Coalbed Methane in Nova Scotia

A Comprehensive Guide to the Technology, Risks, and Activities

Ecology Action Centre
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Coalbed methane (CBM) is a non-renewable fossil fuel that is being developed in Nova Scotia as a source of natural gas. Coal bed methane extraction can cause severe consequences to the environment and public health. In 2014, the Nova Scotia government enacted legislation that prohibited hydraulic fracturing in shale deposits[i]. Unfortunately, coalbed methane production, which is associated with many of the same risks and impacts as fracking, continues to be permitted in this province despite this ban.

CBM brings unacceptable risks to drinking water, clean air, biodiversity and healthy vibrant communities. The Ecology Action Centre works to ensure that communities have the right to limit, regulate or ban industrial activities that negatively impact health and the environment and that these rights should never be compromised. Compared to development opportunities in wind, solar, geothermal and other renewables, development of CBM does not bring us closer to reaching our goals for greenhouse gas emissions or our renewable energy targets. Every decision we make around energy production should be a decision to help mitigate climate change.

Through this webpage, we offer information on the potential environmental impacts of CBM, information about activities near Stellarton, Nova Scotia, and further educational resources on CBM. We also offer examples of communities and people standing up for their rights to clean air and water in Australia, Wyoming and Alberta – areas where CBM is active.

Contents

How is natural gas produced from coal?

Natural gas (methane) occurs during coal formation, and can be released from coal when the rock is depressurized. In general, pumping of water from a coal seam depressurizes the coal, allowing methane to be released from the rock. Produced water and waste water are pumped out of the shallow coal deposit, and this waste requires storage, transport, treatment and disposal. Because natural gas production from CBM wells is much lower than in conventional wells, development requires more wells per square kilometre. Flaring, or burning off methane from wells occurs for several weeks or months until the well can produce sufficient methane for economical production. One study indicated that as many as 50% of CBM projects in six US states have included fracking in their production activities[ii]. Although companies can drill exploration wells, rates of production months or years later will determine whether fracturing is required.

How is CBM related to fracking?

Coalbed methane is an unconventional resource, which means it is slower and more expensive to extract than conventional resources. Unconventional oil and gas resources include

- tight oil: oil found in low-permeability rock, including sandstone, siltstone, shale, and carbonates;
- tight gas: natural gas found in low-permeability rock, including sandstone, siltstones, and carbonates;

- shale gas: natural gas locked in fine-grained, organic-rich rock; and
- coalbed methane (CBM): natural gas contained in coal.

Coal deposits require detailed exploration and research to determine the techniques that will produce methane economically. One technique that is used on some formations is hydraulic fracturing. This is where a high-pressure fluid (often water) with sand and chemicals is injected deep into a tight rock formation (such as shale and coal), creating fractures to release more of the methane.

Fracking of CBM deposits has many of the same environmental concerns as fracking shale deposits[iii], including

- Wells are drilled vertically then horizontally, and the horizontal length of well is fracked over the entire length;
- Each frack uses substantial volumes of water, sources from local lakes, streams and groundwater;
- Chemicals are used to optimize conditions in the well, and natural toxins are released from the coal as it is fractured;
- Hundreds or thousands of truck trips are required to operate the wells, causing road damage, and diesel and noise pollution;
- Substantial volumes of toxic wastewater are produced, in addition to contaminated drill cuttings and sand;
- Flaring of exploration and production wells and compression station emissions release harmful pollutants and greenhouse gases; and
- Large numbers of wells means an increased likelihood of well failures and contamination of drinking water.

Triangle Petroleum estimated the number of wells required to produce shale gas economically in the Kennetcook area at 680 over 70 square kilometres. Stealth Ventures Ltd. estimated the number of production wells by in the Springhill area to produce coal bed methane at 1000 wells over an uncertain area.

For more information about fracking in Nova Scotia, please read "Out of Control: Nova Scotia's experience with fracking for shale gas" published in 2013 by the Nova Scotia Fracking Resource and Action Coalition.

What environmental and health issues are associated with CBM?

Coalbed methane exploration and drilling generally cause more significant impacts on the landscape, air, and water than conventional gas extraction.

