairs.
- **Fracking fragments landscapes.** Because large numbers of wells are required to make fracking economical, industrial road systems are necessary. This process fragments the landscape and cuts off natural wildlife habitats which stresses vulnerable species, decreases biodiversity, and negatively impacts the forest products industry through forest loss. Fragmentation of the land caused by fracking would decrease wildlife and forest health, and restrict recreational hunting and fishing opportunities, as well as cultural practices in natural spaces.
- **Fracking isn't good for farming.** Where fracking occurs near farmland, large amounts of ozone and methane hamper plant productivity, and decrease livestock health. Water crises further impact farmers, forcing competition for water between agriculture and energy production and other users, in addition to water for residential use. Fracking would decrease the viability of food-related farming employment and the ability of farmers to produce food in these areas.

Ecology Action Centre Recommends: The EAC's goal is to foster a society in Nova Scotia that respects and protects nature and provides environmentally and economically sustainable solutions for its citizens. Allowing fracking to proceed in Nova Scotia will not advance that goal.

We urge the Panel and the Government to place a 10-year moratorium on fracking in Nova Scotia.

Frequently Asked Questions

"What is fracking?"

Hydraulic fracturing, or fracking, is a relatively new[1] method of extracting oil and natural gas, which involves horizontal long laterals (wells drilled horizontally along the target formation) and high volume slickwater (a mixture of water, sand and chemicals to optimize the extraction process). These technologies are used together to access petroleum in tight rock formation at depths >500m below the surface and have been used in Canada, U.S.A., and at least 10 other countries. In order to access as much gas as possible and to use the process economically, many wells must be drilled into a target rock layer like shale.

"Has fracking been used in Nova Scotia?"

In Nova Scotia, one company used this technology in three wells near Kennetcook and Noel in 2007 and 2008. The company projected that 680 wells would be required in 70km^2 area in order to produce an economical volume of natural gas. Seven million litres of fresh water were used to frack each of the two Kennetcook wells, a total of 14 million litres. Of the 53 chemicals and chemical mixtures used in this activity, 31 are known to have negative health impacts. At one well, only 15% of the injected fluid was recovered, with the remaining fluid left deep underground. Holding ponds were built at two sites to store fresh water for use in the fracking process, but the company used the ponds for wastewater storage, although permits for this usage had not been issued.

"Why this report now?"

The Ecology Action Centre welcomes the review of hydraulic fracturing by the independent panel led by Dr. David Wheeler, and is pleased that the panel is inviting individuals, organizations and experts to contribute their knowledge, experience and information about fracking. We considered it important to write a thorough report on all of the potential impacts of fracking no Nova Scotia, as our submission to this panel.

"What is the Ecology Action Centre's position on fracking?"

The Ecology Action Centre believes that our finite petroleum resources, particularly unconventional gas, should not be developed at a time when (a) our energy system is inefficient and wasteful; (b) extraction of those resources in other jurisdictions has been linked to serious health and environmental impacts; and (c) long term environmental damage and health impacts far outweigh any short-term economic development from fracking.

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[1] Earthworks, Hydraulic Fracturing 101.
http://www.earthworksaction.org/issues/detail/hydraulic_fracturing_101#.U0RAraizFB0

Section 1: Energy and Economics

The following section is the official submission of the Ecology Action Centre's Energy Issues Committee, prepared by Energy Coordinator Catherine Abreu.

1. Greenhouse Gas Emissions

Concerns regarding the Greenhouse Gas (GHG) emissions associated with shale gas development through hydraulic fracturing are well documented. This section will provide a brief summary of those concerns with key sources.

Increasing Methane Emissions in the US

Several studies have pointed to an unexpected and significant rise in methane emissions in the United States. These emissions are temporally coincident with the US shale gas 'boom' of the past decade. Miller et al. (2013) find that methane emissions in the US are much higher than previously reported; and methane emissions in the US geographically correlated with "fossil fuel extraction and refining." Nisbet et al. (2014) identify a "strong growth" in US methane emissions since 2007:

> There is much to suggest that emissions from human activities have also increased since 2007. In the United States, which has overtaken Russia as the largest gas producer (12), hydraulic fracturing is increasingly important. In Utah, fracking may locally leak 6 to 12% of gas production to the air (13). A full understanding of the greenhouse impact of fracking requires monitoring over the gas-well lifetime and analysis of the transport distribution system.

The concern over rising methane emissions in the US is due to the fact that methane is a far more potent greenhouse gas than carbon dioxide. Were the same amount of methane and carbon dioxide released into the atmosphere, the methane would trap 86 times more heat than the carbon dioxide over a 20-year period. Brandt et al. (2014) question the usefulness of unconventional/shale gas as fuel given its significant methane emissions. Howarth et al. (2011) chart the methane footprint of shale gas and its resulting contribution to climate change.

Lifecycle Emissions of Shale Gas as an Electricity Source

Conventional natural gas is traditionally viewed as an ideal 'transition fuel' as jurisdictions move from dependence on non-renewable fossil fuels (most notably coal) for electricity production to electricity systems that rely on renewable, low-emitting energy sources. This is because conventional natural gas emits about one-third of the GHGs of coal when combusted to produce electricity.

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However, given the high methane emissions and additional carbon dioxide emissions associated with shale gas development, shale gas cannot be viewed in the relatively favourable light that conventional natural gas is. Howarth et al. (2011) of Cornell University focus on the life-cycle emissions from shale gas production and conclude that shale gas has higher life-cycle GHG emissions than coal. Hultman et al. (2011) of the University of Maryland compare the life-cycle emissions of conventional gas and shale gas for electricity generation and find that the GHG impacts of shale gas are 11% higher than those of conventional gas. Jiang et al. of Carnegie Mellon find that the life-cycle GHG emissions of shale gas are approximately 5% higher than the base conventional gas case.

Differences in these findings are due largely to different accounting of methane emissions and flaring during the extraction process. Despite the range in findings, it is clear that shale gas does not have the same GHG portfolio of conventional natural gas.

Long-term planning: We Need a Transition

The GHG concerns outlined above are compounded by the possibility that shale gas development will delay or discontinue a much-needed transition away from fossil fuel dependence toward energy conservation and renewable energy development.

Our current system is highly wasteful. Burning fossil fuels to produce electricity and to fuel transportation is a very inefficient use of precious non-renewable resources. Advances in energy efficiency and conservation are stalled by the onslaught– however temporary– of the plentiful and relatively cheap shale gas energy resource. Developing that resource within a wasteful system means developing a non-renewable fossil fuel in a context where it will be consumed recklessly.

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Short-term cheap gas will divert funding from long-term solutions such as:

a) development of renewable energy sources (solar, wind, hydro, tidal);

b) investment in energy storage research and development;

c) development of smart grids and innovative time-of-day metering; and

d) research into electricity system optimization for integration of intermittent renewable energy sources and GHG reductions (e.g. regional power pooling, vehicle electrification).

In order to seriously address the risks of climate change and secure the future sustainability of our communities, we must transition to a leaner system that consumes far less, that relies on renewable energy to fulfill our electricity and transportation needs, and that conserves the remaining fossil fuels for critical uses such as plastic production and pharmaceuticals. Shale gas development through hydraulic fracturing puts our future at risk.

2. Energy Returned on Energy Invested

The economics of energy resource development are commonly discussed in terms of *energy returned on energy invested* (EROEI): the amount of usable energy acquired from a particular resource compared to the amount of energy expended to obtain that resource.

Shale Gas EROEI

In the early days of oil development, conventional oil resources had an EROEI ratio around 100:1. This means a return of 100 units of energy for an input of 1 unit of energy. Today, the EROEI ratio of conventional oil sits around 25:1. Unconventional sources of energy, such as shale gas, tend to have much lower EROEI ratios. Hughes (2012) estimates an EROEI ratio for shale gas of 5:1, making it far less efficient to develop than conventional natural gas with an estimated EROEI of 7.6:1 and unconventional (eg. oil sands) oil with an estimated EROEI of 17:1. Other sources disagree with Hughes' findings. Aucott and Melillo (2013) estimate an EROEI ratio of 85:1 for gas originating from the Marcellus shale deposit, making it competitive with coal.

A typical shale gas well suffers an exponential decline in production within the first 2 - 4 years of extraction.

