Review of British Columbia's hydraulic fracturing regulatory framework

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EY

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Contents

1. Executive summary

Hydraulic fracturing is a key activity in the extraction of natural gas from unconventional gas reservoirs. The unconventional natural gas industry in British Columbia (B.C.) is growing, and that growth, combined with high profile regulatory decisions related to hydraulic fracturing in other jurisdictions, has resulted in increased attention to the regulation of hydraulic fracturing in this province. More than 75% of B.C.'s natural gas production is from hydraulically fractured wells.

As part of its ongoing effort to continuously improve the energy regulation regime in B.C., the B.C. Oil and Gas Commission ("BCOGC" or "the Commission") engaged EY to conduct a focused assessment of the regulatory framework governing hydraulic fracturing. Specifically, the Commission asked us to:

- Assess the BCOGC's current regulatory framework, including legislation, regulation, guidance, leading practices, policies, permit conditions, and industry standards;
- Develop a detailed map of the relationship between existing regulatory instruments and the key issues presented by hydraulic fracturing;
- Conduct a high-level scan of six selected jurisdictions with an industry and geology similar to B.C.;
- Identify opportunities to improve the framework; and,
- Based on a set of co-developed guiding principles, develop leading-practice recommendations.

Overall, hydraulic fracturing is well regulated in B.C. While we have identified a number of improvement opportunities, the BCOGC is well positioned to capture them using its continuous improvement processes, and in several cases has already begun capturing them through existing initiatives.

Working with the Commission, we adopted an issues-based approach to our assessment. We identified three primary issue groups: water use and protection (water lifecycle), induced seismicity, and quality of life disturbances. We further identified the key issues within those groups and conducted a detailed, internal assessment of the extent that existing regulatory instruments provide coverage of those key issues.

1.1. Approach and findings

Our assessment has determined that, overall, the issues presented by hydraulic fracturing are being managed by the BCOGC. In our current-state assessment, we identified a number of instances where the Commission is demonstrating leadership or particularly effective regulatory practice:

Issue category	BCOGC notable successes
Water lifecycle	► An acknowledged leader in the management of surface water for oil and gas activities ► Issues quarterly and annual reports of oil and gas water use in the province ► Developed a number of decision support tools for industry and other stakeholders, such as the NorthEast and NorthWest Water Tools and the Water Data Portal ► Comparable or better than other jurisdictions in chemical fluid disclosure, having established the FracFocus portal

Induced seismicity	► Has released two detailed reports on induced seismicity: a 2012 report investigating seismicity in the Horn River Basin and a 2014 report investigating seismicity in the Montney Trend. These reports represent some of the leading research into the issue of seismicity triggered by hydraulic fracturing and injection wells ► Has worked with industry to significantly increase the seismic monitoring capability in Northeast B.C. since 2012
Quality of life disturbances	► Has awareness that operational disturbances are an emerging issue and is exploring improvement opportunities ► Effectively utilizes non-regulatory tools, such as stakeholder and community outreach, to mitigate quality of life issues

It is our assessment that the overall framework governing hydraulic fracturing in the province is robust; however we have identified a number of opportunities for improvement. These opportunities largely consist of instances where regulation currently exists but could be enhanced through the Commission's continuous improvement activities.

None of the opportunities that we identified in the three categories constitute major failings of the regulatory framework, nor do we believe that there are any significant sources of risk that remain untouched by regulation.

In total, we identified 23 opportunities for improvement across three themes:

- **Data collection and monitoring (7 opportunities):** instances in which the collection of additional data would enable the Commission to better establish baselines, perform ongoing environmental monitoring, and make more informed regulatory decisions
- **Regulatory authority and oversight (3 opportunities):** instances in which no regulatory instrument directly within the control of the Commission provides the necessary authority to mitigate a risk or respond to an issue
- **Regulatory instrument coverage (13 opportunities):** instances in which existing regulatory instruments could be enhanced to more comprehensively regulate specific issues

As a next step, we prioritized these 23 opportunities:

Priority	Opportunities identified
Priority 1	**5**
Priority 2	**9**
Priority 3	**9**

Priorities were developed based on the existence of evidence, the potential impact, the probability of occurrence, and the level of perceived risk. A detailed discussion of the individual opportunities and the prioritization criteria can be found in section 5 and appendix A of this report

Following the opportunity identification phase, we developed nine draft guiding principles for the regulation of hydraulic fracturing and confirmed those principles through a workshop with the BCOGC's executive committee. We compared B.C. to six other jurisdictions with a similar industry maturity and geology to analyse how these key issues are being mitigated by these six identified relevant jurisdictions and to identify any further areas that may need to be addressed. Overall, we found the key issues that were identified for the Commission were identical across all jurisdictions with only varying levels of importance within the same issue. The report does not contain any discussion of the numerous areas where the Commission's approach is leading compared to other jurisdictions

1.2. Recommendations

Based on the identified opportunities, and informed by the guiding principles and leading practices in other jurisdictions, we developed leading practice recommendations for B.C.

Our three high-level recommendation themes are as follows:

1. **Data collection and monitoring:** We recommend that the Commission enhance its existing data-collection and analysis capability by developing requirements regarding baseline testing, ongoing monitoring, and data submission. Additionally, the Commission should establish a baseline testing and ongoing monitoring regime.

   This recommendation is largely related to baseline testing and ongoing monitoring of water quality near oil and gas wells. For example, this includes developing enhanced water quality testing requirements to provide additional tools for measuring compliance with results-based regulation.

2. **Regulatory authority and oversight:** We recommend that the BCOGC work with the Ministry responsible to ensure that the elements of the *Water Act* and the upcoming *Water Sustainability Act* that are administered by the BCOGC provide:
   - Adequate and appropriate coverage of issues related to water use and protecting ground and surface water from contamination; and,
   - Effective and efficient compliance and enforcement tools

   The Commission administers a broad range of regulation and legislation, but the provisions of the *Water Act* are under the purview of the responsible Ministries. For example, this may include providing increased coverage of groundwater use and a broader range of administrative penalties.

3. **Regulatory instrument coverage:** We recommend that the BCOGC update or modify specific elements of existing regulatory instruments.

   This recommendation relates to opportunities to modify existing regulatory instruments to better cover key issues. Examples include moving requirements related to induced seismicity from permit conditions into regulation and adding more prescriptive engineering and construction requirements for flowback water containment rings into the *Drilling and Production Regulation.*

We also suggest the following four strategic considerations:

1. Explore the implementation of area-based or play-based regulation to mitigate against potential cumulative impacts and to support long-term planning for the industry and the regulator

2. Collaborate with other regulators and with industry stakeholders to implement these recommendations and promote a broader continuous improvement effort

3. Improve stakeholder engagement through direct and timely communication with the public using all channels

4. Consider opportunities to streamline processes and reduce regulatory costs to encourage industry competitiveness

Section 6 of this report discusses these recommendations and considerations in detail.

1.3. Conclusion and next steps

In the short-term, the BCOGC and EY can present the hydraulic fracturing regulatory review findings, jurisdictional comparison and recommendations to the Ministry of Natural Gas Development and other audiences.

In parallel, there is an opportunity to develop an integrated action plan and roadmap that consolidates recommendations from this hydraulic fracturing regulatory review and other relevant reports. To address the longer-term strategic initiatives, the BCOGC can begin the following activities:

- Further analyze area or play-based regulation in British Columbia by understanding impacts to policy, using lessons learned from other jurisdictions, and developing options for a potential pilot program
- Work with government to improve stakeholder engagement through direct and timely communication
- Identify opportunities for improved process efficiency to reduce regulatory costs

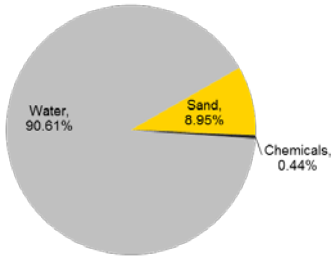
The BCOGC can collaborate with government, other regulators and industry stakeholders to implement these recommendations and promote a broader continuous improvement effort.

2. Background

The British Columbia Oil and Gas Commission ("the Commission" or "BCOGC") is the provincial regulatory agency responsible for overseeing oil and gas operations in British Columbia (B.C.) including exploration, development, pipeline transportation, and reclamation. The BCOGC balances a broad range of environmental, economic and social considerations using a single-window approach. This single-window approach allows a single organization to administer provisions of several acts and regulations, creating a streamlined and largely consistent regulatory environment for oil and gas activity. The BCOGC is the primary administrator of the provisions of the *Oil and Gas Activities Act* (OGAA) and is additionally responsible for administering specific provisions of the *Water Act*, the *Environmental Management Act* (EMA) the *Forest Act*, the *Heritage Conservation Act*, and the *Land Act*, as they relate to oil and gas activities.

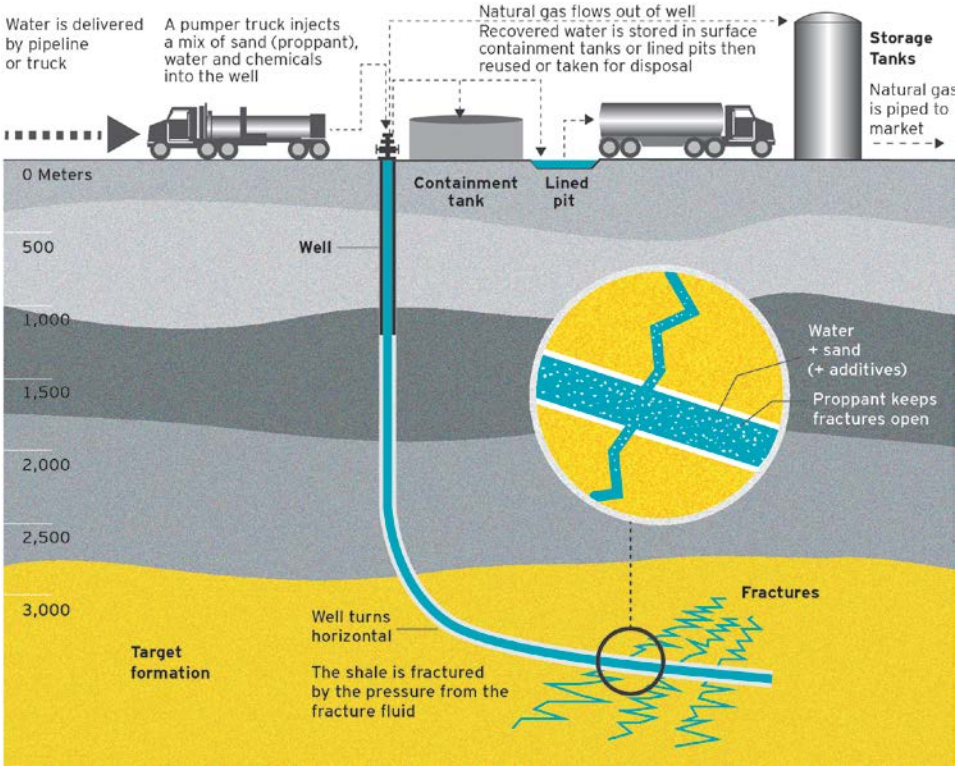
Hydraulic fracturing is a key activity in the extraction of natural gas from unconventional gas reservoirs. In the hydraulic fracturing process, a fluid generally consisting of water (either fresh water or saline water that has been recovered from previous hydraulic fracturing operations or subsurface sources), sand, and a small volume of chemicals are pumped at high pressure into the natural gas well. The pressure of the fluid creates fractures in the gas-bearing formation that generally extend horizontally about 150 meters perpendicular to the wellbore. Fractures also have a vertical extant, known as fracture height, though vertical movement is limited by the overburden pressure of the formations above the activity. These fractures allow the gas trapped in the formation to flow into the well and up to the surface, where it is captured and transported by pipeline to storage and processing facilities.

Figure 1: Composition of hydraulic fracturing fluid, by volume



Source: Arthur et al, 2008

Figure 2: Hydraulic fracturing process



After a well has been fractured, a proportion of the injected fluid flows back to the surface. This fluid is captured and stored until it is reused in other hydraulic fracturing operations or transported to deep injection wells for disposal. Figure 2 illustrates the hydraulic fracturing process. The natural gas industry in B.C. is dependent on hydraulic fracturing: 90% of new wells in the province are unconventional

and more than 75% of the province's natural gas comes from hydraulically fractured wells.

The unconventional natural gas industry in British Columbia (B.C.) is growing, and that growth, combined with high profile regulatory decisions related to hydraulic fracturing in other jurisdictions, has resulted in renewed attention to the regulation of hydraulic fracturing in this province. As part of its continuous improvement efforts, the BCOGC engaged EY to conduct an independent assessment of the regulatory framework governing hydraulic fracturing in B.C. The objective was to assess the current state of the BCOGC's hydraulic fracturing regulation to identify areas where improvements can be made or where the current approach can be enhanced.

Our assessment focused on the following activities:

- Identify the primary issues to be addressed by the hydraulic fracturing regulatory framework
- Assess the BCOGC's current regulatory framework, including legislation, regulations, guidance, leading practices, policies, permit conditions, and industry standards
- Map the regulatory instruments to the issues
- Conduct a high-level scan of six selected jurisdictions with an industry and geology similar to B.C.
- Identify areas where improvements can be made or where the current approach can be enhanced
- Catalog current and ongoing improvement initiatives
- Develop leading practice recommendations based on guiding principles and improvement opportunities

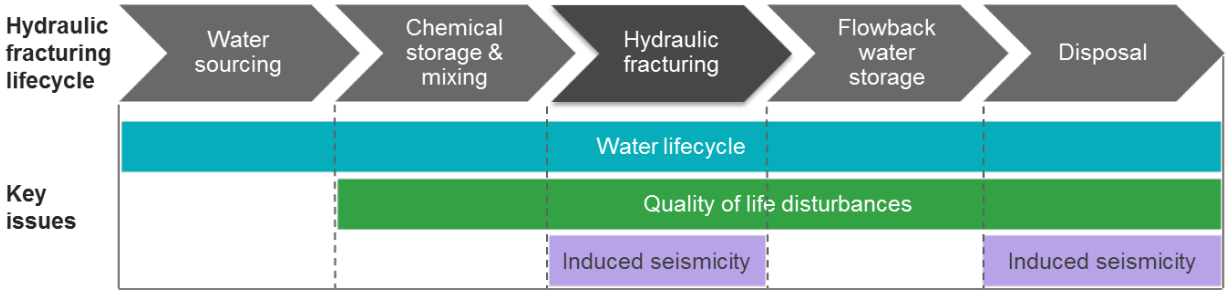
3. Scope

3.1.1. Scope of the analysis

The scope of this project was to explore the regulatory framework that applies to the hydraulic fracturing activities that take place during the production of natural gas. Working closely with the Commission, we focused on environmental, social, and public safety issues to understand how the regulatory framework addresses hydraulic fracturing concerns that are important to British Columbians. The assessment was intended to be a review of the hydraulic fracturing regulatory regime, rather than a science-based, technical, or comprehensive review of all oil and gas regulations.