As with shale gas development, CBM development raises a number of environmental issues such as concentrated land use disruptions – CBM wells are spaced closer than conventional wells with networks of roads and compressor stations. Each new well, road, pipeline and compressor industrializes and fragments the landscape, increasing the ecological pressures on wildlife, streams, and farms.[iv] Large volumes of water from local resources are used in production, which puts pressure on drinking water and agricultural water, already under pressure from changing climate patterns. Significant volumes of wastewater are produced which must be stored, transported, treated and disposed. As seen in Kennetcook from unconventional exploratory drilling in that area, wastewater is a hot-potato issue that is complex and difficult to resolve.

The Council of Canadian Academies recent paper "Environmental Impacts of Shale Gas Extraction in Canada" addressed many issues relating to shallow unconventional developments such as coal bed methane. For example:

> "Accidental surface releases of fracturing chemicals and wastewater, and changes in hydrology and water infiltration caused by new infrastructure, may affect shallow groundwater and surface water resources. A risk to potable groundwater exists from the upward migration of natural gas and saline waters from leaky well casings, and possibly also natural fractures in the rock, old abandoned wells, and permeable faults."[v]

> Jackson et. al suggest that the reason there have been no documented cases of groundwater contamination from shallow CBM extraction is because there is a systematic lack of monitoring of fluid migration and groundwater contamination. "…They do not rule out the potential for contamination in cases of shallow hydraulic fracturing, such as suggested by Tilley and Muehlenbachs (2011) for coal-bed methane extraction in Alberta."[vi]

A recent peer-reviewed report[vii] that provided recommendations to improve risks to health and the environment stated that there is "an urgent need for short- and long-term studies of the potential effects of unconventional energy extraction (including CBM) on human health." They state that there have been "virtually no comprehensive studies published on this topic." France and Bulgaria have health-based bans on hydraulic fracturing and in the United States, New York State has a moratorium on high-volume hydraulic fracturing until a review of the potential health effects is completed.

Coal bed methane modelling and fracturing is still a frontier technology, with even the oil and gas giant Haliburtan admitting that "the complexity of CBM fracking exceeds

current modelling capabilities."[viii] Although some organizations in Western Canada have recommended best practices to mitigate some of the detrimental effects of the industry, many groups have asked governments for a moratorium on CBM while environmentally-protective and health-protective legislation is developed to this new technology[ix, x, xi].

Is CBM technology being used in Nova Scotia?

There are three companies in Nova Scotia with the right to explore and produce natural gas from coal.

- East Coast Energy Inc. holds a coal gas production agreement in the Stellarton area. **East Coast Energy has been actively drilling exploration wells in 2013 and 2014**. The Ecology Action Centre is currently reviewing activities at the Stellarton site (East Coast Energy Inc) to determine what activities and technologies (including CBM) have been used.
- Stealth Ventures and Donkin Tenements Inc have production agreements in the Springhill and Sydney areas respectively. Stealth Ventures has not had active operations since 2009. Link

In order to access company applications, communications and government relating to this project, a freedom of information and protection of privacy (FOIPOP) request was made to the Departments of Energy, Environment and Natural Resources in December 2014 to "provide all records (applications, approvals, correspondence, maps and public consultation information) relating to East Coast Energy Inc".

It is our understanding that the industrial approval was approved for two years by the Department of Environment on October 12, 2012 "for the Construction, Operation and Reclamation of a Petroleum Exploration Well for the purpose of exploring for Coal Bed Methane, and associated works, at or near McLellans Brook, Pictou County in the Province of Nova Scotia"[xii]. The government renewed this approval for five years in 2014[xiii]. Government's terms and conditions of this approval include sections addressing concerns including water withdrawal, wastewater treatment and disposal, fracking, noise, and flaring. As part of these terms and conditions, the company submitted documents on monitoring programs, baseline samples, land agreements, wastewater treatment options, and many others. All of these documents were reviewed by the Ecology Action Centre.