The dramatic divergence between these estimates is worth close scrutiny. Some of the gap can be attributed to differences in the inputs accounted for by Hughes vs. Aucott and Melillo. Hughes considers all energy inputs for drilling, extraction, and transport associated with shale gas extraction; however Aucott and Melillo do not consider inputs from transport in the same manner.

Most importantly, however, is the difference in timespan of inputs used to calculate EROEI. Hughes considers the energy inputs over the lifetime of a typical shale gas well while Aucott and Melillo consider the energy inputs during the initial, most productive phase of the well. A typical shale gas well suffers an exponential decline in production within the first 2 - 4 years of extraction. Upon that decline, the energy inputs required to continue extraction at the well become increasingly disproportionate to the energy being extracted from that well. This trend complicates EROEI for shale gas and has macroeconomic implications for shale gas development.

3. Economics of Shale Gas

Shale Industry claims vs. Independent Analysis

Developers of shale gas and oil (aka tight oil) produced by "fracking" (hydraulic fracturing) claim the following as the entire picture of the economics of shale gas and oil production. These messages are supported by brokerages and the investment banking industry, who suggest long-term growth and good returns for investors in shale plays.

The Shale Industry claims:

A. There is at least 100 years of low cost shale gas in the US, and lots of shale oil as well. Therefore this industry is a good long-term investment.

B. Shale production is a major source of local revenue and jobs.

C. The US is on the brink of "energy independence" due to fracking its abundant shale resources, reversing its decline in energy output. The US will have lower natural gas prices and energy security.

D. Since there is plenty of gas in the US, government should allow export of the gas (LNG, etc.), reversing the long standing US policy of protecting its domestic supply and thus the prices.

US Dept of Energy says [the Marcellus] may provide only 6 more years of gas at current consumption rates.

Independent Analysis reveals:

A. "100 years of gas": "Reserves" of shale gas and oil that are reported by industry are NOT independently verified, and operators have significant financial incentives to exaggerate reserves to attract investment. The US Geological Survey (USGS) downgraded by 80% the reserve estimates provided by industry for the Marcellus shale. While Marcellus is the only major shale play that hasn't declined yet, the US Dept. of Energy says it may provide only 6 more years of gas at current consumption rates[2].

B. "Source of local revenue and jobs": According to US Bureau of Labor Statistics, direct jobs in the entire oil and gas sector of the US grew from 118,000 to 181,000 between the low point in 2003, and the latest figure in 2011, mainly due to the shale "boom". But this growth represents only 1/20th of 1 percent of all employment in the US.[3] By contrast, direct jobs in renewable energy alone were estimated by USBLS to be 186,000 in 2011 (no estimate for 2003).
State revenues (severance tax on shale production) have seen a net loss when road damage from the constant trucking needed for fracking is included. See list below:

State	Cum. Revenue from Shale (Severance Tax)	Est.Road Damages
Texas	\$3.6 Billion	\$4.0 B.
Arkansas	\$182 Million	\$459 M.
Pennsylvania	\$204 Million (Fee, no tax)	\$3.5 B.

C. "US energy independence, due to shale production": This is a myth. US oil consumption is double its current production. Many older fields are in decline. There is no way US shale oil "reserves" could ever make up this huge and growing gap (US Energy Information Agency [USEIA] data):

[2] USGS was asked to assess shale gas reserves in India and Poland: Poland's estimates from industry were downgraded 85% by USGS. In India, industry estimated their reserves as 300 -2100 Tcf (trillion cubic feet). USGS revised the figure to 6.1 Tcf.

[3] Energy Policy Forum, 2013

Total US oil - all types (Million barrels per day):

	Consumption	Production	Gap
1990:	13.1	7.6	-5.5
2012:	14.9	7.2	-7.7

D. "US should allow export of excess gas": There is plenty of shale gas under the ground in the US, but much less is recoverable (see footnote above on realistic USGS estimates for US "reserves"), despite industry claims. Recovery efficiency from shale wells is far less than conventional gas or oil wells:

Recovery efficiency type	Recovery rate per well (average)
Conventional gas	75%
Shale gas	6.5%

Shale production is not cheap, despite artificially low prices. All operating costs are not clearly stated in industry promotion. But audited reports to SEC (Securities and Exchange Commission) do show a fuller story, and reveal that shale production itself is commercially not profitable at current average prices in the US [4].

There were delusions about the real costs, recovery efficiency, and decline rates of shale plays. Facts about these have been obscured, to help attract investment.

Shale gas and oil producers, as well as the majors (Exxon, Shell, et al) invested in shale plays are losing money on most shale production, making it up instead by flipping leases and sometimes landing some liquids-rich wells.

Major write-downs of reserves, as well as operation losses are mounting.

Some shale reserve "write-downs" (2011):

Chesapeake:	$2.1 B.	BHP Billiton:	$2.8 B.
EnCana:	$1.7 B.	Exxon:	$2.3 B.
Shell:	$2.1 B.		

e.g. Chesapeake (the leading Shale proponent in the US) 2012 results: $949M operating loss; income from operating (wells) was only 23% of all revenue, most of which came from selling leases.

Q: Why do the energy majors (Exxon, et al) as well as shale producers stay in shale production if they are losing money?

A: Several reasons: First is the fact that energy majors have steadily declining options globally to expand their reserves (the key to investor support), since most available oil is now controlled by state owned oil companies (Statoil, Gazprom, etc). Forty percent of Exxon reserve replacement in 2012 was shale plays (Bakken). Second, US shale producers hope to gain US approval to export (LNG) shale gas to

[4] A. Berman: Address to Houston Geological Society, Sept, 2013. https://www.youtube.com/watch?v=DHkKa4Zj_94

Asia, EU, etc., where prices are much higher. Finally, there were delusions about the real costs, recovery efficiency, and decline rates of shale plays. Facts about these have been obscured, to help attract investment.

With these facts in mind, it is clear that an economic analysis of shale fracking, using independently verified data (rather than industry data alone) is crucial for the Nova Scotia review of hydraulic fracturing. While the industry claims that the economic benefits are substantial and outweigh the environmental degradation, there is growing evidence that the actual economic benefits (monetary) are minimal or negative, and declining.

It is clear that an economic analysis of shale fracking, using independently verified data (rather than industry data alone) is crucial for the Nova Scotia review of hydraulic fracturing.

It is noted that the industry projections of recoverable shale "reserves", a critical issue, are reported unaudited by the US Energy Information Agency (USEIA). The same information is then reported by the International Energy Agency, supporting these claims. However, USEIA projections on shale potential are derived from industry estimates only. They do not always match actual reporting to state regulators, who keep the most accurate records for royalty purposes. Nor do USEIA estimates always match independent analysis of actual "reserves" of shale gas and oil. It's known that recoverable "Reserves" vs. "Resources" (total gas and oil in the ground) are often lumped together by the industry.

Additional information: based on reports and presentations from analysts cited above.

Only a small percentage of the thousands of wells drilled in the major shale plays is profitable; most are not. This is a fact of all shale production. It is not cheap to produce. Few producers are profiting from the wells alone. But production continues. Why?

- The decline rate of shale wells is very high, averaging 60% the first year in most plays. Therefore it is necessary to drill constantly and to replace the large number of declining wells in order to maintain production levels to satisfy investors.
- All of the major shale plays currently in the U.S. (Bakken, Barnett, etc), except the Marcellus, have hit peak production, and are slowly declining.
- USEIA assessments of shale potential are based solely on industry forecasts of "reserves". But the reserve forecasts are designed to comfort investors, to keep stock prices up since energy values are based on estimated "reserves". As a result USEIA data on reserves have been shown to lack credibility compared to state level data, which are more accurate, since the states collect royalties or severance tax on shale production.
- Investment banks shale strategy worked: the banks bundled the land leases, drilled a few wells to show potential, then ignoring the high decline rate, were able to flip remaining leases for 5-10 times their purchase price. The investment banks also pressured producers to constantly drill, as new wells have decent production at the very first, which produced a glut for several years, dropping gas prices greatly (2009-2012). This created a market impression that gas would be

abundant and cheap for the long run, triggering more electric utilities to build new gas plants. As low prices squeezed many producers, shale mergers and acquisitions jumped from $15 Billion in 2008 to over $40 Billion annually until 2012, greatly increasing the fee collected by the investment banks.