The scope of the assessment focused on three groups of issues identified as the top concerns related to hydraulic fracturing according to interviews and recent independent research[1]:

Figure 3: Issues within the hydraulic fracturing lifecycle



- **Water lifecycle issues**: issues related to the sourcing, use, storage, and safe disposal of the water used for hydraulic fracturing
- **Induced seismicity issues**: issues related to seismicity caused by hydraulic fracturing or the disposal of flowback water in deep disposal wells
- **Quality of life issues**: issues related to disturbances to local quality of life caused by hydraulic fracturing activity

Each primary issue consisted of sub-issues shown in the table below:

Key issue	Sub-issues
Water lifecycle	▸ Water use o Surface fresh water use o Subsurface fresh water use o Alternative sources of water o Disclosure and reporting of water use

[1] Canadian Council of Academies, 2014; BCOGC

	► Surface or groundwater contamination from above o Site locations relative to water sources and aquifer recharge zones o Contents of chemicals used in hydraulic fracturing o Chemical storage and transportation o Public disclosure of the composition of hydraulic fracturing fluid o Surface storage of flowback water o Treatment of flowback water prior to disposal o Transportation of flowback water ► Surface or groundwater contamination from below o The base of groundwater protection (BGWP) o Well casing and cementing construction and string depth o Communication with other wells o Natural pathways o Disposal of flowback water in deep wells
Induced seismicity	► Induced seismicity due to hydraulic fracturing ► Induced seismicity due to deep well disposal
Quality of life disturbances	► Surface footprint ► Increased traffic ► Operational disturbances such as noise, light, and fumes

3.1.2. Scope of information gathered

Our information gathering activities focused on interviews with BCOGC staff, a review of relevant regulatory source material, and a review of relevant secondary research and reports.

We conducted internal interviews with 18 BCOGC subject matter experts in the areas of geology, hydrology, engineering, public policy, legal and communications. While the focus of the assessment was internal, we also held informal discussions with researchers from the Canadian Association of Petroleum Producers (CAPP) and senior officials at the Ministry of Natural Gas Development (MNGD) to gather insight.

In addition to the interviews, we assessed the following primary sources to understand how the current regulatory environment relates to the identified issues:

- Legislation
- Regulation
- Permit conditions
- Guidance/advice relating to hydraulic fracturing issued by the regulator
- Industry recommended practices
- Codes of conduct
- National/international standards referenced in relevant legislation and regulation
- Other published leading practices

The scope of the secondary research focused on both BCOGC internal documentation and reports that focused on hydraulic fracturing in B.C. as well as other jurisdictions across the continent.

Jurisdictional scan scope:

The jurisdictional review consisted of a high-level scan of six jurisdictions selected based on similar industry maturity and geology. The purpose of the scan was to highlight practices in other jurisdictions that B.C. can explore to capture improvement opportunities or manage emerging issues. Given that every jurisdiction has unique geological, policy, and stakeholder characteristics, the scan focused on fit-for-purpose opportunities for B.C. rather than a direct comparison of regulatory instruments across jurisdictions. The scope involved secondary research of the following six jurisdictions:

- Alberta
- Saskatchewan
- Colorado
- North Dakota
- Pennsylvania
- Texas

In addition, EY regulatory and oil and gas industry specialists were interviewed to review research results and provide insights on the hydraulic fracturing and other oil and gas regulatory frameworks.

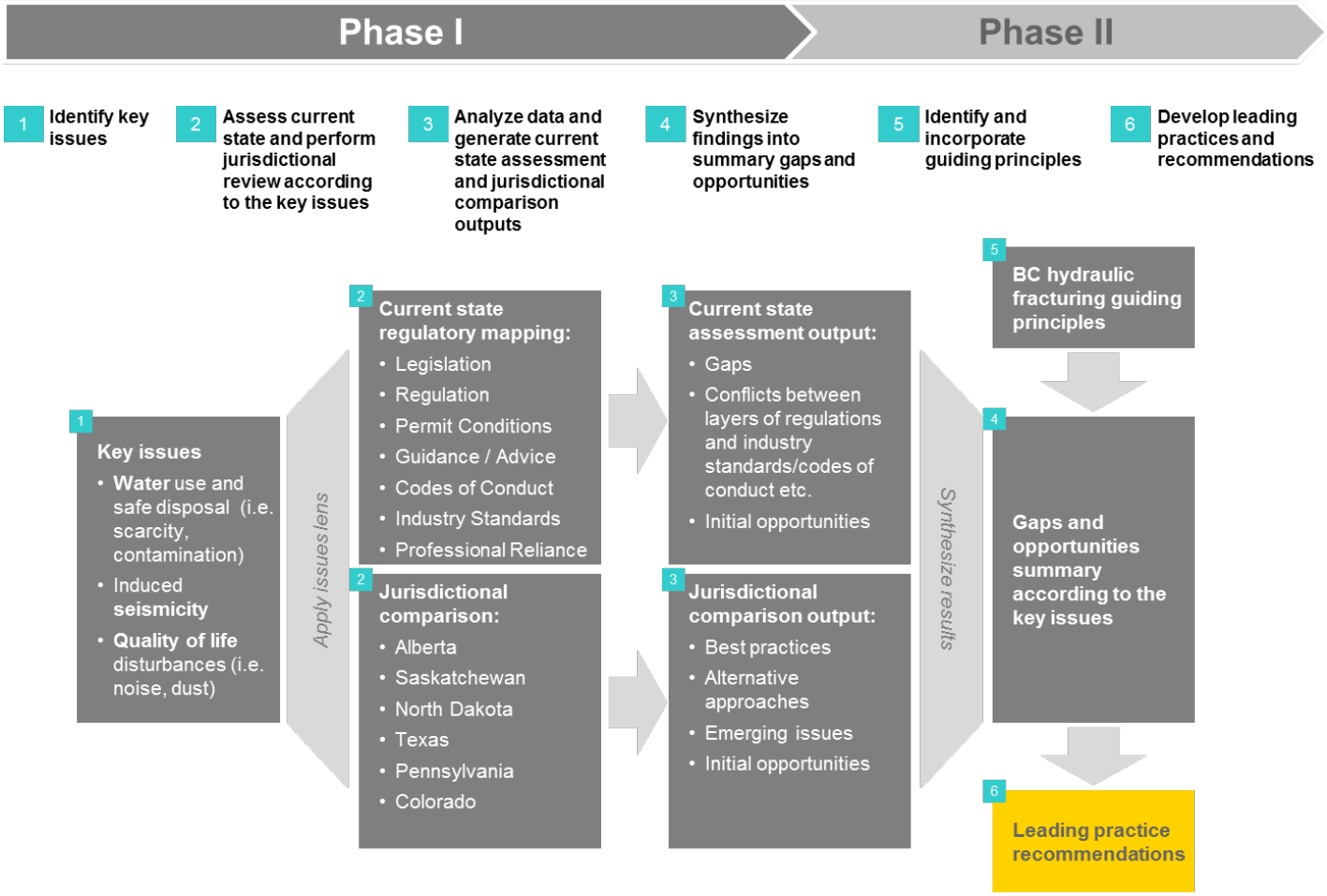
3.1.3. Out of scope

The following elements were not included in the scope of this project:

- Analysis of the regulation of natural gas exploration, drilling, or production beyond the activities directly involved with hydraulic fracturing
- Regulation of site reclamation
- Regulation of sump construction or management
- Regulation of greenhouse gas (GHG) emissions related to natural gas production
- Engagement with people or organizations outside of the BCOGC beyond limited engagement with CAPP and officials from the Ministry of Natural Gas Development
- Comment on or analysis of the scientific, technical, or engineering validity of regulatory instruments or the regulatory framework
- Detailed quantitative, scientific, engineering, or technical analysis of the outcomes of regulation in B.C. or other jurisdictions
- Comment on or analysis of regulatory compliance issues except insofar as they are relevant to leading practices

4. Approach

We used a two phase approach to assess the BCOGC's hydraulic fracturing regulatory framework. The diagram below illustrates the overall approach for the two phases of this project.



Phase I approach:

We applied an issues lens to the primary and secondary research, consisting of interviews, regulatory policy reviews, and reviews of relevant publications. A Hydraulic Fracturing Regulatory Mapping Table (appendix C) was created containing a description of all the regulatory instruments related to hydraulic fracturing and potential opportunities to improve. Concurrently, we investigated how other relevant jurisdictions regulate these key issues to highlight any potential opportunities for B.C. A workshop was conducted with the BCOGC subject matter experts to discuss and review findings. The result of the Phase I analysis was a Fact-Finding Report that detailed the current-state of the hydraulic fracturing regulatory framework. The Phase I Fact-Finding report was then reviewed and revised with BCOGC subject matter experts to validate findings; the results of that phase can be found in Appendix A: Detailed current-state assessment.

Phase II approach:

Following the opportunity identification phase, we developed draft guiding principles for the regulation of hydraulic fracturing and confirmed those principles through a workshop with the BCOGC's executive committee. Based on the Phase I improvement opportunities and the guiding principles, we then developed the leading practice recommendations that are presented in this report.

5. Current-state findings

An important element of the BCOGC's mission is to regulate oil and gas activities for the benefit of British Columbians. Effectively doing so requires balancing resource development on the one hand and conserving the environment and protecting public safety on the other. Moreover, it is not sufficient to find that balance at a single point in time; the oil and gas industry is rapidly evolving and an effective regulatory regime must be flexible enough to respond to new information, research, and changes in technology through its continuous improvement processes. This is particularly true for hydraulic fracturing. The 2014 report by the Canadian Council of Academies (CCA) on the environmental impacts of shale gas extraction in Canada notes that while the technology involved in hydraulic fracturing is well understood, more research is required to fully understand the implications of hydraulic fracturing on a large scale.

The potential issues related to water use and protection, induced seismicity, and quality of life represent areas that continue to require further review. Any risks associated with these issues are, however, believed to be modest[2] and can be effectively managed through a robust regulatory framework. Our investigation of the hydraulic fracturing regulatory framework in B.C. has determined that the issues presented by hydraulic fracturing are being effectively managed by the BCOGC. Moreover, the structure of the framework and the instruments at the Commission's disposal leave the BCOGC well placed to engage in continuous improvement and respond to new issues as they arise.

While it is our assessment that the overall framework governing hydraulic fracturing in the province is robust, we have identified a number of opportunities for continuous improvement. These opportunities largely consist of instances where regulation exists but could be enhanced through the Commission's standard continuous improvement processes. None of the opportunities that we identified constitute major failings of the regulatory framework, nor do we believe that there are any significant sources of risk that remain untouched by regulation or process.

During our jurisdictional review, we found that the key hydraulic fracturing issues that were identified were identical across all jurisdictions, varying only in the level of importance.

5.1. Regulatory process

The regulatory framework for oil and gas activities is made up of a number of instruments that work in concert with each other to achieve desired outcomes. Legislation is at the top of this regulatory hierarchy. The B.C. Legislature passes acts which outline the government's stated policy objectives and dictate the legal requirements that must be met by all operators who fall under the purview of that act. The two primary pieces of legislation governing oil and gas activity in B.C. are the *Oil and Gas Activities Act* and the *Petroleum and Natural Gas Act.*

[2] Green, 2014

Regulation is then drafted under each act to describe the specific expectations, implementation details, and compliance and enforcement tools that will be used to achieve the objectives outlined by the Legislature in the act. For example, the *Drilling and Production Regulation* exists under OGAA and provides specific details regarding the provisions of OGAA that relate to drilling and completing a well.

Permit conditions are a third regulatory instrument. OGAA requires that permits be granted in order to perform certain activities and gives the Commission the authority to grant or refuse them. The Commission also has the authority to attach conditions to these permits. Operators are required by law to comply with the provisions included in legislation, regulation, and permit conditions.

Instruments also exist that influence industry behavior but do not have the force of law. These instruments include guidance issued by the regulator, industry standards, and professional codes of conduct. While some instruments may not have the force of law, the BCOGC does frequently take them into consideration in the adjudication process.

Finally, the BCOGC also provides non-regulatory decision-support tools in order to help industry, First Nations, and stakeholders understand the impact of oil and gas activities. These tools range from research reports to interactive online services such as the NorthEast Water Tool.

5.1.1. Overall hydraulic fracturing regulatory structure

The Commission is responsible for regulating all oil and gas activities in the province. This “one window” approach allows a single organization to administer the provisions of several acts and regulations, creating a streamlined and largely consistent regulatory environment for oil and gas activity.

The Commission is the primary agency responsible for administering the provisions of:

- The *Oil and Gas Activities Act*

Additionally, as part of its “one window” structure, the Commission has the authority to administer selected provisions of a number of specific acts (“specified enactments”) from across several ministries, including:

- The *Environmental Management Act (EMA)*
- The *Forest Act*
- The *Heritage Conservation Act*
- The *Land Act*
- The *Water Act*

The Commission also administers numerous provisions included in regulations created under these acts.

5.1.1.1. Hydraulic fracturing regulatory instruments

There is no single regulatory instrument that governs hydraulic fracturing in B.C. The overall regulatory control of hydraulic fracturing is located in a suite of technical regulations issued under the authority of the *Oil and Gas Activities Act*. While the public perception of hydraulic fracturing is often that it is an isolated activity that occurs in a specific and defined context, the reality is that the hydraulic fracturing of a well is just one element of the process that an oil and gas company undertakes to drill and complete a well. While there is a primary piece of regulation governing drilling and completion activities – the *Drilling and Production Regulation* – the actual act of hydraulic fracturing is just one part of a series of actions that

need to be considered and regulated. Moreover, many of the key issues are not exclusive to hydraulic fracturing; creating a single hydraulic fracturing regulatory instrument would have implications for other oil and gas activities, as many of the issues must be regulated regardless of the existence of hydraulic fracturing in the province.