The development plan is a lengthy document which outlines all of the activities which the company plans to undertake, from cradle to grave. This document is typically prepared by a local consulting firm, in this case, Dillon Consulting[xiv]. Although the development plan submitted to the Department of Energy by the company in 2011 was

heavily redacted (i.e. significant sections of the report are blacked out), some of the remaining information is still concerning. Sections which were completely or mostly redacted include Development Strategy (4 pages), Land Tenure, Resource Assessment (2 pages), Production Techniques and Equipment, Alternative Methods, Production Projections, Abandonment and Reclamation, Gas Marketing, Opportunities for Local Gas Use, Carbon Sequestration, Water Withdrawal, Drill Water, Production Water, Employment and Other Economic Impacts, and Royalties. The Impact Statement on Environmental, Social and Economic Issues was a half-page describing a forest with two brooks, a construction and demolition site and an off-road racing area (page 24-25). The section shows a lack of understanding of local population, society, demographics, culture, land use, land stewardship, ecological health, rare or endangered species, and First Nations land use. The company provided maps of the local area near the wells and asked government to reduce the radius within which private water samples must be collected from homes, however government kept the radius at 1km. There are almost 100 dwellings within 1 km of the two sites.

The development plan also stated that water withdrawal to support this project is proposed to be from MacLellan's Brook[xv]. As the Nova Scotia Water Resource Atlas[xvi] described in detail in 2014, watersheds in this region are some of the smallest in northern Nova Scotia and would not likely be able to sustainably support long-term industrial-scale water withdrawal. The threats to the watershed in this region are considered high, with some watershed in the area considered under the highest threat for northern Nova Scotia (threat from hydrologic change, surface erosion, water quality, and instream habitat).

A water sample from the exploration well was collected by the company in November of 2014[xvii]. We have no information about the context of how this sample was collected, however results show elevated total dissolved solids (TDS of 110000 mg/L), hardness (31000 mg/L) and sodium (27000000 ug/L)are indicative of brine water pumped from the coal formation.

The development plan estimates 300 m^3 of cutting waste will be produced for every well[xviii]. Assuming that the waste meets guidelines for solid waste disposal, it would be transported to the Guysborough Landfill. If the company drills the estimated 1000 wells as described in a CBC interview in 2007[xix], the volume of waste solely from drill cuttings could be more than 100 000 tonnes of waste diverted to this small municipal landfill. This far exceeds the capacity of the Guysborough Landfill, which receives around 66 000 tonnes of waste each year[xx]. Other options suggested for this waste include burial on-site or land-farming of the material. Although drill cuttings could meet guidelines, additional chemicals used in drilling may not be listed in the guidelines, allowing them to be released into the environment for human exposure, with unknown risks and

consequences. Information about the potential volumes of waste water, and methods of storage, transport and disposal have been redacted.

In the terms and conditions of the industrial approval, government approved a treatment solution that includes rental of a mobile water treatment unit to bring wastewater to concentrations of parameters found in the nearby brook, parameters found in the federal guidelines (CCME Water Quality for the Protection of Aquatic Life). The description and scope of this treatment process has been completely redacted[xxi].

The company acknowledges that ammonia may also be present, and could be removed in an additional step of this process, along with other additional pre- and post-treatment steps requested on a "site by site basis". There is no mention of testing for chemical parameters such as proprietary drilling chemicals which are not listed in federal guidelines.

Additional conditions of the industrial approval include:

- A government-approved watercourse and wetland monitoring program must be developed, and samples must test for a list of chemicals and products associated with conventional and unconventional drilling;
- In the event of a spill or contamination of drinking water source, an independent investigation will take place to determine the cause and the company must provide of a permanent alternate source of water if the company is deemed to be responsible for the contamination;
- Hydraulic fracturing is prohibited unless granted by the Minister;
- Liquid wastes including wastewater must be stored in tanks and not ponds;
- Any loss of oil, water or fracking fluid exceeding 20% of fluids injected through the well into the formation must be reported to the government;
- An insurance bond of $10M per well is required before work proceeds;
- A communication plan must be developed to share and track information with First Nations communities.

Although some aspects of this approval reflect the government taking greater precautions, risks to human health, the environment and healthy communities remain and continue to cause great concern.