- Producers: Shale producers make little or no profit from most wells once the high operating costs of their many low-producing wells are fully included. Established producers (e.g. Chesapeake) have tried to find plays that have more liquids per well, but they make most of their money from flipping their leases: at the peak of the shale "revolution" Chesapeake sold leases to BHP Billiton for $4 billion, who later had to write down $2.4 billion of their value.
- The structure of the industry, the strategies of investment banking and supportive analysis of this industry have allowed the real financial costs and poor returns to be buried, for now. The strategy has been to keep producing more gas than the market demands, to keep prices very low so utilities will convert from coal to gas. Once those conversions are wide-scale enough, and the US government allows the export of surplus gas, the price of gas will jump substantially (that is already happening), and thus attract speculative investment, but the market price will have to be much higher for it to be economical.

Shale oil plays are marginally commercial, but will disappoint expectations of US energy independence, and long-term supply.

4. Conclusion

Our energy systems involve huge infrastructural networks and large financial investments. Decisions we make today decide investments we make in infrastructure, which in turn defines the landscape we work within for decades to come. Power plants, pipelines, and transmission networks have lifespans that frequently extend beyond 50 years.

In order to combat climate change and plan for the long-term, it would be most wise to keep fossil fuel resources "in the bank".

Shale gas wells typically have lifespans of less than a decade, with peak production occurring early on in that life. The current shale gas boom may very well turn out to be a shale gas bubble. Yet the impacts of shale gas development have the potential to shape our province, region, and continent for the next half-century and more. Those impacts are taking the shape of large-scale landscape disruption, groundwater contamination, and waste management crises. They may also take the shape of an electricity system that failed to engineer a transition toward sustainability when it was desperately needed.

In order to combat climate change and plan for the long-term, it would be most wise to keep fossil fuel resources "in the bank": invest in a transition toward a leaner and cleaner system, using existing resources, and return to the question of shale gas development in 10 to 15 years, when extraction methods may be safer, our system less wasteful, and our attitude toward the use of non-renewable fossil fuels more responsible.

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Section 2: Groundwater

The following section is the official submission of the Ecology Action Centre's Coastal and Water Issues Committee, prepared by Geoscience Coordinator Jennifer West.

There is a considerable lack of understanding of our groundwater in Nova Scotia

The activities associated with hydraulic fracturing are likely to cause short-term and long-term changes to water resources, including our groundwater and drinking water resources. The combination of our lack of knowledge of groundwater resources in Nova Scotia and how they respond to short-term and long-term change, and the known large-scale changes to water systems in the activities associated with hydraulic fracturing, indicate the need for application of the precautionary principle: We should not proceed with hydraulic fracturing at this time because of a lack of information of our groundwater resources and the known impacts of fracking on water systems.

Hydraulic fracturing, or fracking, is a method of extracting unconventional oil and gas resources, which uses significantly more water than conventional oil and gas extraction. A recent study estimates the life-cycle water consumption and wastewater generation from these activities at approximately 20,000 m^3 of freshwater, per well, over its lifetime (Jiang et al, 2013). This amount of water could supply more than 61,000 average Canadians, or the combined populations of Sydney, Truro and Wolfville (Population Centres, 2014), with water for one year (Calculation). Since the premise of unconventional oil and gas development relies on drilling many wells to make a large formation of shale or tight rock economical, the impact of dozens or hundreds of wells on Nova Scotia water would be considerable and long-lasting.

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Water used in fracking requires large changes to groundwater in three ways:

1. When water is removed from surface resources to be mixed with fracking chemicals, water levels and conditions in local lakes and streams, and in drinking water aquifers can be negatively impacted (Baccante, 2012; Kiviat, 2013).

2. When water is pumped into deep rock formations at high pressures to stimulate shale formations, the groundwater static equilibrium can be altered over short time frames (Myers, 2012).

3. When waste water is pumped to and stored at the surface, shallow water aquifers can be impacted through pond leakages (CBC 2014; NOFRAC, 2013).

Because of the larger volumes of water associated with fracking and the activities which impact groundwater, it is important to present the direct and indirect impacts of fracking on groundwater resources in Nova Scotia.

In Nova Scotia, much like other rural areas in Canada, 40% of residents obtain their drinking water directly from groundwater through privately owned wells (NSE Groundwater, 2014). Although the remaining 60% of residents rely on surface water from lakes and streams for their drinking water, groundwater helps supply these water bodies throughout the year. We are lucky to have access to (mostly) safe drinking water (Nova Scotia Boil Water Advisories, 2014; NSE Natural Water Contaminants, 2014), but we could be doing much more to understand, protect and manage this resource.

Sixty percent of Nova Scotians rely on surface water from lakes and streams for their drinking water, and groundwater helps supply these water bodies throughout the year.

Currently, the government of Nova Scotia has two streams of information about our groundwater. In the first program, the Groundwater Observation Well Network (GOWN), active groundwater monitoring occurs through 39 Groundwater Observation Wells across the province (Nova Scotia Groundwater Observation Network), where instruments in each well collect hourly water level data, and technicians collect water chemistry samples from these wells every 2 – 5 years (Nova Scotia Groundwater Observation Well Network Annual Report, 2012). In the second stream, the Well Logs Database, information on groundwater comes from the drilling of drinking water wells. When these wells are drilled, the provincial regulations (Well Drilling Regulation) require that technicians record rock and groundwater information, which is compiled in this database. This record has provided detailed spatial information on the geology of the province for several decades, but presents only a snapshot of the groundwater conditions at the time that wells were drilled. Although the database contains a large number of points, it is commonly agreed that it has deficiencies (e.g. missing data points, missing information for points, missing location information, groundwater level not recorded, geology not recorded correctly). Since 2010 the Ecology Action Centre's Groundswell project has had the goal of increasing the number of groundwater monitoring sites in the province (West, 2013). Groundswell has 9 observation wells with local volunteers who monitor and upload data from in-situ instruments. The groundwater level data available online through the GOWN and Groundswell are both accessible through online websites (Groundswell online data, GOWN online data).

Hydrogeologists struggle to provide clear information to regulators, industry and municipal and provincial governments even though data relating to local water levels over long time frames, and quantities of water pumped from local aquifers are not available.
- Expert Panel on Groundwater Issues, 2009

These are important projects which continue to improve our understanding of local water levels, but more information is needed in vulnerable areas. For example, several areas have no observation wells (Municipalities of Argyle, Barrington, Queens, Minas Basin north and south shores); some areas have residential development which may be exceeding the capacity of groundwater supply (example, Beaver

Bank well depletions in 2009); and other areas are exposed to industrial scale activities such as dewatering for mine pits (Mining Watch Canada, 2006) and through pumping material into or out of the ground (Parfitt, 2010). Since we all rely on groundwater for our drinking water, either directly or indirectly, more areas of the province need to be monitored to understand groundwater in all areas. In short: "Trying to manage water resources without monitoring is like trying to drive down a back Cape Breton gravel road - at 100 km/hr – on a cloudy, moonless night – with no lights. The first time you know you are in trouble is when you are wrapped around a tree." (Baechlor, Expert Panel on Groundwater Issues)

> **"…In the Kennetcook activities, only 15% of fluid – containing multiple chemicals of concern – injected into the vertically-fracked well was recovered."**
>
> **-NOFRAC, 2013**

In order to make strong decisions on the management of groundwater, we must have more information about its use and abuse across the province. A better understanding of local water levels, combined with the knowledge of how much water is being removed from an aquifer, would provide a much clearer picture of how aquifers evolve over time, respond to pressure and stresses, and adapt to climate change impacts to the water cycle. Currently, there are no regulations that enforce the metering or the reporting of metering of groundwater in Nova Scotia. A strong example of this gap is the lack of baseline and follow up groundwater monitoring at the Kennetcook fracking sites from 2007 to the present (Summers, 2013). Hydrogeologists struggle to provide clear information to regulators, industry and municipal and provincial governments even though data relating to local water levels over long time frames, and quantities of water pumped from local aquifers are not available (Expert Panel on Groundwater Issues, 2009). In order to make meaningful management decisions about our drinking water, including whether to allow fracking, we must have a better understanding of how changes to any part of water in the Nova Scotia water cycle impacts other parts of this system. How will the removal of large volumes of water from lakes and rivers affect local drinking water aquifers? How will the injection of fracking wastewater into deep rock formations, which is permitted in other jurisdictions, impact local drinking water and lakes and streams, and how will it affect our health over long timescales? How have long-term changes in water resources been recorded in First Nations communities, and how is this information being included in management decisions?