A comprehensive assessment of the hydraulic fracturing regulatory framework has to consider:

- The sources and volumes of water used
- The contents, storage, and transportation of chemicals used in fracturing fluid
- The storage, reuse, transportation, and disposal of flowback water after the fracturing processes
- The integrity of the well casing and cement
- The possible pathways between production wells, offset wells, and different geological zones, including the fresh groundwater zone
- Possible induced seismicity
- Quality of life issues such as traffic, noise, light and dust

Given the diverse nature of all of these different issues and the activities involved, the elements of hydraulic fracturing are governed by a number of provincial acts and a suite of oil and gas regulations, including:

- Provincial Acts:
  - The *Oil And Gas Activities Act*
  - The *Petroleum And Natural Gas Act*
  - The *Environmental Management Act*
  - The *Heritage Conservation Act*
  - The *Land Act*
  - The *Water Act*

- Oil and gas regulations:
  - The *Oil and Gas Activities Act General Regulation*
  - The *Drilling and Production Regulation* (DPR)
  - The *Environmental Protection and Management Regulation* (EPMR)
  - The *Pipeline Regulation*
  - The *Oil and Gas Waste Regulation*
  - The *Oil and Gas Road Regulation*
  - The *Consultation and Notification Regulation* (CNR)
  - The *Emergency Management Regulation*

These acts and regulations work in combination to provide comprehensive regulatory oversight covering the issues relevant to hydraulic fracturing.

5.1.1.2. Permitting process

The current regulatory framework for hydraulic fracturing in B.C. allows for flexibility in how activities are regulated through the use of permits. In addition to the advantages offered by the one-window approach and enabled through the use of specified enactments, the regulatory tools in the province are built around a robust permitting process. Companies are required to apply for and receive permits from the Commission in order to carry out a range of activities, including:

- Drilling and completing any well, including water source wells and disposal wells
- Removing water from Crown land
- Using land for oil and gas activities such as storing flowback water in lined earth pits
- Constructing and operating pipelines and facilities
- Building oil and gas roads

The requirement to apply for and receive a permit provides the Commission with three important tools:

- **Conditions:** First, the Commission is able to insert conditions into many of the permits that they have the authority to issue thereby allowing the BCOGC to impose conditions on permit holders without having to create new regulation or legislation. This allows the BCOGC to quickly enable new requirements as information changes or becomes available. In some situations, permit conditions are a way to "pilot test" regulation, consistent with the level of risk and understanding of the activity. Permit conditions may also be amended, providing additional flexibility and the ability to respond to new information
- **Actions:** Second, the Commission can require that certain actions be taken and information be submitted as part of the permit application process. For example, if the Commission mandates that a map illustrating the status and completion zones of all wells within a 3km radius be included in a permit application for a new disposal well permit, the applicant must, by definition, have collected and studied that information
- **Cancellation:** Third, the permit process gives the Commission the power to withdraw permission by cancelling the related permit

5.1.1.3. Compliance and enforcement (C&E)

The Commission also has compliance and enforcement powers enshrined in legislation. The Commission undertakes inspections, audits, and investigations to ensure that the requirements imposed upon the oil and gas industry are being met. The Commission generally works collaboratively with companies to respond to identified instances of non-compliance, but the Commission also has a number of enforcement tools available, including the ability to issue a broad range of orders, including to suspend all operations. The BCOGC can also enforce compliance by cancelling permits and imposing penalties.

5.1.1.4. Instruments outside the Commission's scope

Certain issues and activities related to hydraulic fracturing are also governed by regulatory instruments outside of the Commission's span of control. Federal laws and regulations, such as the *Transportation of Dangerous Goods Act*, apply to some hydraulic fracturing-related issues, such as transporting chemicals by truck. Industry groups also provide recommended practices and guiding principles that oil and gas companies are encouraged to follow. Industry standards also exist, and can be voluntary or given the force of law through reference in a regulation.[3]

[3] For example, some sections of the *Drilling and Production Regulation* require that operators adhere to various CSA standards

5.2. Strengths and opportunities for improvement

As discussed, the overall existing regulatory framework is both comprehensive and effective. Our assessment identified a number of areas where the BCOGC is performing particularly well; it also identified a number of improvement opportunities that the BCOGC can integrate into its continuous improvement roadmap.

5.2.1. Strengths

Our assessment of the current state of the regulatory framework identified a number of instances where B.C. is demonstrating leadership or regulating particularly effectively.

Water lifecycle:

The BCOGC is an acknowledged leader in the management and reporting of surface water and chemical use for oil and gas activities. The Commission has developed several decision support tools for industry and other stakeholders, including the NorthEast Water Tool, the NorthWest Water Tool, and the Water Portal. The Commission issues quarterly and annual reports of oil and gas water use in the province. In addition, the Commission is comparable to or leading other jurisdictions in chemical fluid disclosure, having established FracFocus. FracFocus is an online portal where industry discloses and the public can access chemical additive information.

Induced seismicity:

The Commission is also demonstrating leadership in the regulation and researching of induced seismicity due to hydraulic fracturing. The BCOGC has released two detailed reports into induced seismicity: a 2012 report investigating seismicity in the Horn River Basin and a 2014 report investigating seismicity in the Montney Trend. These reports represent some of the leading research into the issue of seismicity triggered by hydraulic fracturing and disposal wells. As a result of the findings of the 2012 report, the Commission has also worked with industry to greatly increase the seismic monitoring capability in northeast B.C.

Quality of life disturbances:

The BCOGC is effectively using both non-regulatory and regulatory tools to manage the current level of quality of life disturbances experienced by residents of Northeast B.C. The Commission is aware that disturbances to quality of life are a potential emerging issue, and is considering opportunities to better protect against those issues as activity in the region increases.

5.2.2. Opportunities for improvement

Our assessment indicates that, in general, hydraulic fracturing activities in B.C. are well regulated. In a rapidly evolving and growing industry, however, it is reasonable to expect that opportunities to reduce risk, increase efficiency, or improve regulatory coverage will present themselves. As part of the current-state assessment, we engaged in a collaborative and iterative process with BCOGC to review and assess the Commission’s regulatory framework for hydraulic fracturing and identify areas that the BCOGC can target for enhancement or improvement.

Based on our research, interviews with BCOGC staff, and a findings validation workshop, **23 improvement opportunities were identified** and evaluated against the following set of characteristics:

1. **Evidence exists:** There is evidence that the issue objectively exists. This could be scientific evidence, or objective experience on the part of BCOGC officials

2. **Potential impact:** The continued existence of the issue or a single occurrence of an event related to the issue may impact the ability of the regulator to conserve the environment, protect public safety, respect those affected by oil and gas activities, or support resource development

3. **Probability of occurrence**: The probability that issues or events related to the issue will occur. This may also reflect instances where the high volume of a related activity would make it prudent to consider a proactive regulatory response

4. **Perceived risk**: The degree to which the perception that an issue is not being regulated could compromise public confidence in the regulator and require a regulatory response

Based on these criteria, opportunities were assigned a priority rating of 1, 2, or 3:

- **Priority 1 opportunities** are those for which evidence exists, there is a high probability of occurrence, and a high potential impact. **Five Priority 1** opportunities were identified

- **Priority 2 opportunities** are those for which there is moderate probability of occurrence or a high perceived risk, as well as a lower potential impact. **Nine Priority 2** opportunities were identified

- **Priority 3 opportunities** are those with a low potential impact or for which the opportunity involves the type of regulatory instrument in use, rather than the ability of the current regulatory framework to address the relevant issue (for example, regulating induced seismicity through permit conditions rather than provisions in the *Drilling and Production Regulation*). **Nine Priority 3** opportunities were identified

5.2.2.1. Opportunity themes

This assessment process revealed that the identified opportunities could be grouped into three high-level themes:

- Data collection and monitoring
- Regulatory authority and oversight
- Regulatory instrument coverage

The following section describes the themes and presents the improvement opportunities identified in each. The improvement opportunities are discussed in further detail throughout the report and are listed along with their rationale in Appendix B.

Data collection and monitoring opportunities

These include instances in which the collection of additional data would enable the Commission to better establish baselines, perform ongoing environmental monitoring, and make informed regulatory decisions. Most of the opportunities identified in this theme relate to information needed to help track the water use from source through to final disposal. These opportunities are listed in priority below.

Table 5.2-1: Data collection and monitoring opportunities

ID#[4]	Opportunity	Priority
O8	▸ Development of appropriate requirements related to baseline testing and ongoing monitoring of surface or groundwater quality around production zones would provide an additional data to support results-based regulatory requirements and to monitor compliance	1
O7	▸ The EPMR allows for enhanced management to protect aquifers should the Ministry responsible designate an aquifer; no aquifers have yet been designated. There is an opportunity for the BCOGC to collect and provide the Ministry with the data necessary to identify high-risk aquifers. Should an aquifer be designated, additional mitigation requirements could be implemented by the BCOGC related to the protection of the aquifers and associated recharge zones	2
O13	▸ Specific data collection and submission requirements related to the characterization of shallow aquifers in Northeast B.C. would allow for more informed decisions related to the isolation of porous zones containing usable groundwater and determinations for the base of all porous zones containing usable groundwater. Such data collection efforts may also inform any future BGWP mapping initiatives	2
O23	▸ Requirements to collect and submit microseismic monitoring data around hydraulic fracturing activities would allow the BCOGC to better understand the behavior of hydraulic fracturing in different formations, maintain confidence that fractures are not migrating outside of their intended zones, and support efficient resource extraction by encouraging industry adoption of best practices	2
O6	▸ Requiring operators to report the use of water obtained from sources on private land would allow the BCOGC to more accurately report on water use related to hydraulic fracturing, thereby improving transparency	2
O5	▸ Requiring operators to report the use of water obtained from alternative sources, such as municipal grey water or water purchased from municipal water supplies would allow the BCOGC to more accurately report on water use related to hydraulic fracturing,[5] thereby improving transparency	3
O9	▸ Development of appropriate requirements related to baseline testing and ongoing monitoring of domestic water well quality around production wells would provide an additional data to support results-based regulatory requirements and to monitor compliance	3

Regulatory authority and oversight opportunities

These include instances where no regulatory instrument provides the necessary authority to mitigate a risk or respond to an issue. These opportunities are listed in priority below.

Table 5.2-2: Regulatory authority and oversight opportunities

ID#	Opportunity	Priority
O1	▸ Increased regulatory authority over the use of water obtained on private land would allow the BCOGC to better manage water use, particularly in periods of drought	2
O2	▸ The ability to issue higher penalties for violations of the Water Act would allow the BCOGC to more effectively enforce compliance with the Act	2
O4	▸ The upcoming *Water Sustainability Act* will include provisions related to groundwater thereby addressing the gaps in the Water Act concerning the protection of groundwater in B.C. Successful implementation of the act and its regulations will support the sustainable management of groundwater in B.C.	2

[4] ID # is a unique identifier for the opportunity that allows it to be tracked throughout the report and mapping table. The opportunities are identified in the order in which they are discussed in appendix A

[5] The scope of this opportunity excludes freshwater withdrawn from surface sources on private land. For discussion of freshwater from sources on private land, see opportunity 6

Regulatory instrument coverage opportunities

Regulatory instrument coverage opportunities are instances where existing regulatory instruments could be enhanced to more comprehensively regulate specific issues. These include areas where existing guidance is not sufficient, more prescriptive regulations are required, or where issues currently managed through the use of permit conditions should be managed through regulation.

This theme represents the largest group of opportunities that we identified. This supports our larger conclusion that overall regulatory framework is functioning well and that there are no major issues that are untouched by regulation. These opportunities are listed in priority below.

Table 5.2-3: Regulatory instrument coverage opportunities

ID#	Opportunity	Priority
O16	▸ Enhanced regulation related to pressure testing and casing centralization would provide additional tools to protect against uncontrolled fluid flow occurring behind well casing	1
O10	▸ The BCOGC's current guidance for flowback water storage is outlined in information letter # OGC 09-07. Adding these requirements into regulation would give them the force of law and would provide the BCOGC better C&E options to protect against water contamination due to leaks or spills	1
O11	▸ Open tanks, such as containment rings, could benefit from more specific regulation to better protect against leaks or spills	1
O22	▸ There is an opportunity to improve public awareness related to the Commission's use of minimum separation requirements (setbacks) in decision-making	1
O17	▸ Requirements to evaluate the integrity of nearby wells, either active or abandoned, prior to hydraulic fracturing would protect against contamination of freshwater due to conduits created by other wells	2
O21	▸ Light emissions, fumes from diesel engines and other air quality issues such as ground level ozone are currently addressed through industry best practice, but given that this is an emerging issue, there is an opportunity to consider increased guidance/permit conditions/regulations in cases where hydraulic fracturing occurs near occupied buildings or populated areas	2
O3	▸ Requiring limits on pumping rates for water source wells would give the BCOGC the ability to more comprehensively manage the sustainable use of groundwater	3
O12	▸ While the DPR requires that porous zones containing usable water be isolated, there are no regulatory definitions of "usable" groundwater or "porous zones." Clearer definitions would reduce the likelihood of interpretation errors and allow the BCOGC to more consistently apply the regulation and evaluate compliance	3
O14	▸ Guidance on the criteria or methodology for identifying porous zones containing useable groundwater would provide consistency with respect to interpretations by qualified professionals	3
O15	▸ Permit holders are allowed to conduct hydraulic fracturing operations to depths of close to 600 meters without additional permit conditions. As future knowledge regarding the BGWP and hydraulic fracture propagation distances is developed, a review of this prescribed depth limit may be advisable	3
O18	▸ Baseline and ongoing testing of water quality near disposal wells is currently done on a case-by-case basis using permit conditions. Including these requirements in regulation and applying them more broadly would provide an additional tool to measure compliance with results-based regulatory requirements	3
O19	▸ Regulation of induced seismicity caused by hydraulic fracturing is currently done through permit conditions. There is an opportunity to improve transparency and effectiveness by moving these requirements into regulation to be more consistently applied and enabling access to a broader set of C&E tools	3
O20	▸ Regulation of induced seismicity caused by injection wells is currently done through permit conditions. There is an opportunity to improve transparency and effectiveness by moving these requirements into regulation to be more consistently applied and enabling access to a broader set of C&E tools	3

5.2.3. Opportunities outside the scope of the Commission

During our current-state assessment, a number of initial opportunities were considered that were determined to be outside the scope of the Commission and therefore will not be included in the

recommendations. These opportunities are described in the table below and include a rationale for their exclusion.