Case Study #1: Alberta

CBM activity in Alberta is most advanced compared to other provinces, and several cases of contamination have made national and international headlines. Ann Croft and Jessica Ernst have both stood up for their rights to clean water, and are pressuring

governments to address industry and regulatory negligence in protecting the environment and personal property.

Ann Craft is a real estate agent living in rural Alberta, near 4 shallow coal bed methane wells owned by Quicksilver Resources. Her 80-acre property includes several out-buildings and livestock. In February 2012, she experienced an event on her property that heaved and split her wooden porch. She was climbing her stairs and was bounced by a seismic event or earthquake twice. She later found cracked concrete and buckled metal siding that could also have been related to the event. Repeated appeals to government resulted in letters stating "it was probably an earthquake or other anomaly." The following year, she and her animals started getting sick and she identified strange substances coming from the ground around her property, and Styrofoam material being eaten away by her domestic drinking water. She started receiving water from a hauling company, and symptoms started to decrease. In June 2013, the hauling company delivered toxic produced water to her cistern instead of clean drinking water. She and her animals were directly exposed to this substance and she immediately had severe burning, itching and blotches on her skin, and animal began to lose their fur. "Even by industry standards produced water makes a nasty brew: it typically contains salts, heavy metals, radioactive particles, oil, hydrocarbons, dissolved gases, H2S, biocides, corrosion inhibitors and emulsion breakers. …All health providers familiar with her case admit that her symptoms are consistent with repeated exposure to hydrocarbons."[xxii] The government initiated a study of the event and possible connections with Quicksilvers wells but changed the scope of the study so that it did not address the wells close to Ann's home, nor did it address chemicals used in production, nor include testing local water supplies. The new study did not find any problems and the government closed the case on Ann's health and property concerns. She has since launched a $850 000 lawsuit against the trucking company that delivered contaminated water.

In a similar case of contamination, Jessica Ernst of Rosebud Alberta alleges in court that "EnCana Corporation broke multiple provincial laws and regulations and contaminated a shallow aquifer used by a rural community with natural gas and toxic industry-related chemicals." The claim methodically reports how Alberta's two key groundwater regulators, Alberta Environment and the ERCB, "failed to follow the investigation and enforcement processes that they had established and publicized." Her lawsuit, being presented at the United Nations, accuses EnCana, Alberta Environment and Energy Resources Conservation Board of negligence and unlawful activities.[xxiii]

In 2014, an Alberta court dismissed all key arguments made by the government of Alberta against the lawsuit of Ernst, including the fear that it may unleash a flood of

lawsuits against a government that supports hydraulic fracking of energy wells with numerous subsidies. The Alberta government argued that Ernst's $33-million lawsuit had no merit; that the government owed no duty of care to landowners with contaminated water; and that the government had statutory immunity. But Wittmann's ruling disagreed on all major counts and ordered the lawsuit against the government to proceed.[xxiv]

Case Study #2: Coal Seam Gas (CSG/CBM) in Australia

Coalbed methane (or coal seam gas, CSG) currently represents much of Australia's petroleum resources, with known reserves occurring in the eastern region, in Queensland and New South Wales. "The Australian Bureau of Agricultural and Resource Economics predicted that CSG production would grow by 14.9% per annum, accounting for 30% of Australia's natural gas production by 2029–30"[xxv].

In 2011, government confirmed that 493 wells were producing CBM in New South Wales, and 4489 in Queensland. During the first six months of 2011 there were 23 spills of waste water, four uncontrolled releases of waste water and three breaches of waste water storage during floods, according to Queensland's Department of Environment and Resource Management. In 2010, two incidents relating to water contamination from BTEX chemicals were reported in Australia, even though in both cases the companies involved said they did not use BTEX chemicals in fracking fluids. One of the greatest environmental concerns is preserving the waters of the Great Artesian Basin from contamination and depletion, especially in the Surat and Galilee basins in Queensland[xxvi].