Although the water cycle is impacted from fracking at several stages, recent studies have documented the impacts to groundwater from the migration of fracking fluid (injected into the ground) and waste waters (pumped out of the ground) from faulty casings in the vertical portion of the well (Nikiforuk, 2013). Some studies have also shown that contamination can come from communications from the horizontal segment of the well, though it is not as common (Ingraffea and Engelder, 2011).

According to industry reports (University of Pittsburg, 2013) the injection of fracking fluid into the ground is often associated with fluid loss, and poor recovery of fluid. For example, in the Kennetcook activities, only 15% of fluid – containing multiple chemicals of concern (NOFRAC, 2013) – injected into the vertically-fracked well was recovered. The remaining fluid was lost into the target formation, and into unknown fracture and pore systems (NOFRAC, 2013). Recently Myers (2012) has shown that fluids at depth can reach the surface in as little as ten years:

> *"Interpretative modeling shows that [natural] advective transport could require up to tens of thousands of years to move contaminants to the surface, but also that fracking the shale could reduce that transport time to tens or hundreds of years. ... Simulated pressure returns to pre-injection levels in about 300 [days]. The overall system requires from 3 to 6 years to reach a new equilibrium reflecting the significant changes caused by fracking the shale, which could allow advective transport to aquifers in less than 10 years."*

With the large volumes of chemicals injected with fracking fluid, injection into potentially hundreds of wells, and commonly low fluid recovery rates, this study suggests that it is possible that our drinking water could be impacted by harmful chemicals within one or two generations. Although the development of Myer's model boundary conditions have been disputed, which led to concern about the model results (Saiers, J.E. and Barth, E. 2013), it will be interesting to see the time frames of advective transport in improved models.

It is possible that widespread drinking water contamination in active fracking areas will occur in the coming decade.

Although Nova Scotia currently prohibits deep well injection of wastewater from fracking, this method is common in 32 states in the USA (EPA, Class II wells). This method has been used in oil and gas waste disposal for decades, and has been associated with contaminated drinking water aquifers (USGAO, 1989) and more recently, small seismic events (Walsh, 2013). A report from the US General Accounting Office states that "because groundwater moves very slowly, any contaminants that enter it will remain concentrated for long periods of time, and clean-up, if it is technically feasible, can be prohibitively costly." (USGAO, 1989, p. 2). This report, in addition to a ProPublica report on injection wells (Lundgarden 2012), gives numerous examples of aquifers with contamination that is too extensive to remediate – from two decades past when fewer wells were drilled, and when the practice of horizontal drilling was not yet developed. Natural pathways from shale gas formations in the US to groundwater aquifers have been documented (Warner et al., 2012), and in areas where fracking is active, thermogenic methane was found in the well water of many homes near well drilling pads (Osborn et al, 2011). Methane concentrations– in 51 of the 60 well sites in this study – were 17 times higher in active drilling areas than in non-active drilling areas. With evidence that the activities associated with hydraulic fracturing increase the speed of fluid and wastewater migration to our drinking water, it is possible that widespread drinking water contamination in active fracking areas will occur in the coming decade.

Over-pumping of aquifers has also been documented in several areas where fracking is occurring. In Texas, the amount of water used for fracking doubled between 2008 and 2011 (Galbraith, 2013a), and many communities which coincide with areas of large water withdrawals from local oil and gas companies have experienced water shortages (Galbraith, 2013b), prompting the state to develop a plan for water management by 2017. Water shortages have also been documented in California and Wyoming, which some attribute to hydraulic fracturing activities (Bacher, 2014). Water shortages are not common in Nova Scotia, but with added strain on vulnerable bedrock aquifers from hydraulic fracturing, drinking water and irrigation water shortages would be possible.

Unconventional oil and gas resources such as shale gas require high numbers of well pads to access a petroleum resource in order to be economical. For example, in the development proposal by Triangle in 2007, the final phase of natural gas extraction would have included 680 wells from Truro to Wolfville (Elmworth Development Plan Application, 2008). A simplified estimate of potential wells in the province could be in the range of 1800 wells, based on the relative size of these blocks (600 in the Windsor Block, 400 in the Truro Block and 800 in the North Shore Block). Industry reports that rates of well failure (leakage) for the first year after construction is 7% and 30 years after construction is 60% (Ingraffea, 2013), suggesting that at the very least, based on the above simple estimates, Nova Scotia could be dealing with over one thousand leaking wells after several decades of unconventional oil and gas activity. It is possible that development of natural gas from shale in Nova Scotia would result in (a) extensive groundwater contamination and (b) insufficient monitoring to know when contamination has occurred.

Nova Scotia could be dealing with over one thousand leaking wells after several decades of unconventional oil and gas activity.

The government of Nova Scotia currently allocates $24.9M to the Department of Environment. As a division within the Department of Environment, the Environmental Monitoring and Compliance (EMC) Division receives $11.079M of this amount (Budget calculation). Its mandate is to "d*eliver field operations related to environmental promotion and protection from regional offices throughout Nova Scotia. This includes outreach and education, processing applications, inspection and enforcement.*" Inspectors must spread their time between not only oil and gas operations but also activities associated with domestic oil spills, mines, quarries, floods, chemicals spills and other activities. Unfortunately, these important tasks, which protect our environment and essentially our health, represent a mere 0.116% of the total provincial budget (Provincial Budget 2013). It is possible that inspectors tasked with inspection and enforcement of regulations at hundreds of wells in the province, in addition to long term, would miss leaks, accidents, compliance breaches and other potentially harmful issues.

It is possible that [government] inspectors tasked with inspection and enforcement of regulations at hundreds of wells in the province…would miss leaks, accidents, compliance breaches and other potentially harmful issues.

Without a commitment of a substantial increase in long-term funding of monitoring, modeling, metering, analysis and management of groundwater by the government, *there is no way to evaluate the true risks to groundwater from hydraulic fracturing in a meaningful way*. Because of our lack of knowledge of existing groundwater conditions in the province, it is possible that the provincial review of fracking cannot provide an accurate recommendation on the long-term and short-term risks to our drinking water resources.

In the face of documented direct and indirect impacts to groundwater from fracking over short and long time frames, it is difficult to consider allowing fracking to occur in Nova Scotia at an industrial scale when

1. We do not have adequate baseline understanding of the trends, evolution, quantity or quality of our groundwater in Nova Scotia.

2. Water use in hydraulic fracturing consists of water volumes that could add stress to groundwater resources.

3. Studies indicate that groundwater contamination from hydraulic fracturing might reach surface aquifers within several decades of drilling activities.

4. Studies indicate that the presence of active well drilling pads increases the risk of methane contamination of drinking water.

5. Over-pumping of aquifers for hydraulic fracturing can result in water shortages for drinking water and other industries such as agriculture.

It is clear that Nova Scotia has a considerable lack of understanding of our groundwater. A substantial restructuring of provincial funding is required to gain an understanding of the impact of large volumes of water being removed from and moved through our water cycle. It is known that activities associated with hydraulic fracturing are likely to cause short-term and long-term changes to water resources, including our groundwater and drinking water resources, and we have seen in other jurisdictions that these impacts can be long lasting and prohibitively expensive to remediate. The combination of our lack of knowledge of groundwater resources in Nova Scotia and how they respond to short-term and long-term change, and the known large-scale changes to water systems in the activities associated with hydraulic fracturing, indicate the need for application of the precautionary principle: The Coastal and Water Issues Committee believes that we should not proceed with hydraulic fracturing at this time because of a lack of information of our groundwater resources and the known impacts of fracking on water systems.

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Section 3: Transportation

The following section is the official submission of the Ecology Action Centre's Transportation Issues Committee, prepared by volunteer Stuart Campana.

The road looked like it had been hit by a bomb: fracking, transportation infrastructure and sustainability in Nova Scotia

Unconventional natural gas wells typically last anywhere from five to thirty years. During that time, a frantic parade of hundreds of trucks per day will rumble down mostly rural roads, completely overwhelming transportation infrastructure that was not designed for such use. It would be as if the streams of traffic from Highway 102 were suddenly diverted through the small town of Guysborough, with its tiny roads.

Any energy project is going to bring about some amount of increased traffic. Even wind power requires heavy trucks to transport turbines and concrete foundations (Wilke et al, 2011). What sets fracking apart is not the presence of vehicles or the size of the trucks, but the endless procession that continues, week after week, until the rural roads disintegrate. Fracking trucks inflict long-term damage on transportation infrastructure, leaving rural communities to pick up the cost when the gas is all gone (Heinberg, 2013, Ridlington, 2013).