Table 5.2-4: Opportunities outside the scope of the Commission

Initial opportunities	Rationale for why opportunity is outside of Commission's scope
▸ An initial opportunity related to "green" chemical incentives was considered	▸ This opportunity is a matter of policy rather than regulation. There is an opportunity to use non-regulatory incentives to encourage operators to move towards using more "green" fluids. The use of non-regulatory incentives resides with the Ministry of Natural Gas Development
▸ Protection under trade secret laws allows for some exemption in chemical component disclosure. An initial opportunity to remove the exemption was considered given that this exemption could impact the public's confidence in the disclosure regulation.	▸ The current chemical use disclosure framework in place through fracfocus.ca is leading practice ▸ The BCOGC has been proactively working with hydraulic fracturing services companies to identify the emergency contact at each company in order to more quickly facilitate any required response in the event of an emergency ▸ Trade secret exemptions are the jurisdiction of the Federal Government and are outside of the BCOGC's control
▸ An initial opportunity was considered related to the regulation of transportation and traffic related disturbances outside of specified oil and gas roads	▸ While the issues surrounding increased traffic and transportation of potentially hazardous materials by truck are important, the BCOGC does not regulate traffic on public roads in B.C., and therefore any opportunities related to traffic are outside of its regulatory purview

6. Recommendations

Regulatory leading practice recommendations were developed based on the findings of current state analysis and the hydraulic fracturing guiding principles. This section presents the Commission's guiding principles, the recommended actions to capture the identified improvement opportunities, and longer term strategic considerations for the Commission to further explore. These leading practice recommendations can be implemented as part of the Commission's continuous improvement effort.

6.1. Hydraulic fracturing guiding principles

Following the opportunity identification phase, we developed draft guiding principles for the regulation of hydraulic fracturing and confirmed those principles through a workshop with the BCOGC's executive committee. The hydraulic fracturing guiding principles define the fundamental aspects of the desired future state of the hydraulic fracturing regulatory framework. These principles align with the Commission's mandate to regulate oil and gas activities for the benefit of British Columbians by protecting public safety, respecting those affected by oil and gas activities, conserving the environment, and supporting resource development.

These hydraulic fracturing guiding principles serve as a clear set of criteria for analyzing improvement opportunities and driving the development of the regulatory leading practice recommendations.

6.1.1. Nine hydraulic fracturing guiding principles:

1. Hydraulic fracturing regulatory decisions should be informed by the appropriate application of **data** and **scientific analysis**
2. Hydraulic fracturing regulatory framework **balances** both **results-based** regulation to encourage **innovation** and **prescriptive** regulation to **protect** key public values
3. Hydraulic fracturing regulatory framework is **transparent, unambiguous, and enforceable**
4. Hydraulic fracturing regulatory framework is **comprehensive** and **sufficiently flexible** to respond to complex issues and enable **continuous improvement**
5. Compliance with hydraulic fracturing regulation is achieved using a comprehensive set of **effective, efficient,** and **fit-for-purpose tools**
6. Hydraulic fracturing-related activities should **minimize impacts to the environment** while **maximizing the benefits of resource extraction**
7. **Impact** on **areas, regions,** or **plays** is considered when making decisions about hydraulic fracturing related activities
8. Hydraulic fracturing regulatory framework **considers** the **impact on industry competitiveness**
9. Opportunities to **cooperate, collaborate** and **standardize** the regulation of hydraulic fracturing across jurisdictions are supported

1. **Hydraulic fracturing regulatory decisions should be informed by the appropriate application of data and scientific analysis**

Sound and defensible decisions are essential to building a rational regulatory framework. This approach requires systematic data collection and scientific analysis, which is critical for measuring compliance with results-based regulation.

An appropriate level of data collection and analysis is necessary to support decision making and compliance monitoring while avoiding “paralysis by analysis”. Situations may exist where a regulatory response is required to manage perceived risks that are causing particular public concern.

2. **Hydraulic fracturing regulatory framework balances both results-based regulation to encourage innovation and prescriptive regulation to protect key public values**

A results-based framework enables innovation by allowing for more flexibility in achieving desired outcomes. Results-based regulations focus on measuring the outcome achieved rather than on prescribing and measuring compliance with a process. In a results-based framework, data must be gathered and analyzed to measure compliance with the desired outcome. Conversely, in a prescriptive framework, operators are evaluated based on ability to meet all of the prescriptive requirements and regulation is generally front-end loaded through the authorization process. Compliance is measured by monitoring processes and procedures.

The Commission aims for a results-based framework that is prescriptive where specifically required. Prescriptive regulatory tools may be required to protect key public values where risk tolerance is low and similarly, where operators require guidance or more detailed regulatory instruments to meet the desired outcomes.

3. **Hydraulic fracturing regulatory framework is transparent, unambiguous, and enforceable**

Clearly defined and transparent regulation supports the protection of key public values by setting industry up for success in their ability to follow the framework and achieve the Commission’s desired results. Requirements should be constructed in a manner that is measureable, enforceable, and practical. In addition, transparency and enforceability builds public confidence in the regulatory framework.

4. **Hydraulic fracturing regulatory framework is comprehensive and sufficiently flexible to respond to complex issues and enable continuous improvement**

A flexible structure allows the Commission to adapt to emerging issues and lessons learned to ensure that regulation remains comprehensive. This flexibility establishes a culture of continuous improvement that allows for the timely integration of best-practices from other jurisdictions and the response to changes from emerging technological improvements.

5. **Compliance with hydraulic fracturing regulation is achieved using a comprehensive set of effective, efficient, and fit-for-purpose tools**

Compliance tools should be appropriate and broad enough to effectively and efficiently address the issues being enforced. Effective tools have the influence to deter undesired behaviour and efficient tools are cost and time efficient rather than administratively burdensome.

Monitoring and investigation tools should be aligned with the regulatory approach. Prescriptive regulation requires inspection capability while results-based regulation requires monitoring and testing capability.

6. Hydraulic fracturing-related activities should minimize impacts to the environment while maximizing the benefits of resource extraction

The regulatory framework supports the Commission's mandate to protect public safety and respect those affected by oil and gas activities while maximizing the benefits of resource extraction. This balance ensures benefits to B.C. by protecting the environment while maximizing resource extraction.

7. Impact on areas, regions, or plays is considered when making decisions about hydraulic fracturing related activities

This principle aims to measure cumulative impacts and combine the multitude of separate regulatory activities related to hydraulic fracturing into a single application and review process. There are several benefits of considering the regions or plays in the decision making process:

- Consider cumulative effects by taking a broader view in planning future development. This approach can better protect against potential cumulative impacts, including environmental outcomes that may not be visible when using a more granular, activity-based process
- Increased opportunities for collaboration between oil and gas industry participants by allowing easier integration of land use activities. This collaborative approach would limit impacts to the environment by sharing resources and infrastructure
- Increased integration will mean reduced costs for operators and a smaller surface footprint as a result of less scattered development
- May promote an efficient, less administratively burdensome approach to the regulation of hydraulic fracturing activity if the authorization process is streamlined with fewer applications

By contrast, an activity-based application process (as defined under OGAA) can be an efficient, less time consuming decision-making model. It is easier to get alignment on an approval when multiple stakeholders are involved. Additionally, there is a potentially lower risk of tying up the development of an entire area if a legal or other issue arises. Under this model, there is less impact if fundamental design plans for an area change over long periods of time. On the other hand, the play or area based model better protects against cumulative impacts over a longer term and better supports continuous improvement.[6]

[6] EY has recently released a report on the potential and implications of play-based regulation in Alberta. The report can be accessed from EY's website, here: http://www.ey.com/Publication/vwLUAssets/EY-Alberta-oil-gas-regulatory-paradigm-shift/$FILE/EY-Alberta-oil-gas-regulatory-paradigm-shift.pdf

8. Hydraulic fracturing regulatory framework considers the impact on industry competitiveness

It is important to recognize that the level of regulatory burden imposed on industry directly impacts the Province's ability to be competitive in attracting economic investment and maximizing the benefits of resource extraction. Therefore, the regulatory framework should not unnecessarily exceed the extent of rigour required to mitigate risks.

9. Opportunities to cooperate, collaborate and standardize the regulation of hydraulic fracturing across jurisdictions are supported

Cooperation and collaboration of regulation across jurisdictions provides benefits from standardization, knowledge sharing and economies of scale. Standardization of regulatory practice provides consistency and transparency for operators, the public, First Nations, and stakeholders. Sharing of practices and lessons learned leads to the advancement of leading practices and continuous improvement initiatives. Lastly, the cost and time to implement requirements is reduced for individual regulators by working with bodies such as the Canadian Standards Association (CSA) to develop and update technical requirements.

6.2. Detailed recommendations

Following from our identified improvement opportunities and informed by both the hydraulic fracturing guiding principles and practices in other jurisdictions, we have developed leading practice recommendations at the theme and individual opportunity levels. For each theme, we provide a high-level overarching recommendation, and for each improvement opportunity we provide recommended actions or next steps that can be integrated into the Commission's continuous improvement efforts. The BCOGC generally has the ability to modify or adjust the technical requirements of regulations under its control. However, in order to implement some of the following recommendations, the BCOGC may have to work with other Ministries in order to align with Government direction.

In addition to the recommendations, this section also presents some longer-term strategic considerations for the Commission to explore.

6.2.1. Data collection and monitoring recommendations

Sound data and the capability to analyse that data and place it in a larger context is an essential component of a robust regulatory framework. In B.C., the Commission collects significant amounts of environmental and technical data and has a large staff of technical experts on hand to provide interpretation and insight to decision makers. There is, however, an opportunity to enhance the current monitoring regime related to water quality near hydraulic fracturing activities. We recommend that the Commission enhance its existing data-collection and analysis capability by developing requirements regarding baseline testing, ongoing monitoring, and data submission in cases where:

- The collection of additional data would be actively used by the Commission to support more effective regulatory decision making;
- Additional data would support efforts to measure compliance with key results-based regulatory requirements;
- Disclosure of key well completion information would maximize resource extraction; and,
- Environmental or technical baseline testing and ongoing monitoring would build public, First Nations, and stakeholder confidence in the regulatory framework.

The Commission should supplement its baseline testing and ongoing monitoring regime, such that it:

- Considers both the costs and benefits of conducting baseline testing and ongoing monitoring;
- Avoids data collection that doesn't directly benefit policy development and decision making; and,
- Remains flexible enough to allow for timely and efficient decision making.

Table 6.1-1: Detailed data collection and monitoring recommendations

ID#	Opportunity	Actions
Priority 1 opportunities		
O8	Development of appropriate requirements related to baseline testing and ongoing monitoring of surface or groundwater quality around production zones would provide an additional data to support results-based regulatory requirements and to monitor compliance	The BCOGC has recently: ► Developed an initial discussion paper on baseline testing and ongoing monitoring of water quality near production wells ► Used permit conditions to require ongoing water quality monitoring near disposal wells We recommend the following next steps: ► Utilize the initial discussion paper as a basis to conduct a more thorough analysis of options for the development of baseline testing and ongoing monitoring requirements ► Use the results of tests of water quality near disposal wells to inform the development of a larger monitoring regime ► Develop requirements to conduct baseline testing and ongoing monitoring ► Conduct further analysis to evaluate appropriate monitoring processes and protocols and to assess the benefits of different options against the cost to industry and the regulator ► Consider initiating focused discussion and collaboration with the Western Regulators' Forum to identify if water monitoring principles from oil and gas activities in other jurisdictions can be applied to hydraulic fracturing in B.C. ► Explore opportunities to collaborate with CAPP and industry stakeholders
Priority 2 opportunities		
O7	The EPMR allows for enhanced management to protect aquifers should the Ministry responsible designate an aquifer; no aquifers have yet been designated. There is an opportunity for the BCOGC to collect and provide the Ministry with the data necessary to identify high-risk aquifers. Should an aquifer be designated, additional mitigation requirements could be implemented by the BCOGC related to the protection of the aquifers and associated recharge zones	Provincial initiatives are currently underway to characterize and map aquifers and recharge zones and to assess aquifer vulnerability ► Commission should consider collaborating with industry and the relevant Ministries to develop an approach to this data collection, sharing, and use ► These initiatives could support development of criteria to related to identification of specific aquifers that may require enhanced protection ► Criteria should be established to define “vulnerable” in the context of aquifers ► In the event that vulnerable aquifers are identified and designated, there would be an opportunity to develop appropriate risk mitigation techniques and activities
O13	Specific data collection and submission requirements related to the characterization of shallow aquifers in Northeast B.C. would allow for more informed decisions related to the isolation of porous zones containing usable groundwater and determinations for the base of all porous zones containing usable groundwater. Such data collection efforts may also inform any future BGWP mapping initiatives	Evaluate cost and benefits of options for collecting aquifer characterization data in Northeast B.C. ► One potential option would be to include provisions for the submission of data in BGWP identification guidelines currently under development by BCOGC. Similar provisions exist in Alberta
O23	Requirements to collect and submit microseismic monitoring data around hydraulic fracturing activities would allow the BCOGC to better understand the behavior of hydraulic fracturing in different formations, maintain confidence that fractures are not migrating outside of their intended zones, and support efficient resource extraction by encouraging industry adoption of best practices	► Develop guidance to industry that explicitly categorizes microseismic data as well completion data, therefore requiring that it be submitted after a well completion activity ► Consider adopting confidentiality periods to balance the concerns of industry with the competitive benefits realized by public disclosure ► Work collaboratively with industry to develop microseismic data submission requirements, including the type of data required (for example, raw data, summary reports, diagrams, etc.)