The Lock the Gate Alliance formed in 2010 in response to environmental and health concerns associated with extensive CSG in Australia impacting local farms and rural communities. The Alliance declared that farmers should "lock their gates" and prohibit further expansion of CSG. Lock the Gate has over 30 000 supporters and 230 local groups, and their goal is to protect water systems, agricultural land, brushlands and wetlands, the health of all Australians and the culture and heritage of Australia's Aboriginal culture and heritage. They called on government to (i) enact a moratorium on CSG; (ii) create no-go zones and strengthen laws; (iv) place national standards on coal and gas pollution and prioritize compliance and enforcement; (v) stop industry subsidies; (vi) reject current proposals in sensitive areas; (vii) research greenhouse gas emissions from coal and gas mining; and (iix) launch a royal commission on investigate the management of CSG.

The Sunrise Project[xxvii] is another group that is "supporting and empowering Australian communities to protect land, water, community health and the global climate from the

negative impacts of the fossil fuel industry, and to hasten the inevitable shift to an efficient, renewable energy economy"[xxviii]. This organization provides information, training, strategy support and resources (including grants) for organisations and communities striving to improve Australia and the world.

In February 2013, the government launched an internal commission to review CSG which was followed shortly afterward by the enactment of a 6 month moratorium. Thuis internal commission released a report with recommendations to proceed with CSG, but slowly and with stronger legislation. In January 2015, the New South Wales government extended the moratorium to 2016, with a broader and more independent review process[xxix].

Case Study #3: Wyoming

CBM gas development in the Powder River Basin of Wyoming has been called the "hottest natural gas play in North America" by industry however the boom and bust pursuit of CBM is presenting enormous challenges for urban and rural citizens, ranchers and farmers, and impacted municipalities.

Laramie County has seen an increase in drilling applications in recent years from 147 applications in 2013 to 1,570 in 2014, and government is considering a proposal that would bring as many as 5,000 new wells to Converse County.[xxx] In 2009, over 400 miles of power lines were constructed to serve the CBM wells and compressor stations. Compressor stations are often powered by jet engines whose noise shatters the solitude of rural living. Hundreds of semi-trucks and pickups driving to and from methane sites kick up clouds of dust, resulting in increased respiratory problems for livestock and humans. Domestic and stock water wells are drying up or becoming contaminated with gas or other development-related constituents. [xxxi]

In Wyoming, wells that aren't producing must be bonded (insured) to cover the cost of reclamation. Many coal-bed methane producers went bankrupt following a drop in natural gas prices several years ago and were unable to cover the cost of closing their wells.

In 2014, High Plains Gas did not post the bond for 2300 wells, more than doubling the total number of abandoned wells in the state. Wells abandoned by operators represent thousands of orphaned wells that are emitting methane and other gases, and the state Governor's office estimated plugging that number of wells could cost upwards of $13 million.[xxxii]

In March 2012, several environmental groups launched a lawsuit against the Wyoming Oil and Gas Conservation Commission arguing that the agency was not allowing the

public to access chemicals used at industrial shale and coal gas sites. "The groups alleged the commission denied their state open records requests to review fracking fluid ingredients." Nearly all of the company requests to withhold trade secrets had been granted (50 out of 52 requests), and some were granted even though some companies did not comply with state requirements. Unfortunately, the Natrona County District sided with the state of Wyoming, saying the lists of the fracking chemicals used are trade secrets that may be withheld from the public under Wyoming's open records law.[xxxiii]

Some victories have occurred in Wyoming. Communities in the Hoback Basin consistently voiced opposition to exploration and development in this area. The result was an agreement with a Land Trust to purchase all of the company's leases and forfeit exploration and development rights with the Wyoming Range Legacy Act. The bill had broad support from many Wyoming groups and individuals, including: Former Governor Freudenthal, the Wyoming Outfitters and Guides Association, Wyoming State AFL-CIO, Wyoming Tourism Bureau, Wyoming Game Wardens Association, and local landowners, ranchers, outfitters, sportsmen, business owners and conservation groups.[xxxiv]

Want to learn more?

What's the problem with fracking? Physicians, Scientists and Engineers for Healthy Energy (US).

This article briefly outlines the history of shale gas and CBM in the US, including the review of fracking by the Environmental Protection Agency (EPA), definition of fracking in the California Senate, and the "Haliburton Loophole" around the Safe Drinking Water Act by Congress.