The economic costs, increased physical danger and environmental degradation of fracking all contribute to a landscape that is detrimental to any form of sustainable transportation or active living.

Local and sustainable transportation infrastructure can't help but suffer in a community where large trucks rush down narrow roads at frequent intervals. The economic costs, increased physical danger and environmental degradation of fracking all contribute to a landscape that is detrimental to any form of sustainable transportation or active living. The costs of fracking – economic and otherwise – are too high to justify its presence in Nova Scotia.

Fracking as a Major Industrial Operation

Fracking requires a lot of trucking. Sand, gravel, concrete and water all need to be transported back and forth between the site and service yard or disposal area. And not just once: the Pennsylvania Department of Environmental Protection estimates that a horizontal well requires 1,000 trips by heavy trucks over its lifetime (Fears, 2011). Tractor trailer and tri-axle trucks are standard fare, but the real heavy lifting is done by the 40,000kg water trucks.

The US Department of Conservation breaks down the estimated trucking per well for the noted phases of work as follows:

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<u>Rig Mobilization, Site Preparation, Demobilization</u>	
Drill Pad and Road Construction Equipment	10 – 45 truckloads
Drilling Rig	30 truckloads
Drilling Fluid and Materials	25 – 50 truckloads
Drilling Equipment (casing, drill pipe, etc.)	25 – 50 truckloads
Completion Rig Mobilization/ Demobilization	15 truckloads
<u>Well Completion</u>	
Completion Fluid and Materials	10 – 20 truckloads
Completion Equipment (pipe, wellhead)	5 truckloads
Hydraulic Fracture Equipment (pump trucks, tanks)	150 – 200 truckloads
Hydraulic Fracture Water	400 – 600 truckloads
Hydraulic Fracture Sand	20 – 25 truckloads
Flow Back Water Removal	200 – 300 truckloads
Well Production Equipment	5 – 10 truckloads

Total = 895 to 1,350 truckloads

While the precise number of trips depends on the size of the well (in gallons), the minimum is still 895 tanker truck trips (COGCC). At the other end of the spectrum, a large well may require as many as 28,400-172,800 trips over the lifetime of the well pad (COGCC).

Water requirements in particular that necessitate many of these trips: 350-1,500 of them per frack, with each well fracked up to 18 times (Wilke et al, 2011; NOFRAC, 2012). Millions of gallons of water must be transported to the well site before fracking can occur. Then the waste water (known within the industry as "flow back") must be transported to a disposal site (Sumi, 2008). Trucking of the hydraulic fracture equipment, sand and water, accounts for more than 80% of fracture trucking, spread over weeks before and after fracking (DOEC, 2009).

Rural roads are not designed to withstand the same kind of weight and density that highways are built for.

- Abramzon et al., 2014

Rural Roads

There are good reasons why natural gas fracking does not take place in cities or next to highways where the road infrastructure is built to support heavy volumes. Preparation for drilling includes the clearing of all trees, shrubs and other vegetation – leveling the landscape over approximately 3.1 acres. For logistical reasons, it is difficult to clear land in urban areas, so fracking tends to take place in remote (i.e. rural) areas (Ridlington and Rumpler, 2013).

Rural roads are not designed to handle that kind of traffic density. Roads – especially aging ones – deteriorate very quickly under the repeated weight of massive fracking trucks (Betterroads.com). But more importantly, rural roads are simply not designed to withstand the same kind of weight and density that highways are built for (Abramzon et al., 2014). Road failure ultimately occurs from either "fatigue cracking in the asphaltic concrete layer or rutting in the subgrade soils beneath the pavement" (Wilke et al., 2011). Roads with an intended twenty-year lifespan require major repairs after five years under conditions of fracking traffic (Heinberg, 2013). On gravel roads, the damage comes even more quickly. Cracks, potholes and ruts create roads that are impassable by anything smaller than the kinds of giant trucks employed by the fracking industry.

Fracking trucks spent weeks rumbling down roads in a small Texas community. Leaving potholes, crumbling shoulders and a thick coating of mud from drill pads, "[the road] looked like it'd been hit by a bomb" said Jim Webster, Commissioner of Parker County, Texas. Truck traffic from the Barnett Shale cost his County $265,000 in repair work (Sumi, 2008).

The damage isn't limited to existing roads. Fracking demands the creation of new roads as well, bringing with it all the same problems of wear-and-tear along with a host of new ones related to environmental disruption and a further leveled landscape. In the U.S., transportation infrastructure to support fracking has damaged over 360,000 acres of land since 2005 (Ridlington, 2013).

Repair Costs

The long-term impacts tend to arrive sooner rather than later. By the time the fracking operation ends, the cost to replace and repair transportation infrastructure may even outstrip the return on actual gas production. In 2012, Texas earned $3.6 billion in taxes from all oil and gas production within the state. Meanwhile, the Texas Department of Transportation estimated the cost of repairs to Texas roads at $4 billion (Rogers, 2012). The Texas City of Keller even commissioned a study to identify a re-construction fee structure for each mile of road, finding that they should be charging fracking companies up to $20,000 per mile (Belcheff & Associates, 2010).

By the time the fracking operation ends, the cost to replace and repair transportation infrastructure may even outstrip the return on actual gas production.

Pennsylvania found itself in a similar predicament. During the Marcellus Shale drilling in 2010, the state estimated fracking road repairs at $265 million (Ridlington, 2013). By 2013, Pennsylvania was directing $8.7 billion, state-wide, into necessary bridge repairs (Rogers, 2012). Recent attempts have been made to quantify the cost of Pennsylvania road repairs per well, with Abramzon et al. (2014) estimating repair costs at $13,000 - $23,000 for each well.

Fracking is a major industrial operation. Even the smallest of gas wells still requires a quantity of trucks virtually guaranteed to overwhelm roads that were never built to withstand a fraction of that much traffic. The repair costs can be massive.

Health and Environmental Damage

The nature of fracking's transportation requirements opens up the community to a host of environmental hazards. From the ferrying of dangerous wastewater to the environmental problems brought on by the creation of new roads, the dangers of fracking are multiplied and spread through the industry's need for extensive transportation systems.

1. Wastewater on Roads

The endless stream of trucks is not just hauling clean water. The highly saline wastewater from fracking operations contains a dangerous mix of chemicals that cannot be processed in a normal waste treatment plant. One proposed solution is to spread the contaminated water on winter roads for de-icing. According to the Environment America Research and Policy Center (EARPC), drilling operators have been "known to spray wastewater on dirt and gravel roads to control dust, or on paved roads to melt ice" (Ridlington, 2013). This reduces company costs, but the run-off can contaminate the surrounding environment with chemicals that companies prefer not to disclose (NOFRAC, 2013). Triangle Petroleum suggested solutions to the waste water problem, including melting on site for the waste in Kennetcook, which was approved by the province but not implemented, or by deep well injection, which was not approved.

Peter Hill, executive chairman of Triangle Petroleum, has repeatedly cited the dangers and risks associated with trucking wastewater in an attempt to coerce the province into allowing his company to choose alternate, less expensive options than trucking waste to industrial facilities for disposal.

- Bundale, 2011

Peter Hill, executive chairman of Triangle Petroleum, has repeatedly cited the dangers and risks associated with trucking waste water in an attempt to coerce the province into allowing his company to choose alternate, less expensive options than trucking waste to industrial facilities for disposal (Bundale, 2011).

According to Hill, the impact of 5 to 6 trucks per day over half a year is too much of a burden on the environment and on transportation infrastructure to be an effective waste water management solution. "The damage to the environment, townships, roads, sites, traffic density and most importantly road safety would be too dangerous. […] It's far too expensive and dangerous." (NOFRAC 2013)

Hill's concern over the potential for damage from 1,200 trucks stands in stark contrast to the 2,400 truck trips his company employs per frack, without complaint (Howe, 2012; NOFRAC, 2013). The fracking industry cannot have it both ways. It is clear that industrial leaders understand the risks, but are unwilling to do anything about them, except insofar as those risks can be used to leverage concessions out of desperate governments.

The fracking industry – with a prescient example right here in Nova Scotia – has not been forthcoming about the costs and risks of transporting dangerous wastewater. Nevertheless, there's strong evidence to suggest that myriad dangers accompany every tanker trip down the road. The health and safety of pedestrians, cyclists and even drivers is thus called into question.