ID#	Opportunity	Actions
O6	Requiring operators to report the use of water obtained from sources on private land would allow the BCOGC to more effectively manage water use during periods of drought and more accurately report on water use related to hydraulic fracturing, thereby improving transparency	Consider developing and implementing regulation requiring that operators report the use of fresh water withdrawn from sources on private land ► Other jurisdictions such as Alberta and Pennsylvania require that operators report both volume and source of water used[7]
Priority 3 opportunities		
O5	Requiring operators to report the use of water obtained from alternative sources, such as municipal grey water or water purchased from municipal water supplies allow the BCOGC to more accurately report on water use related to hydraulic fracturing, thereby improving transparency	To the extent required for reporting and to conservatively manage water resources, consider updating the most appropriate regulations to require that operators report the use of water acquired from alternative sources[8]
O9	Development of appropriate requirements related to baseline testing and ongoing monitoring of domestic water well quality around production wells would provide an additional data to support results-based regulatory requirements and to monitor compliance	As part of a larger water quality monitoring regime, evaluate the costs and benefits of requiring baseline testing of domestic water wells near hydraulically fractured natural gas wells ► Consider working with CAPP to create more formal industry requirements based on CAPP's operating principles for hydraulic fracturing

6.2.2. Regulatory authority and oversight recommendations

The BCOGC's "one-window" structure and its use of specified enactments is helpful for providing a consistent and streamlined regulatory process for oil and gas activity in B.C. While the use of specified enactments provides consistency and flexibility, it does require that the Commission work closely with the Ministries responsible for those acts to facilitate continuous improvement. There are a number of opportunities related to the protection and sustainable management of water that can be captured by collaborating with the Ministry responsible for the *Water Act*. Moreover, the impending implementation of the B.C. *Water Sustainability Act* provides an opportunity to ensure that the BCOGC has the necessary authority to sustainably govern the use of water for the oil and gas sector.

We recommend that the BCOGC work with the Ministry responsible to ensure that the elements of the *Water Act* and the upcoming *Water Sustainability Act* that are administered by the BCOGC provide:

- Adequate and appropriate coverage of issues related to water use and protecting ground and surface water from contamination; and,
- Effective and efficient compliance and enforcement tools.

[7] Alberta Energy Regulator, 2012

[8] The scope of this opportunity excludes freshwater withdrawn from surface sources on private land. For discussion of freshwater from sources on private land, see opportunity 6

Table 6.1-2: Detailed regulatory authority and oversight recommendations

ID#	Opportunity	Actions
Priority 2 opportunities		
O1	Increased regulatory authority over the use of water obtained on private land would allow the BCOGC to better manage water use, particularly in periods of drought	Evaluate options for managing the sustainable use of water sourced from private land for oil and gas activities, particularly during periods of scarcity or drought.
O2	The ability to issue higher penalties for violations of the *Water Act* would allow the BCOGC to more effectively enforce compliance with the Act	Work with the relevant government ministries to include an appropriate range of administrative penalties in the regulation that is being developed for the new *Water Sustainability Act*
O4	The upcoming *Water Sustainability Act* will include provisions related to groundwater thereby addressing the gaps in *the Water Act* concerning the protection of groundwater in B.C. Successful implementation of the Act and its regulations will support the sustainable management of groundwater in B.C.	Work with the relevant government ministries to ensure that regulation developed for the new *Water Sustainability Act* provides the tools necessary to sustainably manage use of groundwater for oil and gas activities

6.2.3. Regulatory instrument coverage recommendations

The BCOGC administers a number of instruments covering the issues related to hydraulic fracturing. The oil and gas sector is a fast-moving industry, and it is to be expected that the regulation and other instruments under the purview of the BCOGC will need to evolve alongside the industry. As part of the Commission's ongoing continuous improvement activities, we recommend that the BCOGC update or modify specific elements of existing regulatory instruments where:

- Provisions should be updated to more comprehensively govern complex issues;
- Where appropriate and where permit conditions are being consistently applied, requirements currently enforced through the use of permit conditions should be added to regulation to allow for more consistent application and provide a broader range of compliance and enforcement tools;
- Emerging issues require updated provisions;
- Ambiguous provisions and terms should be more clearly defined to reduce the risk of misinterpretation; and,
- Provisions related to the protection of usable water from contamination should be updated to provide more specific requirements.

Table 6.1-3: Detailed regulatory instrument coverage recommendations

ID#	Opportunity	Actions
Priority 1 opportunities		
O16	Enhanced regulation related to pressure testing and casing centralization would provide additional tools to protect against uncontrolled fluid flow occurring behind well casing	► Develop clearer guidance for pressure testing and casing centralization and evaluate the costs and benefits of moving that guidance into the Drilling and Production Regulation ► Consider working with the Western Regulators' Forum to develop consistent pressure testing and centralization requirements ► Opportunity to explore the development of a CSA Express Document or CSA standards around pressure testing and casing centralization ► Additionally, there is currently no requirement to conduct cement bond logs[9] (CBL) or submit the interpretation of any that do take place to the Commission. The Commission should consider amending the *Drilling and Production* regulation to require that a CBL be run and the results and interpretation be submitted to the Commission for each completed well
O10	The BCOGC's current guidance for flowback water storage is outlined in information letter # OGC 09-07. Adding these requirements into regulation would give them the force of law and would provide the BCOGC better C&E options to protect against water contamination due to leaks or spills	In conjunction with the ongoing Western Regulators' Forum initiative to update the guidance regarding the storage of flowback water, develop and implement a plan to include this updated guidance in the relevant regulation, such as the *Drilling and Production Regulation*
O11	Open tanks, such as containment rings, could benefit from more specific regulation to better protect against leaks or spills	Enhance the existing performance-based regulations by developing and applying more prescriptive engineering, construction, and use requirements for open tanks, such as c-rings: ► Identify an appropriate regulatory instrument to govern storage of flowback water in open tanks ► Include appropriate requirements in the identified instrument
O22	There is an opportunity to improve public awareness related to the Commission's use of minimum separation requirements (setbacks) in decision-making	The BCOGC currently conducts stakeholder engagement and monitors complaints of local disturbances. As activity increases in the province, we recommend that the BCOGC: ► Consider conducting outreach and communication activities to increase awareness of the use of permits for controlling the distance between hydraulic fracturing activities and occupied spaces ► Consider developing more comprehensive guidance and best practice for industry regarding the separation of activity from occupied spaces ► If it becomes necessary to increase the minimum setbacks included in regulation, consider temporal limits on those setbacks to avoid long-term sterilization of land. I.e., greater setbacks while hydraulic fracturing activity is occurring ► Encourage industry to develop communication plans to raise awareness of best practices related to setback distances
Priority 2 opportunities		
O17	Requirements to evaluate the integrity of nearby wells, either active or abandoned, prior to hydraulic fracturing would protect against contamination of freshwater due to conduits created by other wells	► Require that operators develop and submit a hydraulic fracture risk plan that includes a risk assessment of offset wells using the IRP 24 methodology[10] ► Consider working with the Western Regulators' Forum to develop consistent fracture risk planning processes

[9] A cement bond log is a sonic tool that detects the integrity of the bond of the cement with the casing using acoustic resonance

[10] IRP 24 is an ENFORM Industry Recommended Practice regarding interwellbore communication. See section 7.1.3.3 for further discussion of IRP24

ID#	Opportunity	Actions
O21	Light emissions, fumes from diesel engines and other air quality issues such as ground level ozone are currently addressed through industry best practice, but given that this is an emerging issue, there is an opportunity to consider increased guidance/permit conditions/regulations in cases where hydraulic fracturing occurs near occupied buildings or populated areas	The BCOGC currently conducts stakeholder engagement and monitors complaints of local disturbances, which can be addressed in the context of permit conditions or guidance to industry. As activity increases in the province, consider making changes to the relevant regulations to enhance the current approach to managing light, noise disturbances, as well as emissions related to hydraulic fracturing
Priority 3 opportunities		
O3	Requiring limits on pumping rates for water source wells would give the BCOGC the ability to more comprehensively manage the sustainable use of groundwater	The BCOGC has developed a new Water Source Well Approval Framework that will incorporate pumping limits into well permits for shallow water source wells. Implementation is planned for February 2015
O12	While the DPR requires that porous zones containing usable water be isolated, there are no regulatory definitions of "usable" groundwater or "porous zones." Clearer definitions would reduce the likelihood of interpretation errors and allow the BCOGC to more consistently apply the regulation and evaluate compliance	Consider changing the provisions in the *Drilling and Production Regulation* that reference "porous zones containing usable water" to reference the "base of groundwater protection". The Commission should then provide a definition of the base of groundwater protection (BGWP) either in the *Drilling and Production Regulation* or in a directive/guidance ► This solution provides two benefits: it addresses the unclear definitions of usable and porous, and it provides the BCOGC with the flexibility to define the base of groundwater protection as it develops its BGWP mapping efforts
O14	Guidance on the criteria or methodology for identifying porous zones containing useable groundwater would provide consistency with respect to interpretations by qualified professionals	The BCOGC is currently developing guidelines for professionals to evaluate base of groundwater protection based on a review of methodologies used by other jurisdictions and consideration of available B.C. aquifer data. We recommend the following next steps: ► Hold discussions with CAPP and/or qualified professionals to determine different methods used in B.C. to assess the BGWP prior to drilling ► Implement requirements for companies to submit a BGWP determination, completed by a qualified professional, prior to or following drilling ► Collaborate with the Western Regulators' Forum to understand best practices and develop consistent methodologies across the region
O15	Permit holders are allowed to conduct hydraulic fracturing operations to depths of close to 600 meters without additional permit conditions. As future knowledge regarding the BGWP and hydraulic fracture propagation distances is developed, a review of this prescribed depth limit may be advisable	► The commission should begin collecting data to inform future mapping efforts. As data is collected, the Commission can evaluate the relevant regulatory requirements (currently section 21 of the Drilling and Production Regulation) to determine if more specific or effective requirements or processes should be developed ► Collaborate with the AER to learn best practices for BGWP mapping. Alberta has extensively mapped its BGWP ► There is an opportunity to collaborate with the Western Regulators' Forum to develop a regional BGWP mapping shared by western provinces ► Potential risks of hydraulic fracture propagation to fresh groundwater have been examined in other recent academic reports and the analysis may be useful for consideration in future discussion
O18	Baseline and ongoing testing of water quality near disposal wells is currently done on a case-by-case basis using permit conditions. Including these requirements in regulation and applying them more broadly would provide an additional tool to measure compliance with results-based regulatory requirements	The BCOGC has recently used permit conditions to mandate ongoing water quality monitoring around disposal wells on a case by case basis. The BCOGC has considered this issue through the B.C. Disposal Well Working Group and has determined that adding requirements on a case-by-case basis is appropriate given the small number of these wells and the unique context of each individual well. As activity increases, however, the Commission should periodically evaluate the appropriateness of moving monitoring requirements into regulation to allow for more consistent application and a broader range of compliance and enforcement tools

ID#	Opportunity	Actions
O19	Regulation of induced seismicity caused by hydraulic fracturing is currently done through permit conditions. There is an opportunity to improve transparency and effectiveness by moving these requirements into regulation to be more consistently applied and enabling access to a broader set of C&E tools	Implement the recommendations of the 2014 Investigation of Observed Seismicity in the Montney Trend ► Incorporate geological and geophysical analyses into application evaluations ► Continue to monitor seismic events recorded by the Canadian National Seismograph Network (CNSN) and request dense array deployments in areas where more detailed information is required ► Consider placing those permit conditions which are consistently used into regulation ► Continue to promote and support the sharing of dense array data with researchers and the publication of research results ► Investigate whether it would be appropriate to place conditions on hydraulic fracturing in areas that could be adversely affected by fault reactivation
O20	Regulation of induced seismicity caused by injection wells is currently done through permit conditions. There is an opportunity to improve transparency and effectiveness by moving these requirements into regulation to be more consistently applied and enabling access to a broader set of C&E tools	Implement the recommendations of the 2014 Investigation of Observed Seismicity in the Montney Trend, as outlined above

6.3. Strategic considerations

In addition to our specific recommendations, we have identified four strategic considerations that the Commission could use to inform the overall regulatory framework governing hydraulic fracturing.

6.3.1. Area or play-based regulation

Explore the implementation of area-based or play-based regulation to mitigate against potential cumulative impacts and to support long-term planning for the industry and the regulator

Through continuous improvement, the Commission is looking for new ways to enable growth while supporting the efficient, safe, and orderly development of energy resources and minimizing the environmental footprint of these activities.

Regulating activities at the area or play-based level could allow the BCOGC to capture the following potential benefits:

- Broader view of cumulative effects of development activities
- Collaboration between industry players
- Improved regulatory effectiveness and reduced burden
- Optimized facility development
- Increased ability to capture technology changes
- Lower operating costs and less complex abandonment processes
- Shorter development cycle

While hydraulic fracturing is one part of the activity in an area undergoing oil and gas development, the estimated growth of hydraulic fracturing presents an opportunity for increased coordination around land and water use and collaboration to drive innovation and efficient resource extraction.

6.3.2. Collaboration with other regulators

Collaborate with other regulators and with industry stakeholders to implement these recommendations and promote a broader continuous improvement effort

Canada has vast energy resources across multiple jurisdictions, each with its own regulatory regime. The rapid pace of technological progress and industry growth provides an opportunity to collaborate on processes, policies, technologies, and lessons-learned between regulators through channels such as the Western Regulators' Forum. Moreover, oil and gas operators frequently operate in multiple jurisdictions and national and international standards bodies can facilitate the development and implementation of consistent best-practices across boundaries. Ultimately, the Commission must provide a regulatory environment that makes sense for B.C., but capturing opportunities to share knowledge and effort is an important strategic consideration. The Commission should continue and build upon its current collaboration efforts.

Collaboration could provide the following benefits:

- Standardization of regulatory practice which provides consistency and transparency for operators, public, First Nations, and stakeholders

- Advancement of leading practices and continuous improvement initiatives through the sharing of practices, knowledge and lessons learned
- Reduction of the burden and time to implement for individual regulators by working with bodies such as the CSA to develop and update technical requirements

Our assessment recommends collaboration as part of the implementation phase; however, there is an overarching opportunity to collaborate in the investigation and design of regulatory instruments to better address current and emerging issues.

6.3.3. Direct and timely communication with stakeholders

Improve stakeholder engagement through direct and timely communication with the public using all channels

The BCOGC is responsible for implementing the stated policy of the Government of B.C. While it is not the role of the regulator to comment on the merits of those policies, the regulator does have a responsibility to communicate with the public, industry, First Nations, and stakeholders about the implementation of those policies. The Commission's mission is to regulate oil and gas activities for the benefit of British Columbians; maintaining the trust and confidence of British Columbians is foundational to achieving that mission. The Commission is an accomplished regulator with a strong roster of technical and public policy experts. The public presentation of that image will protect the public's trust and confidence in the Commission, and ultimately result in stronger and more collaborative regulation.

Direct communication with the First Nations, stakeholders, and the public, including via the media, could enable the following benefits:

- Building external confidence in the effectiveness of the existing regulatory framework through transparent and timely communication
- Allowing the regulator to be more directly proactive and responsive to public, First Nations, and stakeholder concerns when they occur
- Increased public engagement to improve input into the development of regulation and risk management processes
- Improved public awareness of the hydraulic fracturing regulatory framework to manage public concerns and reduce instances of misperception or speculation created by a lack of information

As a first step, we recommend that the Commission explore opportunities to improve public awareness of hydraulic fracturing regulation by working with Government to develop a more timely communications and media relations strategy and process.