"This historical overview offers a glimpse into the importance of accurate framing and defining of scientific questions and how scientific information pertains to policy debates."

Unconventional Gas: The environmental challenges of coalbed methane development in Alberta. The Pembina Institute. 2003.

This report shows the distinctively different character of much CBM development compared to conventional oil and gas exploration. It describes how the density of CBM wells and the large land base that may be affected raise concerns about cumulative

impacts and land fragmentation by wells, pipelines and roads. **The list of key questions at the end serves as a "citizens' guide," enabling landowners and other stakeholders to understand the critical issues and ask the right questions about projects on their land or in their area.**

Coalbed Methane: Best Practices for British Columbia. Dogwood Initiative. 2010.
This is a very thorough document outlining best practices recommended for the safe use of coalbed exploration and development in British Columbia, including the first recommendation: "**Place a moratorium on CBM development until legislation is established which addresses the economic, environmental, and social concerns regarding CBM development.**" (page 46) The format of this report (outline of concerns, discussion of potential risks and benefits, recommendations) is similar to the recent **Report of the Nova Scotia Independent Review Panel on Hydraulic Fracturing**.

Petroleum Resources Act (Amended), November 20, 2014.
This is the Act which prohibits hydraulic fracturing in Nova Scotia, with the most important statement: "No person shall engage in high-volume hydraulic fracturing in **shale formations unless exempted by the regulations for the purpose of testing or research**."

Coalbed Methane: A BC Local Government Guide. West Coast Environmental Law. 2006.
This is a detailed guide for municipal leaders which outlines regulatory tools that encourage responsible development of CBM resources. The first recommendations include: "1. **Establish consultation protocols** with the Oil and Gas Commission regarding coalbed methane development. 2.**Review/revise Regional Growth Strategies** and the local government's Official Community Plan to establish clear objectives in relation to coalbed methane development. 3. **Review zoning and development bylaws**."

Coalbed Methane: What is it? What could it mean for BC? West Coastal Environmental Law. 2003.
This is a short guide describing some benefits and risks of CBM in British Columbia. It includes a citizens guide for landowners and community leaders to be more informed and empowered about CBM. It could be easily printed and shared over email.

Life Inside a Science Project. Globe and Mail, Andrew Nikoforuk. 2005.
An extensive report on the natural gas and CBM industry in the town of Rosebud Alberta, within the global and North American economic and energy context.

Excerpt: "Rosebud may be tiny, but the reason for its trepidation is as big as the continent: the natural gas crisis. With demand outstripping supply, the continent is running out of gas."

Briefing Note, CBM. Friends of the Earth. 2013.
This short report describes UK's CBM resources, and their associated threats to climate change, energy policy, local environments, and human health.

"Friends of the Earth believes the answer to the UK's energy problems is not unconventional gas such as CBM, but cutting energy waste and developing clean British energy using our potential for wind, wave and solar power."

Position statement on shale gas, shale oil, coal bed methane and 'fracking'. 2012. Coalition of NGOs.
This position paper represents Food and Water Europe, Friends of the Earth Europe, Greenpeace, and the Health and Environment Alliance, and outlines concerns with these technologies based on climate, energy, water pollution, water use, air pollution, and six other areas.

"Until all these problems are adequately addressed, we believe that no further shale gas, shale oil and coal bed methane activities should proceed. We call on all Member States to suspend all ongoing activities, to abrogate permits, and to place a ban on any new projects, whether exploration or exploitation."

Onshore co-produced water: extent and management. Australian Government National Water Commission.

This Waterlines report was commissioned in 2010 to raise and discuss issues associated with the management of water produced during oil and gas production, including coal seam gas (CSG) production.

"While it is recognised that there are broader impacts on other water users—including the environment—associated with CSG development, the focus of this paper is on the practical management of co-produced water at the surface."

Other Sources:

Armstrong, J., C. Mendoza, and A.W. Gorody. 2009. **Potential for Gas Migration due to Coalbed Methane Development**. Worley Parsons, Calgary, Alberta for Alberta Environment, Edmonton, Alberta.

Blyth, A. 2008, **An Independent Review of Coalbed Methane Related Water Well Complaints Filed with Alberta Environment**. Alberta Research Council, Edmonton, Alberta, 13p.