2. Dangers of Increased Traffic

Public safety suffers in fracking communities. Numerous communities have documented the sudden and sustained increase in traffic collisions brought on by nearby fracking. Moreover, this is dangerous traffic, as these notoriously unsafe trucks haul hazardous wastewater.

In Tioga County, Pennsylvania, emergency calls from 2007 to 2009 increased by over 30%. Local officials explain that, due to nearby fracking, they've seen a shift in the types of collisions within the area: "We're seeing more accidents involving large rigs. … Tractor trailers, dump trucks. Vehicles – tractor trailers hauling hazardous materials. Those are things, two years ago, that [Tioga was not] dealing with on a daily basis. It was more two-car accidents" (Detrow, 2011).

By 2011, the state found that 911 calls had increased in seven of eight counties. Many of the increased collisions involved heavy trucks (Ridlington, 2013). These are not isolated incidents. The EARPC found that traffic accidents undergo a general increase in drilling regions across the country.

In Western North Dakota, traffic collisions cost the region an additional 33% after the arrival of fracking operations.

- Upper Great Plains, 2011

Public services are strained to the breaking point by the influx of heavy truck traffic. In Western North Dakota, traffic collisions cost the region an additional 33% after the arrival of fracking operations (Upper Great Plains, 2011). From a human health perspective, the increased calls inhibit the quick response ability of emergency teams. Drilling trucks cause traffic jams, which slow down fire engines and ambulances (Detrow, 2011). Moreover, out-of-town workers are often unable to give an accurate description of their location, further impeding the timely arrival of responders.

3. Cyclists and Pedestrians

The risk of an accident on foot or on a bicycle is exacerbated by the poor condition of the roads, which lend themselves quite easily to swerving vehicles and flat tires. Interestingly, there is some evidence to suggest that roads in disrepair are also more susceptible to flooding, as was the case during Hurricane Sandy (Rogers, 2012).

The Province of Nova Scotia announced in October 2013 that it supports the Blue Route, a province-wide network of bikeways that would involve many rural roads. The safety of cyclists, as well as pedestrians, on these routes where fracking trucks frequent is of particular concern. Unlike fracking, tourism is already a staple of Nova Scotia's economy. Unsafe roads due to fracking trucks would be a hazard and a deterrent to tourists.

4. Culture of Risk: Unsafe Vehicles

Safety is not a priority within the culture of the fracking industry. Drivers are routinely pressured to stay awake for long periods of time and trucks are driven well past the point of being road-worthy (Urbina, 2012). Pennsylvania State Police removed from the road 40% of the 2,200 oil and gas industry trucks they inspected between 2009 and 2012 because they were in a state of disrepair too unsafe to drive (NOFRAC, 2013).

Consequently, the jobs themselves are also hazardous. The US Center for Disease Control and Prevention reports that nearly one in three of the 648 deaths of oil field workers from 2003 through 2008 were in highway crashes. Police indicate that poorly maintained trucks were a factor in many of those crashes (Urbina, 2012).

An industry culture stripped of all considerations beyond profit is bound to clash with communities where quality of life holds sway. The fracking industry has – at a minimum – blurred the line between efficiency and outright negligence. In town after town, high collision rates have accompanied fracking like a disease. The statistics don't point to mere bad luck, but rather, to an industry culture built around disregard for human lives. In rural areas where resources are already strained, this leads to deaths.

The fracking industry – with a prescient example right here in Nova Scotia – has not been forthcoming about the costs and risks of transporting dangerous wastewater. Nevertheless, there's strong evidence to suggest that myriad dangers accompany every tanker trip down the road. The health and safety of pedestrians, cyclists and even drivers is thus called into question.

Bearing the Costs

Fracking takes its toll, but doesn't pay any back. Local communities typically bear the brunt of the financial burden when it comes time to repairing roads and bridges. Few rural towns or villages have the resources to shoulder these costs, and so they struggle to pick up the pieces long after the fracking has moved on. New transportation infrastructure is put on hold until the old infrastructure can be brought back to a state of decent repair.

> **Initially, there are physical dangers from speeding trucks. Later, budgets dedicated entirely to road repairs will stall the construction of new roads and bridges for rural towns.**
>
> **-Barth, 2011**

Incorporating Externalities

Fracking companies understand that their industry produces a variety of externalities not included in their income-expense calculations. Wear and tear on roads is a real cost, but the industry is able to pass this off to local residents (Food and Water Watch, 2011). Indeed, the industry acknowledges that it cannot turn a profit if it is to be responsible for associated infrastructure repairs (Kennedy, 2011). It relies on a heavy subsidy of free public infrastructure to remain afloat.

This untenable situation saddles communities with undesirable short, intermediate and long-term repercussions (Ridlington, 2013). Initially, there are physical dangers from speeding trucks. Later, budgets dedicated entirely to road repairs will stall the construction of new roads and bridges for rural towns (Barth, 2011). Money for sustainable transportation – buses, bike lanes, etc. – goes toward conventional transportation instead. Property values decrease near fracking operations. In Wise County, Texas, properties near natural gas rigs lost 75% of their value (Food and Water Watch, 2011). Thus draining money out of the community, fracking repeatedly constrains its host's ability to swallow the financial costs of the operation.

Deliberate Targeting

Low-income areas are less likely to muster the resources to protest fracking activities, leaving them vulnerable to deliberate targeting from fracking companies. The industry has been known to leverage its power against small communities. For example, load restrictions are typically placed on rural roads when they are soft in the spring, but fracking companies have been putting pressure on municipalities to waive those restrictions for economic reasons (Wilke, 2011). The promise of short-term financial gains is also used to encourage residents to overlook environmental damage (Heinberg, 2013).

Drilling rigs operate 24/7, making plenty of noise on their own, even without the assistance of endless conveys of trucks.

- Food and Water Watch, 2011

Whether or not fracking is an economically viable enterprise, when all of its costs are included, it certainly does not make economic sense for its host communities. Sustainable transportation is deprived of financial resources, as transportation money flows into repairs

Active Living: Who Would Want to Go Outside Anyway?

Planners promote active living by implementing safety measures and advocating for mixed-use roads. In rural communities, scenic vistas and the quiet sounds of nature are not only an integral part of active living, but also indispensable to any tourism in the area. Forests give way to well pads, while farmland turns into roads and pipelines (Ridlington, 2013). Scenic vistas are replaced by an unappealing landscape that few would visit and fewer still would wish to venture into.

Property values decrease near fracking operations. In Wise County, Texas, properties near natural gas rigs lost 75% of their value.

-Food and Water Watch, 2011

Air and noise pollution are serious concerns around fracking sites. Drilling rigs operate 24/7, making plenty of noise on their own, even without the assistance of endless conveys of trucks (Food and Water Watch, 2011). Air pollution comes from the trucks themselves, and also from the well bore, as the well is drilled and gas is vented (Ridlington, 2013). Where companies also spread hazardous wastewater on the roads, one could be forgiven for giving up on going outdoors at all.

Active living is a major draw in rural areas, both for residents and tourists. It relies on little more than readily-available resources: roads, paths and pleasant sights, sounds and smells. However, all of these can be marred by what is effectively the annexation of the landscape. By its very nature, fracking is destructive to essential components of rural living.

Conclusion

Fracking is an enormous industrial project, undertaken in communities that are ill equipped politically, economically and socially to cope with the risks of such an operation. Moreover, fracking is both inherently dangerous and an industrial culture that values economic gains over human health and safety.

All of this is problematic for sustainable transportation and active living, which are at the mercy of the state of the roads and the condition of the landscape. Rural communities are left with crippling costs, in the form of transportation infrastructure repairs that inevitably follow the arrival of fracking operations.

The primacy of financial concerns within the fracking industry has been repeatedly demonstrated through its prioritization of expediency over driver safety; wastewater dumping over safe removal; old trucks over new or repaired vehicles.

The backbone of Nova Scotia is precisely the type of rural community for which the fracking industry has shown little regard, both within Nova Scotia and around North America. Opening the province up to fracking also opens it up to the dismantling of our rural transportation infrastructure and the disabling of sustainable transportation and active living, in communities where such activities are integral to the quality of life. Without major reforms, the cost of fracking is unacceptably high. The Transportation Committee believes that the province would benefit most from a 10-year moratorium on fracking.

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Section 4: Wilderness

The following section is the official submission of the Ecology Action Centre's Wilderness Issues Committee, prepared by volunteer Katie Perfitt.