6.3.4. Cost reduction and process efficiency

Consider opportunities to streamline processes and reduce regulatory costs to encourage industry competitiveness

Oil and gas resources are developed and sold in a globally competitive market. The robust and comprehensive protection of the environment and public safety is the overriding concern for its regulation; it is the role of government to establish policies regarding the appropriate balance between resource development and risk mitigation, and it is the role of the regulator to implement those policies. Within the context of those policies, the regulator should consider the burdens imposed by the costs and complexity

of the regulatory framework and its associated processes. While it is not the responsibility of the regulator to be directly concerned with the margins of oil and gas operators, finding opportunities to operationalize the government's desired policy outcomes while reducing the cost and complexity of the regulatory framework can contribute to a more robust industry for the province and economic benefits to B.C.

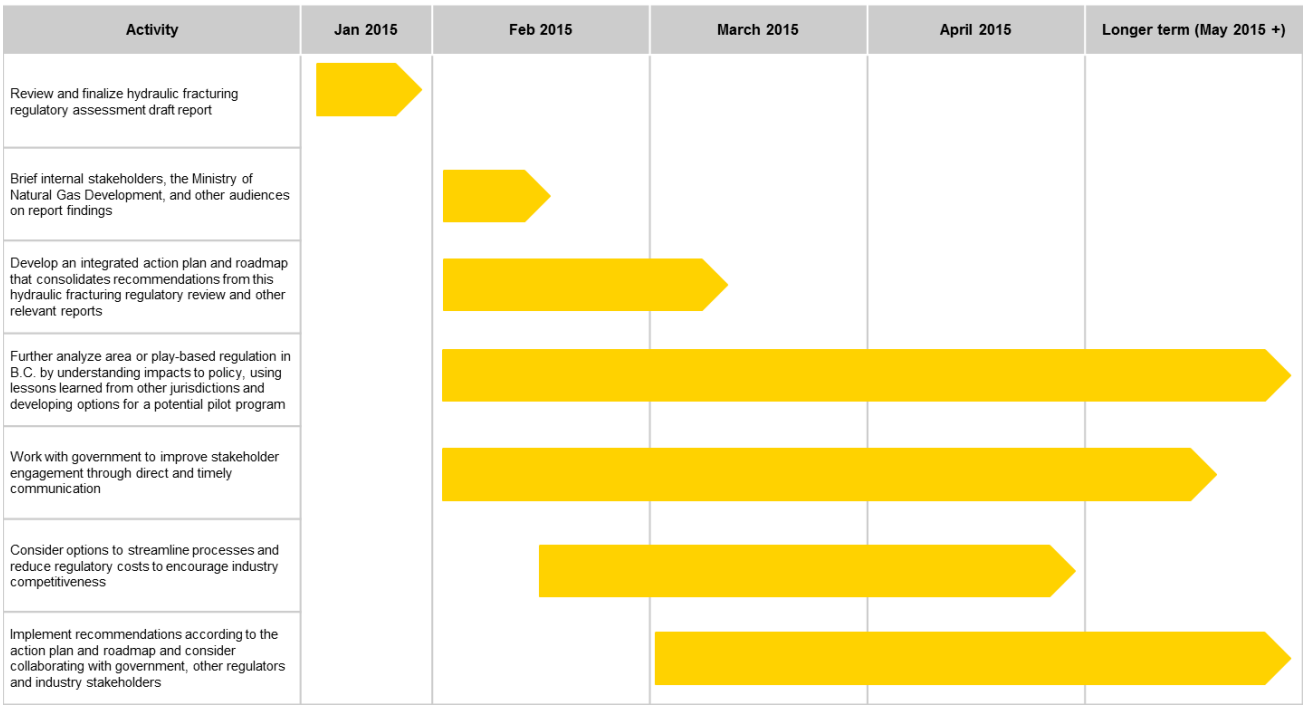
This is not to say that cost reduction should be the overriding concern; the Commission has a responsibility to conduct research, collect and analyze data, protect the environment, and ensure that those affected by oil and gas activities are being respected. We recommend that the Commission:

- In cases where it makes sense to do so, perform a cost benefit analysis of the regulatory changes outlined in this report as part of the action plan and implementation roadmap;
- Streamline data collection and analysis by identifying areas where current data collection isn't necessary; and,
- Build on existing initiatives, such as the ongoing Business Transition Strategy, to identify opportunities to streamline processes and procedures

6.4. Proposed next steps

After reviewing, revising, and briefing the Ministry of Natural Gas Development and other audiences on the findings and recommendations in this report, we recommend the following next steps, some of which can run in parallel:

Figure 4: Proposed next steps



The timeline above is a high-level illustration of how the BCOGC can sequence the proposed next steps.

7. Appendix A: Detailed current-state assessment

7.1. Water lifecycle

Many of the environmental concerns around hydraulic fracturing in B.C. are related to the use and protection of fresh water. While B.C. has abundant water supply, water in the province is a shared resource and is integral to the province's ecological and environmental health.

The B.C. Oil and Gas Commission uses a broad range of regulatory tools to control and monitor water use and protect against contamination, including legislation, regulation, permits, approvals, directives, and online disclosure and decision-making tools.

7.1.1. Water use

The hydraulic fracturing process requires large amounts of water (anywhere from 6,000 to 80,000+ cubic meters of water per well, a total of 5.3 million cubic meters in 2013)[11]. In 2013, approximately 62% of water use for hydraulic fracturing came from surface sources of fresh water on Crown land (e.g., rivers, lakes, etc.) with the remaining coming from water source wells, recycled flowback water, private acquisition, and other sources.

While the volume of water used is large in an absolute sense, the total amount used is low relative to the total hydrological context in B.C.[12]

7.1.1.1. Surface fresh water use

In 2013, 62.3% of water used in hydraulic fracturing in B.C. was gathered from surface sources on Crown land.

7.1.1.1.1. Surface fresh water use risks and issues

Two potential risks exist surrounding the use of surface fresh water:

1. The total amount of water withdrawn from a source over time, if not monitored and sustainably managed, could have adverse social, ecological, or economic impacts.
2. A large amount of water being removed from a source over a short period of time, if not monitored and sustainably managed, could place stresses on the environment during particular times of the year.[13]

[11] B.C. Oil and Gas Commission, 2013d
[12] B.C. Oil and Gas Commission, 2013d

7.1.1.1.2. Surface fresh water use regulatory instruments

Table 7.1-1: Surface fresh water use regulatory instruments summary

Instrument type	Instrument	Coverage
Legislation	Water Act	▸ Section 8 gives the BCOGC the authority to issue approvals for short-term water use ▸ Section 8 allows the BCOGC to temporarily suspend short-term water withdrawal approvals during drought or due to misuse ▸ Gives the authority to qualified BCOGC representatives designated as Regional Water Managers to issue long-term water licenses for oil and gas activities
Legislation	Land Act	▸ Provides the BCOGC with the authority to issue permits for borrow pits which are often used for fresh water storage ▸ Use of accumulated water in borrow pits requires an approval under section 8 of the Water Act
BCOGC-issued guidance and advice	Short Term Use of Water Application Manual	▸ Provides guidance for applying for a short term water use approval
BCOGC-issued guidance and advice	Water License Application Manual	▸ Provides guidance for applying for a long-term water license
Industry recommended practice	CAPP Operating Practice	▸ Outlines recommended practices for water use, including obtaining required licenses and permits, evaluating potential sources of water to ensure sustainability, monitoring appropriate parameters for water sources, collecting measurement data, basing water withdrawal on the amount of water actually available, and collaborating and sharing leading practices
Industry recommended practice	American Petroleum Institute (API) HF2	▸ Provides recommended practices for water use

Surface water use is covered by legislation, BCOGC-issued guidance and advice, and industry recommended practice.

Legislation

Water Act

Use of surface water on Crown land is governed by the *Water Act.* OGAA gives the Commission the authority to issue short term (less than two years) approvals to use or divert water from rivers, lakes, streams, or dugouts under section 8 of the *Water Act*. The Commission typically issues water withdrawal approvals for a maximum of twelve months.

Applications for short term approvals must specify the total volume of water requested, the maximum withdrawal rate (in cubic meters per day), the time frame during which water may be withdrawn, the circumstances under which water may be withdrawn, and the specific location(s) where withdrawal will occur.

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[13] Canadian Council of Academies, 2014

Section 8 of the *Water Act* also allows the BCOGC to attach conditions to approvals, including temporary suspension of water withdrawal during times of water shortage. Oil and gas operators rely on short term water use approvals for activities that are short term in nature, including the exploration and testing phase of activities on a lease.

The *Water Act* also allows designated Regional Water Managers to issue and administer long-term water licenses. The BCOGC has several Regional Water Managers on staff with the ability to grant licenses. Long-term licenses are generally sought by oil and gas applicants in situations where the applicant is moving from the testing and exploration phase of activity to full development, or where they intend to construct permanent infrastructure, such as a pipeline.[14]

Land Act

The use of "borrow pits" (also commonly referred to as dugouts) as surface storage for water is governed by the *Land Act*. These pits "are excavations that provide material (borrow) for fill, for the construction of roads, well pads, and other oil and gas related activities."[15] OGAA gives the Commission the authority to issue permits for borrow pits under the *Land Act.* If these pits are used to store water acquired from a different source, then no further permits are required to withdraw and use that water. However, if a borrow pit accumulates additional water naturally (for example, from rainfall, runoff, etc.), then an approval under section 8 of the *Water Act* must be issued before any naturally accumulating water can be withdrawn and used. In summary, a company requires an additional Section 8 approval to remove any water that accumulates in a borrow pit other than water that the company has placed there.

BCOGC-issued guidance and advice

The *Short Term Use of Water Application Manual*[16] provides guidance for applying for a short term water use approval. The *Water License Application Manual*[17] provides guidance for applying for a long-term water license.

Industry standards, principles, and recommended practice

CAPP Operating Practices

The Canadian Association of Petroleum Producers (CAPP) provides "operating practices" for water sourcing, measurement, and reuse in hydraulic fracturing. This operating practice supports three CAPP industry guiding principles as follows:

- "We will safeguard the quality and quantity of regional surface and groundwater resources, through sound wellbore construction practices, sourcing fresh water alternatives where appropriate, and recycling water for reuse as much as practical"

[14] B.C. Oil and Gas Commission, 2013b
[15] B.C. Oil and Gas Commission, 2013b
[16] B.C. Oil and Gas Commission, 2013b
[17] B.C. Oil and Gas Commission, 2013c

- "We will measure and disclose our water use with the goal of continuing to reduce our effect on the environment"
- "We will continue to advance, collaborate on and communicate technologies and best practices that reduce the potential environmental risks of hydraulic fracturing"[18]

Meeting the requirements of the operating practice involves:

- Obtaining required licenses and permits for water withdrawal
- Evaluating potential sources of water to ensure sustainability while balancing social and economic considerations
- Monitoring appropriate parameters for water sources (for example, pressure, volume, water levels, precipitation data)
- Collecting measurement data
- Basing water withdrawal on the amount of water actually available at a given time
- Collaborating and sharing leading practices with other operators

Adherence to the operating practice is voluntary but encouraged by CAPP.

API HF2: Water Management Associated with Hydraulic Fracturing

The American Petroleum Institute (API) has produced a document providing guidelines and recommended practices to industry around water use in hydraulic fracturing operations that contains the following recommendations:[19]

- Well operators should engage proactively with local authorities around water use to ensure that the resource requirements of local communities are not negatively impacted and to ensure compliance with local regulation
- Basin-wide planning can be beneficial
- Available information about water quality characteristics should be reviewed, and operators should consider working with local regulators to assess baseline characteristics of ground and surface water in the area
- A hierarchy of potential water sources should be developed and "where feasible, priority should be assigned to the use of wastewater from other industrial facilities"[20]
- When withdrawing water from surface sources, consideration should be made for the time of year, current hydrological conditions, and short-term needs of the local community

[18] Canadian Association of Petroleum Producers, 2012e
[19] American Petroleum Institute, 2010
[20] American Petroleum Institute, 2010

7.1.1.1.3. Surface fresh water use opportunities and observations

Table 7.1-2: Surface fresh water use opportunities and observations summary

Aspect	Observations	Opportunities
► Data gathering, reporting and control of off-book water sources	► The Commission has a comprehensive ability to regulate the collection and use of surface water from sources on Crown land only	► Increased regulatory authority over the use of water obtained on private land would allow the BCOGC to better manage water use, particularly in periods of drought
► Limitation of penalties available	► The use of surface water is governed by the Water Act, the BCOGC is limited to the administrative penalties available under that act, rather than the significantly larger penalties available under OGAA ► Water Act offers a quick and easy ticketing process but penalties not sufficiently high to change behavior. Process in OGAA is more burdensome, as no penalty under OGAA has been successfully applied ► The low Water Act penalties are offset by the fact that companies are sensitive to the press – regardless of monetary cost, there is a reputational cost that incentivizes compliance	► The ability to issue higher penalties for violations of the Water Act would allow the BCOGC to more effectively enforce compliance with the Act

While the Commission's ability to regulate the use of surface water is comprehensive, two opportunities exist:

1. Increased regulatory authority over the use of water obtained on private land would allow the BCOGC to better manage water use, particularly in periods of drought
2. The ability to issue higher penalties for violations of the *Water Act* would allow the BCOGC to more effectively enforce compliance with the Act

While the Commission has a comprehensive ability to regulate the collection and use of surface water from sources on Crown land, the Commission believes that approximately 20% of water used in hydraulic fracturing operations in 2013 came from "off-book" sources, such as private landowners or municipalities.[21] **Any surface water source located on privately owned land that is not part of a stream is not governed by the *Water Act* and is therefore outside of regulatory oversight.**

The issue related to regulatory authority over off-book sources has two implications:

- First, the Commission doesn't currently have authority to comprehensively manage overall water use. For example, an attempt by the Commission to regulate the use of water can create an incentive for companies to turn to private sources. This implication could be problematic given that the most stringent regulation of water use occurs at times when the water system is stressed.