Energy Resources Conservation Board (ERCB). 2006. Directive 35: **Baseline Water Well Testing Requirement for Coalbed Methane Wells Completed above the Base of Protection**. ERCB, Calgary, Alberta, Canada. May 8, 2006.

Cheung, K et. Al. **Produced fluids and shallow groundwater in coalbed methane (CBM) producing regions of Alberta, Canada: Trace element and rare earth element geochemistry**. 2009. International Journal of Coal Geology.

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[i] Petroleum Resources Act (Amended), November 20, 2014. http://nslegislature.ca/legc/bills/62nd_2nd/3rd_read/b006.htm

[ii] Coalbed Methane: Best Practices for British Columbia. Dogwood Initiative. (date unknown)

[iii] http://www.nofrac.com/wp-content/uploads/2013/04/out-of-control-full-report3.pdf

[iv] West Coast Environmental Law. 2003. Coalbed Methane: What is it? What could it mean for BC?

[v] http://www.scienceadvice.ca/uploads/eng/assessments%20and%20publications%20and%20news%20releases/shale%20gas/shalegas_fullreporten.pdf

[vi] http://www.scienceadvice.ca/uploads/eng/assessments%20and%20publications%20and%20news%20releases/shale%20gas/shalegas_fullreporten.pdf page 67

[vii] http://www.annualreviews.org/doi/pdf/10.1146/annurev-environ-031113-144051

[viii] http://www.halliburton.com/public/pe/contents/papers_and_articles/web/a_through_p/h03493.pdf

[ix] Coalbed Methane: Best Practices for British Columbia. Dogwood Initiative. (date unknown)
[x] West Coast Environmental Law. 2003. Coalbed Methane: What is it? What could it mean for BC?
[xi] Griffiths M. and Severson-Baker, C. 2003. Unconventional Gas: The environmental challenges of coalbed methane development in Alberta. The Pembina Institute.
[xii] 2015-03 FOIPOP 3 Approval 2012
[xiii] 2015-03 FOIPOP 1 Approval 2014
[xiv] 2015-03 FOIPOP 19 Development Plan
[xv] 2015-03 FOIPOP 7 Supporting Doc 2012 (Page 2)
[xvi] http://earthsciences.dal.ca/www/PDFs/Final_Atlas_Mar_20_2014.pdf
[xvii] 2015-03 FOIPOP 21 Sample Results (Page 7)
[xviii] 2015-03 FOIPOP 19 Development Plan (Page 27)
[xix] http://www.cbc.ca/news/canada/nova-scotia/nova-scotia-approves-coal-bed-methane-project-1.659039
[xx] Personal communication, Bruce Avery, March 11, 2015.
[xxi] 2015-03 FOIPOP 18 Reverse osmosis treatment (Veolia)
[xxii] http://thetyee.ca/News/2014/12/04/Nightmare-of-Ann-Craft/
[xxiii] http://www.ernstversusencana.ca/
[xxiv] http://thetyee.ca/News/2014/12/10/Alberta-Wont-Appeal-Ernst-Decision/
[xxv] http://archive.nwc.gov.au/__data/assets/pdf_file/0007/18619/Onshore-co-produced-water-extent-and-management_final-for-web.pdf, page 4
[xxvi] http://www.abc.net.au/news/2015-02-03/environmental-regulator-investigates-possible-csg-water-spill/6064956
[xxvii] http://www.sunriseproject.org.au/
[xxviii] http://www.sunriseproject.org.au/about/
[xxix] http://www.sbs.com.au/news/article/2013/03/12/factbox-csg-australia

[xxx] http://theenergycollective.com/edfenergyex/2186091/wyoming-new-drilling-raises-new-questions-about-air-quality
[xxxi] http://www.powderriverbasin.org/coalbed-methane/
[xxxii] http://wyomingpublicmedia.org/post/state-seizes-wells-indebted-coal-bed-methane-operator
[xxxiii] http://www.sourcewatch.org/index.php/Wyoming_and_fracking
[xxxiv] http://www.wyomingrange.org/the-legacy-act.html