Habitat fragmentation from fracking will drastically affect our biodiversity and ecological health

Nova Scotia's biodiverse terrestrial and aquatic ecosystems are valuable not only as ecological assets. The forests, wetlands, lakes, and rivers across our province provide ecosystem services upon which many Nova Scotians livelihoods depend. Habitat disruption resulting from forest fragmentation (Drohan et al, 2010) and degradation of water quality goes hand in hand with accommodating the well pads, road networks, transmission pipelines and increased traffic that accompany shale gas development. Indicator species in the Eastern US have been shown to be sensitive to these habitat changes. Species with smaller geographic ranges are at a heightened risk to population reduction, extirpation, or extinction as a result of this habitat disruption (Gillan and Kiviat, 2012).

Habitat fragmentation – the discontinuity of organisms' preferred environment - already exists as one of the single largest issues in biodiversity conservation in Nova Scotia.

Habitat fragmentation – the discontinuity of organisms' preferred environment - already exists as one of the single largest issues in biodiversity conservation in Nova Scotia. Land use change, rural development, and transportation networks have, over the past 200 years, impacted flora and fauna in a drastic way. The map in Figure 1 shows the extent of Nova Scotia's road networks. Populations of the mainland moose, the American marten, and the Canada lynx are listed as provincially endangered, experiencing the squeeze of an increasingly fragmented landscape (MacDonald and Clowater, 2007). In 2013, 19 new species were added to Nova Scotia's list of provincially endangered species, bringing the total to 60.

Populations of the mainland moose, the American marten, and the Canada lynx are listed as provincially endangered; experiencing the squeeze of an increasingly fragmented landscape.

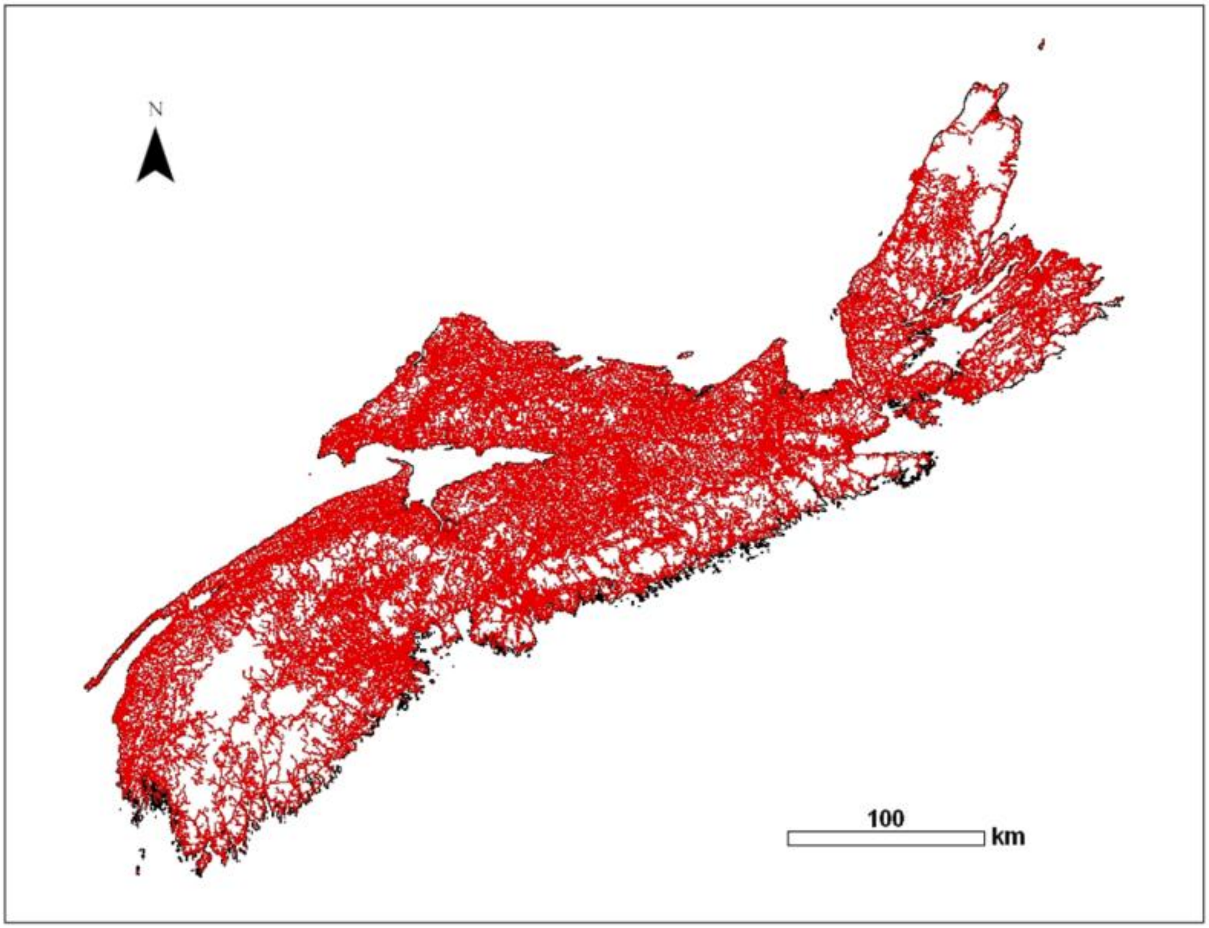

Figure 1: Road system in Nova Scotia, from logging roads to 100 series highways. Map shows significant wildlife habitat fragmentation in Nova Scotia. Source: Provincial Roads Layer, Geomatics Centre, circa 2004.

> **Forest loss, necessary to develop shale gas, will lead to a loss of land base for the forest products industry.**

The forestry sector in Nova Scotia continues to struggle through the boom and bust cycles in the market, as well as the exploitative relationship between corporations and the Province in the past (Woodridge Associates, 2001). Forest loss, which is inevitable when developing shale gas, will lead to a loss of land base for the forest products industry.

Shale gas and coal bed methane extraction require high levels of primary inputs, including water. A study found that the more fresh water that was withdrawn from rivers and streams, the higher the alteration is to the natural flow regime of the water body, and that this was linked to more severe adverse effects on the health of stream plants and fish. Where water withdrawals were high, researchers observed lower amounts of fluvial dependent fish species, benthic invertebrate species, etc., and saw increases in generalist species not as susceptible to these changes (Kanno and Nokoun, 2010). Thus, freshwater withdrawals can completely change the species composition in aquatic environments.

Surface and groundwater contamination are listed as major risks to lake and stream health, according to a recent report by the United Nations Environment Programme. Contamination can occur through: leakage from wells into the water table; leakage from fracking fluid or from waste water into the water table; leakage from improperly treated water and fracking fluids from flowback into the soil and water table and surface water; and migration of natural occurring toxic substances (UNEP 2012).

In order to frack, companies do not require buy-in from all landowners in a region, since they can drill horizontally beneath un-leased properties.

Today, there are an estimated 27 million litres of fracking waste-water in Nova Scotia, much of which contains Naturally Occurring Radioactive Materials (NORMs) and other toxic chemicals. Holding ponds in Kennetcook and Noel remain full from small-scale exploratory drilling. Waste water from these ponds have leaked on at least two occasions, and are known to have released thousands of litres of untreated waste into local streams (CBC, 2014).

Private landowners will also have less control over the activities taking place near their properties. Hydraulic fracturing does not rely on small pockets to develop – it occurs on widespread regions over shale plays. In order to frack, companies do not require buy-in from all landowners in a region, since they can drill horizontally beneath un-leased properties.

Nova Scotians recognize the need to reclaim the economy from large profit-driven corporations and instead build sustainable, local alternatives. Political promotion of fracking (Davis and Ronbinson, 2012) contradicts the need for a localized economic system based on natural and cultural heritages and renewable energy. The cumulative risks associated with fracking are too severe, and the benefits too short-term. It is for these reasons that the Wilderness Committee calls on the Province of Nova Scotia to implement a 10-year moratorium on hydraulic fracturing.

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Section 5: Food

The following section is the official submission of the Ecology Action Centre's Food Issues Committee, prepared by volunteer Catherine Hart.

There is an irreconcilable conflict between farming and fracking.

Fracking has been impacting the availability and quality of water, livestock and crop health, and the overall viability of people to shape their food system.