[21] Interview with BCOGC staff

For instance, when the BCOGC suspended Section 8 water withdrawals in the Peace area in 2010, 2012, and 2014 during summer drought, companies turned to off-book sources of water for hydraulic fracturing operations

- Second, the Commission does not have complete information on cumulative water usage for oil and gas activities in the province. Companies are not required to report the collection of water from off-book sources, and accordingly the Commission is unable to make water-issue decisions based on complete information. This opportunity is captured in the water disclosure section 7.1.1.4

The second opportunity is related to the BCOGC's ability to enforce the regulation surface water use and penalize operators who are not compliant. **Because the BCOGC's authority to regulate surface water use is provided under the *Water Act*, the Commission is limited to the penalties that Act defines.** Administrative penalties under the *Water Act* involved fines ranging from $230 to $575. This is a significantly lower penalty than those outlined in OGAA's *Administrative Penalties Regulation*, which allows for fines of up to $500,000. *Water Act* administrative penalties are administered through the use of tickets, which is a less burdensome process than issuing administrative penalties under OGAA.

Findings from jurisdictional review

Water allocations and usage at the input stage of the water lifecycle are a bigger issue in areas subject to drought or seasonal shortages, such as southern Alberta and Saskatchewan, than in B.C. where scarcity is less of a concern. As such, it may not be appropriate to enhance the existing approach to these more rigid standards.

7.1.1.2. Subsurface fresh water use

In 2013, approximately 8% of the water used in hydraulic fracturing (683,528 m^3) was groundwater taken from water source wells.[22] The *Petroleum and Natural Gas Act* defines water source wells as: "[A] hole in the ground drilled to obtain water for the purpose of injecting water into an underground formation in connection with the production of petroleum or natural gas." These wells differ significantly from water supply wells, such as domestic water wells, in that they are subject to the requirements for oil and gas wells present in OGAA.

7.1.1.2.1. Subsurface fresh water use risks and issues

The use of groundwater from water source wells presents the following potential risks:

- The total amount of water withdrawn from a source over time, if not adequately monitored and sustainably managed, could have adverse social, environmental, or economic impacts[23]
- In cases where water source wells are hydraulically connected to surface water bodies, groundwater extractions during low flow periods could place short term/seasonal stresses on the aquatic environment

Water extracted from water source wells can be either fresh water (from shallow, fresh water aquifers) or brackish/saline (from deep saline aquifers). In 2013, the vast majority of groundwater used for hydraulic fracturing was from fresh-water aquifers[24], primarily due to the increased cost of extracting, treating, and using saline water. For additional information about the use of brackish/saline water, see section 7.1.1.3.

7.1.1.2.2. Subsurface water use regulatory instruments

Table 7.1-3: Subsurface water use regulatory instruments summary

Instrument type	Instrument	Coverage
Legislation	Petroleum and Natural Gas Act	▸ Defines water source wells to ensure that the withdrawal of subsurface water for use in hydraulic fracturing is subject to regulation under OGAA
Legislation	Oil and Gas Activities Act	▸ Expressly defines the drilling, operation, and abandonment of water source wells as oil and gas activities, requiring that companies apply for a permit
Regulation	Drilling and Production Regulation	▸ Requires that water source well permit holders not injuriously affect the use of water for domestic or agricultural purposes ▸ Requires that permit holders report their monthly water withdrawal volume
Permit Conditions	Water Source Well Permits	▸ Water Source Well permit applications are reviewed by BCOGC hydrogeologists and conditions may be imposed (such as hydrogeological testing and monitoring requirements) to mitigate potential effects of groundwater pumping on groundwater availability
Industry recommended practice	API HF2	▸ The American Petroleum Institute provides recommended practices for water use

[22] B.C. Oil and Gas Commission, 2013d
[23] Canadian Council of Academies, 2014
[24] B.C. Oil and Gas Commission, 2013d

Subsurface water access for use in hydraulic fracturing is governed by legislation and regulation. Voluntary industry practices covering groundwater use in hydraulic fracturing also exist.

Legislation

Petroleum and Natural Gas Act

The *Petroleum and Natural Gas Act* defines water source wells as: "[A] hole in the ground drilled to obtain water for the purpose of injecting water into an underground formation in connection with the production of petroleum or natural gas." This definition ensures that subsurface water drawn for use in hydraulic fracturing occurs from water source wells, which are subject to regulation under OGAA. However, water wells used by oil and gas industry for other purposes (e.g., drilling, cooling, dust control, etc.) are not water source wells and are generally unregulated.

Oil and Gas Activities Act

Section 111 of OGAA defines the drilling, operation, and abandonment of water source wells as an oil and gas activity. Accordingly, companies require a well permit to drill and operate a water source well. No additional permits are "required for withdrawal of water from a subsurface aquifer, unless the withdrawal rate exceeds 75 litres/second, in which case the B.C. Environmental Assessment Office permitting process applies."[25]

Regulation

Drilling and Production Regulation

The *Drilling and Production Regulation* is the primary instrument used for regulating the withdrawal of subsurface water for use in hydraulic fracturing.

Section 72 of the *Drilling and Production Regulation* stipulates that:

- "A permit holder must not operate a water source well in a manner that injuriously affects the use of the water source for domestic or agricultural purposes"; and,
- "A well permit holder must report the quantity of water production from a water source well to the Commission no later than 25 days after the end of the month in which the production occurred"

[25] B.C. Oil and Gas Commission, 2014d

Permit Conditions

Water Source Well Permits

Water source well permit applications are reviewed by BCOGC hydrogeologists and conditions may be imposed (such as hydrogeological testing requirements and monitoring) to mitigate potential effects of groundwater pumping on groundwater availability.

Industry standards, principles, and recommended practice

CAPP Operating Practices

The Canadian Association of Petroleum Producers (CAPP) provides "operating practice" for water sourcing, measurement, and reuse in hydraulic fracturing. This operating practice supports three CAPP industry guiding principles as follows:

- "We will safeguard the quality and quantity of regional surface and groundwater resources, through sound wellbore construction practices, sourcing fresh water alternatives where appropriate, and recycling water for reuse as much as practical"
- "We will measure and disclose our water use with the goal of continuing to reduce our effect on the environment"
- "We will continue to advance, collaborate on and communicate technologies and best practices that reduce the potential environmental risks of hydraulic fracturing"[26]

Meeting the requirements of the operating practice involves:

- Obtaining required licenses and permits for water withdrawal
- Evaluating potential sources of water to ensure sustainability while balancing social and economic considerations
- Monitoring appropriate parameters for water sources (for example, pressure, volume, water levels, precipitation data)
- Collecting measurement data
- Basing water withdrawal on the amount of water actually available at a given time
- Collaborating and sharing leading practices with other operators

Adherence to the operating practice is voluntary but encouraged by CAPP.

API HF2: Water Management Associated with Hydraulic Fracturing

The American Petroleum Institute provides guidelines and recommended practices to industry around water use in hydraulic fracturing operations.[27]

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[26] Canadian Association of Petroleum Producers, 2012e
[27] American Petroleum Institute, 2010

The following API recommendations are relevant to subsurface water use:

- Well operators should engage proactively with local authorities around water use to ensure that the resource requirements of local communities are not negatively impacted and to ensure compliance with local regulation
- Basin-wide planning can be beneficial
- If water is going to be withdrawn from shallow (non-saline) groundwater sources, operators "should consider the use of non-potable water where feasible and possible"[28]

7.1.1.2.3. Subsurface water use opportunities and observations

Table 7.1-4: Subsurface water use opportunities and observations summary

Aspect	Observations	Opportunities
Regulation of subsurface water	▸ The Commission currently issues permits to drill and operate water source wells. In addition, volumes of water extracted from water source wells must be reported to the BCOGC within 25 days from the end of the month ▸ Water Source Well permit applications are reviewed by BCOGC hydrogeologists and conditions may be imposed to mitigate potential effects of groundwater pumping on groundwater availability ▸ New initiative: The BCOGC has developed a new Water Source Well Approval Framework that will incorporate pumping limits into well permits. Implementation is planned for February 2015 ▸ Current initiative: Changes under Water Sustainability Act should provide sufficient coverage. Goal of Provincial Government is implementation in 2016	▸ Requiring limits on pumping rates for water source wells would give the BCOGC the ability to more comprehensively manage the sustainable use of groundwater ▸ The upcoming Water Sustainability Act will include provisions related to groundwater thereby addressing the gaps in the Water Act related to the protection of groundwater in B.C. Successful implementation of the Act and its regulations will support the sustainable management of groundwater in B.C.

The Commission currently issues permits to drill and operate water source wells. In addition, volumes of water extracted from water source wells must be reported to the Ministry of Finance within 25 days from the end of the month. While all water source well permit applications are reviewed by BCOGC hydrogeologists who may impose conditions, **requiring limits on pumping rates for water source wells would give the BCOGC the ability to more comprehensively manage the sustainable use of groundwater**. Groundwater extraction at rates exceeding sustainable yield could result in groundwater declines, influences to connected surface water bodies, or impacts to other groundwater users.

While B.C. is currently the only jurisdiction in Canada that does not license groundwater to control volumes extracted, the BCOGC is developing new operating practices as a condition of application that

[28] American Petroleum Institute, 2010

will require aquifer testing as part of a water source well application and will result in pumping limits being inserted into permits for water source wells. This new framework is intended to be implemented in February 2015.

It should also be noted that **groundwater is not currently regulated through the B.C. *Water Act*, (but is proposed to be regulated under the upcoming *Water Sustainability Act*)** and, with the exception of water source wells regulated by the BCOGC through OGAA, other types of groundwater use are not regulated. B.C. is unique in this regard. Water wells used by oil and gas industry for purposes other than hydraulic fracturing (or water floods for enhanced oil recovery) are not water source wells under OGAA, and are largely unregulated. Bringing these wells into regulation, such as by changing the definition of a water source well in the PNG Act, would be beneficial to allow more fulsome management of the groundwater resource for the full range of activities associated with hydraulic fracturing.

7.1.1.3. Alternative sources of water

Industry is exploring ways to reduce fresh water use through consumption of alternative sources of water. These alternatives include brackish/saline water from deep water aquifers and grey water from municipalities.[29] Increasingly, companies are also reusing flowback water from previous hydraulic fractures.

7.1.1.3.1. Alternative sources of water risks and issues

The use of alternative water sources presents extraction, transportation, and storage risks, especially the reuse of flowback water from previous hydraulic fractures.

7.1.1.3.2. Alternative sources of water regulatory instruments

Table 7.1-5: Alternative sources of water regulatory instruments summary

Instrument type	Instrument	Coverage
Legislation	Petroleum and Natural Gas Act	▸ Defines water source wells (which includes deep saline wells) to ensure that subsurface water use for hydraulic fracturing is subject to regulation under OGAA
Legislation	Oil and Gas Activities Act	▸ Expressly defines the drilling, operation, and abandonment of water source wells as oil and gas activities, requiring that companies apply for a permit
Regulation	Drilling and Production Regulation	▸ Requires that permit holders report their monthly water withdrawal volume from deep saline wells
Industry recommended practice	API HF2	▸ Recommends that potential opportunities for beneficial reuse of flowback and produced fluids from hydraulic fracturing be evaluated prior to treating for surface discharge or reinjection

Alternative sources of water are covered by legislation, regulation, and industry recommended practice.

Legislation

Petroleum and Natural Gas Act and Oil and Gas Activities Act

Water source wells for deep saline water are governed in the same manner as water source wells for fresh water. See section 7.1.1.2 for more information about the regulation of water source wells.

Regulation

Drilling and Production Regulation

Water source wells for deep saline water are governed in the same manner as water source wells for fresh water. See section 7.1.1.2 for more information about the regulation of water source wells.

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29 http://www.vancouversun.com/technology/Shell+uses+recycled+water+Dawson+Creek+fracking/7208998/story.html

Industry standards, principles and recommended practice

API HF2: Water Management Associated with Hydraulic Fracturing

The American Petroleum Institute recommends that "operators should make it a priority to evaluate potential opportunities for beneficial reuse of flowback and produced fluids from hydraulic fracturing, prior to treating for surface discharge or reinjection."[30]

7.1.1.3.3. Alternative water sources opportunities and observations

Table 7.1-6: Alternative water sources opportunities and observations summary

Aspect	Observations	Opportunities
Data gathering, reporting and control of off-book water sources	▸ Technological improvements have been made in alternative water use: Progress has been made in the use of saline/brackish, grey and flowback water which reduces the requirement for fresh water ▸ Companies are economically incentivized to reuse flowback water because long-term disposal of flowback water in deep injection wells can cost as much as $70 per cubic meter	▸ Requiring operators to report the use of water obtained from alternative sources, such as municipal grey water or water purchased from municipal water supplies would allow the BCOGC to more accurately report on water use related to hydraulic fracturing, thereby improving transparency

While some opportunities exist in the reporting and allocation of alternative sources of water, technological improvements have been made in alternative water use, and companies are economically incentivized to reuse flowback water. **Requiring operators to report the use of water obtained from alternative sources, such as municipal grey water or water purchased from municipal water supplies would allow the BCOGC to more accurately report on water use related to hydraulic fracturing**. On the other hand, progress has been made in the use of saline/brackish, grey, and recycled flowback water which reduces the requirement for fresh water. Hydraulic fracturing service providers have made improvements in their ability to use water from deep saline wells, and companies routinely reuse the majority of flowback water returned from hydraulically fractured wells. There are no provincial or federal laws or regulations governing or encouraging the reuse of flowback water, though companies have a strong financial incentive to do so, as long-term disposal of flowback water in deep injection wells can cost as much as $70 per cubic meter.

[30] American Petroleum Institute, 2010

7.1.1.4. Water use disclosure

Water use disclosure covers volume of water licensed for use, volume of water actually used, and sources of fresh water. The amount of water used in hydraulic fracturing has led to concerns from the public over the effect of removing that water from ground and surface sources. Disclosure of industry water use provides an avenue for the Commission and industry to respond to public concerns.

The Commission currently requires short-term surface water approval holders, water license holders, and water source well permit holders to report their monthly water withdrawal data. The Commission discloses water use using the following tools:

- Annual and quarterly water usage reports published on the Commission website
- The NorthEast Water Tool (NEWT) and NorthWest Water Tool (NWWT) online decision support tools
- The Water Information Portal, a tool that displays available water quantity and quality information in northeast B.C.