Land and water are required for farming, but their quality is being compromised by industry activities relating to fossil fuels. The negative environmental and health impacts associated with fracking continue to be documented alongside the pressure to expand operations without caution. This is happening at a time when the number of farms, particularly small-scale ones, continues to decrease relative to the consolidation of our global food system. A small number of profit-minded international agri-businesses are responsible for the vast majority of the production and distribution of the world's food. This has served to undermine the ability of small-scale farmers everywhere to contribute to the food sovereignty of their communities. Fracking is a like-minded profit-driven industry, one that has no intentions to steward the land for future generations, and whose solution to robbing communities of their clean drinking water has been to drown out their voices with payment in bottled water. With respect to food production, fracking has been impacting the availability and quality of water, livestock and crop health, and the overall viability of people to shape their food system.

Nova Scotia is a water rich province, with ample surface water resources that would be compromised by the substantial amount of water required for fracking. Globally we are already experiencing a water crisis, and it is illogical and self-destructive to engage in an extractive process that will further decrease water availability for agricultural production and human use. For example, in the state of Texas, drought, overuse of water, and now fracking are reinforcing climate change impacts which in turn have a negative effect on water availability: presently there are thirty communities at risk of running out of water (Goldenberg, 2013). In addition to demanding high volumes of water, fracking combines water with sand and chemicals before pumping the mixture into a well, in order to loosen up the rock storing natural gas and create enough pressure underground to extract it. Much of the initial water used is subsequently contaminated, adding to the global water crisis with each instance of fracking by eliminating its ability to be used for anything else. In Colorado, it is projected that fracking will have used 6 billion gallons of water by 2015 (Food & Water Watch, 2012). Yet organic growers like Jim Fitzgerald have already been forced to deal with the impact of droughts on their farms (Smith-Heavenrich, 2014).

It is illogical and self-destructive to engage in an extractive process that will further decrease water availability for agricultural production and human use.

In terms of water quality, fracking fluid contains a small percentage of chemicals as noted above. However the proportion is not the issue when, according to Earth Works, "very small quantities of some fracking chemicals are capable of contaminating millions of gallons of water" (EarthWorks). It is inevitable that there will be leaks from where wastewater is stored because the cement casing and sealing of wells used to keep wastewater from groundwater are not 100% guaranteed to be effective (FracFocus, 2014). In fact, leaks have been recorded as "a consequence of normal operations" (Food & Water Watch, p. 2), and the industry has reported leaks from 7% of new wells and from 60% of older wells (Nikiforuk, 2013). Similar to the health impacts experienced by humans exposed to contaminated water, there were twenty-four incidents in the United States investigated by Professor Robert Oswald and veterinarian Michelle Bamberger linking fracking operations to farm animal sickness (Bamberger and Oswald, 2012). In one instance, 16 cows drank fluid from a fracked well in Louisiana and began "bellowing, foaming and and bleeding at the mouth, then dropped dead" (Estabrooks, 2011). Additionally, a herd of cattle in Pennsylvania experienced a stillbirth rate of 50% after a grazing field was contaminated by fracking fluid (Milmo and Wasley, 2013). Overall in Pennsylvania, above the shale-rich Marcellus formation, there has been a 16% decrease in dairy cows over three years in counties with over 150 wells (Food & Water Watch, 2012). This has been linked to some chemicals used in fracking fluids known to be "endocrine disruptors" that can cause infertility in livestock and people (Fracking, Gas and Health, 2014).

"...16 cows drank fluid from a fracked well in Louisiana and began 'bellowing, foaming and bleeding at the mouth, then dropped dead'."
- Estabrooks, 2011

Not only is water impacted, but fracking degrades air quality as well. Methane has direct negative impacts on plants. By inhibiting their ability to use nitrogen, make cellulose, and take up water (Fracking, Shale Gas and Health, 2014), airborne chemicals decrease plant and farm productivity. Volatile organic chemicals combined with truck emissions and gas compressors at well sites create ozone (Food & Water Watch, 2012), and although ozone is predominantly associated with car exhaust, fracking produces so much of it that in Sublette, Wyoming, a town of 9,000 residents and an estimated 300 km^3 of natural gas trapped in shale, there are ozone levels as high as Los Angeles (Estabrook, 2011).

Ozone is predominantly associated with car exhaust, [but] fracking produces so much of it that in Sublette, Wyoming, a town of 9,000 residents..., there are ozone levels as high as Los Angeles.

At the ground level, ozone reduces the ability of plants to grow and reproduce as well as decreasing their marketability by discolouration (Smith-Heavenrich, 2014). One cattle farmer stated "ozone is more lethal to crops than all other airborne pollutants combined" (Estabrook, 2011). Although most plants in shale gas areas may not significantly bioaccumulate pollutants, their slowed growth and lower quality is a concern for farmers and the rest of the food system which subsequently experiences a decrease in food availability. In addition to soil contamination, it has been pointed out that the heavy trucks associated with extraction processes compact soil, making it very difficult for farmers to return the land to a productive growing condition (Fracking, Shale Gas and Health, 2014). The roads that the trucks use and the well pads also cause fragmentation of the landscape, which increases the difficulty of farming and reduces the land available for food production (Fracking, Shale Gas and Health, 2014).

The reduction of crop and livestock health and productivity has a direct impact on the availability of food within a food system already under pressure from distribution and affordability barriers. This is one of the reasons that the National Farmers Union (NFU) is calling for a moratorium on fracking in Alberta (NFU, 2012). "We are in the heart of Alberta's oil and gas country where our ability to produce good, wholesome food is at risk of being compromised by the widespread, virtually unregulated use of this dangerous process," says Jan Slomp, a Rimbey area dairy farmer and Region 7 (Alberta) Coordinator for the NFU. "Not many of these stories get made public because the oil and gas companies usually force farmers to sign confidentiality agreements in return for replacement of their water wells," he added. Groundwater, in particular, is essential to producing high quality food, but many farmers in Alberta have experienced well water contamination and have become more vocal about their concerns (NFU, 2012). Fracking has been seen to decrease property values (Schwartz, 2011). It also decreases the likelihood that food procurers who deal with farmers in areas known for fracking will want to purchase their products for fear of contamination. For example, Ken Jaffe, a dairy farmer in the Catskills sells his grass-fed beef to co-ops, markets and high-end restaurants in New York City (Estabrooks, 2011). He feels that these clients would not be inclined to purchase from him if fracking operations were near his farm. Organic farmers are especially vulnerable to losing their value-added prices due to contamination near their growing operations (Food and Water Watch, 2012). The overall impact on the food system has been recognized by farmers in Northern Ireland who have voiced concerns about fracking destroying the thirty billion dollar food and drink industry in the country (Milmo and Wasley, 2013).

Groundwater, in particular, is essential to producing high quality food, but many farmers in Alberta have experienced well water contamination and have become more vocal about their concerns.
- National Farmers Union, 2012

While the focus here has been on farming and formal agricultural production, environmental impacts would also negatively affect the wild food component to our food system. It would hurt the ability of people to hunt and fish recreationally (Food and Water Watch, 2012) as well as hunt and gather to fulfil cultural practices. With respect to First Nations communities in Nova Scotia, it is notable that the rights of Mi'kmaq people to hunt, fish and trap are constitutionally protected, and the rights of all peoples to food and water as human rights cannot be negated. Fracking would decrease the quality of our food and the viability of farming and food-related employment. In a time when access to healthy, local food is vital to our health, the Food Issues Committee believes there is no place in Nova Scotia for an industry that would erode our strong local food economy.

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Conclusion

We have the opportunity to learn from the experiences of other jurisdictions. The present review and associated moratorium are an opportunity for Nova Scotia and Nova Scotians to understand the costs and benefits of fracking for the province.

Fracking is a relatively new technology and impacts a number of sectors in our communities. Some impacts – road damage and greenhouse gas emissions – are immediate, while others are longer-term – contamination of groundwater, which may take years or decades to be observed at the surface. We need more time to study and observe the wide array of long-term impacts from fracking. As studies are still emerging, the most severe impact of developing and burning fossil fuels is on the global climate. As the IPCC stated clearly in their recent report, we must strive to keep all remaining fossil fuels in the ground, starting now.

Although we are in an era of uncertainty about health and environmental impacts related to fracking, we are in an era of certainty about the impact of burning fossil fuels on our planet. For these reasons, the Ecology Action Centre supports extending the review and moratorium for ten years, and reframing the conversation around supporting a greener, cleaner Nova Scotia that does not burn fossil fuels.