7.1.1.4.1. Water use disclosure regulatory instruments

Table 7.1-7: Water use disclosure regulatory instrument summary

Instrument type	Instrument	Coverage
License condition	Water Act long-term license	▸ Mandates that long-term license holders report monthly water usage (in cubic meters) to the Commission on a quarterly basis
BCOGC-issued guidance and advice	Directive 2011-02	▸ Mandates that short-term approval holders report monthly water usage (in cubic meters) to the Commission on a quarterly basis

Water use disclosure is regulated through license conditions and BCOGC-issued guidance and advice.

License conditions

Holders of long-term water licenses for oil and gas activities are required to report their monthly water withdrawal activity from each licensed location. Reports must be submitted quarterly.[31]

BCOGC-issued guidance and advice

Directive 2011-02

In March 2011, the BCOGC-issued a directive requiring that companies withdrawing water using approvals issued under Section 8 of the *Water Act* must report their monthly water withdrawal data (total cubic meters per month) to the Commission on a quarterly basis.[32]

[31] B.C. Oil and Gas Commission, 2013c
[32] B.C. Oil and Gas Commission, 2011

7.1.1.4.2. Water use disclosure opportunities and observations

Table 7.1-8: Water use disclosure opportunities and observations summary

Aspect	Observations	Opportunities
Disclosure of water from off-book sources	▸ Representatives from both industry and the BCOGC consider the water reporting tools in the province to be leading practice ▸ The Commission has increased the regulatory requirements around reporting and disclosure of water use over the last two years, including requiring that long-term license holders begin reporting water use as of January 2014	▸ Requiring operators to report the use of water obtained from sources on private land would allow the BCOGC to more accurately report on water use related to hydraulic fracturing, thereby improving transparency

The Commission has increased the regulatory requirements around reporting and disclosure of water use over the last three years, including requiring that long-term license holders begin reporting water use as of January 2014. Representatives from both industry and the BCOGC consider the water reporting tools in the province to be leading practice.[33] However, companies are not required to disclose water withdrawn from "off-book" sources, such as dugouts on private land or water purchased from municipalities (see section 7.1.1.1). This results in an information gap that creates challenges for the Commission to comprehensively report on all sources of water used for hydraulic fracturing. "Off-book" sources are estimated by the BCOGC to be approximately 20% of total water consumption[34]; **requiring operators to report the use of water obtained from sources on private land would allow the BCOGC to more accurately report on water use related to hydraulic fracturing.**

[33] Interviews with representatives from the Canadian Association of Petroleum Producers and from the BCOGC
[34] B.C. Oil and Gas Commission, 2013d, p. 18

7.1.2. Surface or groundwater contamination from above

Sources of surface and subsurface water contamination risk can be broadly conceived of in two categories: sources of contamination from above the surface and sources of contamination from below the surface. The potential for surface or subsurface water contamination due to above-surface activities exists when there is a potential for a spill, leak, or release of a contaminant. Depending on the nature of the hydraulic fracturing operation, potential contaminant sources could include: flowback water, saline groundwater, hydraulic fracturing chemicals, fuel, oil, hydraulic fluid, or other non-potable or hazardous liquids/substances that may be stored, handled, or transported.

7.1.2.1. Site locations relative to water sources and aquifer recharge zones

Northeast B.C. contains extensive networks of surface and subsurface fresh water sources, including lakes, streams, wetlands, and underground aquifers that feed domestic fresh water wells and that are recharged from the surface. Fresh water sources may be vulnerable to contamination due to spills or releases of contaminants at the ground surface.

7.1.2.1.1. Site locations relative to water sources risks and issues

During hydraulic fracturing operations, flowback water, fracturing fluid additives, and other potential contaminants are used and stored on the well pad. When contaminants of concern are used and stored near water resources, the risk of contamination from a spill is present. Regulation of the location of oil and gas activities as well as the setback distances relative to water resources is important for protecting against these risks.

7.1.2.1.2. Site location regulatory instruments

Table 7.1-9: Site location regulatory instrument summary

Instrument type	Instrument	Coverage
Legislation	Land Act	▸ Gives the BCOGC the ability to regulate land use through the permitting process ▸ The BCOGC has the option to reject the permit application or attach conditions or caveats to mitigate the impact of the oil and gas activity
Legislation	Heritage Conservation Act	▸ Gives the BCOGC the ability to permit or deny the use of areas of land that are considered heritage property in B.C.
Regulation	Environmental Protection and Management Regulation	▸ Section 4 outlines the Government's environmental objectives with respect to environmental setbacks and environmentally sensitive locations ▸ Section 10 defines the requirements to not cause a material adverse effect on the quality, quantity or natural timing of flow of water in the aquifer ▸ Section 13 requires that a person conducting oil and gas activities in a wetland "must, to the extent practicable, maintain natural flow of water" ▸ Sections 22 through 25 define the minimum riparian management and reserve distances ▸ Section 34 gives the Minister responsible for administering the Water Act the authority to identify aquifers and groundwater recharge areas
Industry recommended practice	CAPP Operating Practices	▸ Provides recommendations for regional and domestic baseline water quality monitoring
Industry recommended practice	American Petroleum Institute (API) HF2	▸ Provides recommended practices for water use and the protection of fresh water sources

Site location relative to water sources and aquifer refresh zones are covered by legislation, regulation, and industry recommended practice.

Legislation

Land Act

The *Land Act* gives the BCOGC the ability to regulate land use through the permitting process according to the following Sections:

- Section 11 of the *Land Act* allows the BCOGC to lease Crown land, grant a license to Crown Land, or grant a right of way over Crown land
- Section 14 allows the Commission to issue a temporary permit (less than two years) for the use of Crown land
- Section 38 allows the BCOGC to lease Crown land and attach any terms or reservations it feels are advisable
- Section 39 allows the BCOGC to grant a license to use Crown land and attach any terms or reservations it feels are advisable

Heritage Conservation Act

Section 12 of the *Heritage Conservation Act* gives the Commission the ability to permit or deny the use of areas of land that are considered heritage property in B.C.

Regulation

Environmental Protection and Management Regulation

The *Environmental Protection and Management Regulation* governs the site location relative to surface water bodies and groundwater aquifers according to the following sections:

- Section 4 outlines the Government's environmental objectives as they relate to oil and gas activities, including:
    a) "that wellsites, facility areas, road right of way and pipeline corridors not be located within
        i. 100 m of where water is diverted by a waterworks or stored in a water storage reservoir, or
        ii. 100 m of where water is diverted by a water supply well or the ground water capture zone for the water supply well, whichever is greater,

    unless

        iii. any adverse effects on the waterworks, water supply well, water storage reservoir or ground water capture zone can be effectively mitigated, or
        iv. the person proposing to locate the operating area is the holder of the authorization for the waterworks, water supply well or water storage reservoir;

    b) that operating areas not be located
        i. within an identified ground water recharge area,
        ii. within a designated watershed, or
        iii. on top of an identified aquifer

    unless the operating area will not have a material adverse effect on the quality and quantity of water and the natural timing of water flow"

- Section 10 defines the requirements to "not cause a material adverse effect on the quality, quantity or natural timing of flow of water in the aquifer"
- Section 13 requires that a person conducting oil and gas activities in a wetland "must, to the extent practicable, maintain natural flow of water"
- Sections 22 through 25 define the minimum riparian[35] management area, riparian reserve zone, and riparian management zone for different classes of streams, wetlands, and lakes. Different distances in meters are stipulated based on criteria, including the size of the body of water and its fish content
- Section 34 gives the Minister responsible for administering the *Water Act* the authority to identify aquifers and groundwater recharge areas

Industry standards, principles, and recommended practice

CAPP Operating Practices

CAPP provides an operating practice document for baseline groundwater testing in hydraulic fracturing. This operating practice supports two CAPP industry guiding principles:

- "We will safeguard the quality and quantity of regional surface and groundwater resources, through sound wellbore construction practices, sourcing fresh water alternatives where appropriate, and recycling water for reuse as much as practical"
- "We will continue to advance, collaborate on and communicate technologies and best practices that reduce the potential environmental risks of hydraulic fracturing"[36]

Meeting the requirements of the operating practice involves:

- Testing domestic water wells within 250 meters of a wellhead prior to drilling
- Developing and implementing procedures to address the concerns of stakeholders related to changes in their wells
- Working with government to design and implement regional groundwater monitoring programs
- Comparison of testing results to appropriate water quality standards including the presence of natural gas and relevant organic or inorganic constituents in the water

Adherence to the operating practice is voluntary but encouraged by CAPP.

API HF2: Water Management Associated with Hydraulic Fracturing

The American Petroleum Institute provides guidelines and recommended practices to industry around water use in hydraulic fracturing operations.[37]

The following API recommendations are relevant to the protection of fresh water:

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[35] A riparian zone or riparian area is the interface between land and a river or stream
[36] Canadian Association of Petroleum Producers, 2012e
[37] American Petroleum Institute, 2010

- Available information about water quality characteristics should be reviewed and operators should consider working with local regulators to assess baseline characteristics of ground and surface water in the area

7.1.2.1.3. Site location opportunities and observations

Table 7.1-10: Site location opportunities and observations summary

Aspect	Observations	Opportunities
Well pad locations relative to aquifer recharge zones	► The location of well pads is currently governed by the BCOGC through the permitting process: the proposed location is compared against known areas of concern, including potential wildlife-sensitive areas, surface water sources, and heritage conservation sites	► The EPMR allows for enhanced management to protect aquifers should Ministry responsible designate an aquifer; no aquifers have yet been designated. There is an opportunity for the BCOGC to collect and provide the Ministry with the data necessary to identify high-risk aquifers. Should an aquifer be designated, additional mitigation requirements could be implemented by the BCOGC related to the protection of the aquifers and associated recharge zones
Baseline and ongoing water testing	► The Commission has the option to reject the permit application or attach conditions or caveats to mitigate the impact of the oil and gas activity ► Current initiative: The BCOGC has written a discussion paper on baseline testing and ongoing monitoring	► Development of appropriate requirements related to baseline testing and ongoing monitoring of surface or groundwater quality around production zones would provide an additional data to support results-based regulatory requirements and to monitor compliance ► Development of appropriate requirements related to baseline testing and ongoing monitoring of domestic water well quality around production wells would provide an additional data to support results-based regulatory requirements and to monitor compliance
Environmental Protection and Management Regulation limited to Crown land	► The provisions of the EPMR do not currently apply to private land due to a desire not to compromise land owners' rights	► The BCOGC could more comprehensively protect water resources if the EPMR directly applied to water resources on private land

The location of well pads is currently governed by the BCOGC through the permitting process. When an oil and gas company submits a permit application to drill a well or build a natural gas facility the proposed location is reviewed with respect to proximity to potential wildlife-sensitive areas, surface water sources, heritage conservation sites, ground water capture zones, natural range barriers, waterworks, and other relevant data using prescribed geospatial layers in the Land and Resource Data Warehouse. The Commission has the option to reject the permit application or attach conditions or caveats to mitigate the impact of the oil and gas activity.

Three opportunities have been identified relating to site location relative to aquifers and aquifer recharge zones:

- The *Environmental Protection and Management Regulation* has provisions for the protection of identified[38] aquifers and recharge zones however, to date, no aquifers or recharge areas have been identified by the Province. While the Minister responsible for administering the *Water Act* has the ability to identify aquifers and recharge zones, the data required to do so has not yet been collected. **There is an opportunity for the BCOGC to collect and provide the Ministry with the data necessary to identify high-risk aquifers**. Should an aquifer be designated, additional mitigation requirements could be implemented by the BCOGC related to the protection of the aquifers and associated recharge zones
- The Commission also does not mandate baseline or ongoing testing of surface or groundwater quality. **Development of appropriate requirements related to baseline testing and ongoing monitoring of surface or groundwater quality around production zones would provide an additional data to support results-based regulatory requirements and to monitor compliance.**
- Oil and gas companies in the province may conduct some testing of nearby domestic water wells on behalf of residents, but the data collected are not required to be reported to the OGC and may be confidential. **Development of appropriate requirements related to baseline testing and ongoing monitoring of domestic water well quality around production wells would provide an additional data to support results-based regulatory requirements and to monitor compliance.**
- The *Environmental Protection and Management Regulation* applies only to Crown land, not private land. **The BCOGC could more comprehensively protect water resources if the EPMR directly applied to water resources on private land**

[38] "Identified" is defined by section 34 of the *Environmental Protection and Management Regulation*

7.1.2.2. Contents of chemicals used in hydraulic fracturing fluid

Hydraulic fracturing fluids contain various chemicals designed to facilitate the fracturing process. While these chemicals make up a relatively small percentage of the total composition of fracturing fluid (0.5-2%), the total volume of fluid used in hydraulic fracturing (up to 80,000+ cubic meters per well in the Horn River Basin, 6,000 to 10,000 cubic meters in the Montney) means that on an absolute basis, material amounts of potentially harmful chemicals are used.

7.1.2.2.1. Chemical mix risks and issues

If proper separation between the fractured well and other porous zones is not maintained or if a spill occurs during transportation or storage of hazardous chemicals, there is a risk that the chemicals used in hydraulic fracturing could contaminate ground or surface water. In addition, reducing the use of toxic or harmful chemicals in hydraulic fracturing fluids reduces the risk of groundwater contamination in the event of a failure during fracturing or a spill on the surface during fluid/chemical transportation, mixing, and storage.

7.1.2.2.2. Chemical mix regulatory instruments

Table 7.1-11: Chemical mix regulatory instruments summary

Instrument type	Instrument	Coverage
Legislation	Hazardous Products Act (Canada)	▸ Requires the disclosure of hazard information for controlled products in materials safety data sheets (MSDSs) ▸ Outlines the workplace hazardous materials information system (WHMIS) labeling requirements for controlled products ▸ Describes the conditions under which the MSDS information for ingredients that have been exempted from disclosure under the Hazardous Materials Information Review Act can be disclosed to medical professionals
Legislation	Hazardous Materials Information Review Act (Canada)	▸ Allows suppliers of controlled products to claim an exemption from public disclosure ingredient information if those ingredients are considered confidential business information
Regulation	Controlled Products Regulation	▸ Outlines the specific criteria for defining controlled products whose ingredients are then subject to WHMIS labeling requirements and hazard disclosure through the use of MSDSs
Regulation	Hazardous Materials Information Review Regulation	▸ Describes the criteria considered when evaluating claims for disclosure exemptions under the *Hazardous Materials Information Review Act*
Industry recommended practice	CAPP Operating Practice	▸ Outlines suggested analysis and risk management practices for chemical additives

Chemical mix is covered by legislation, regulation, and industry recommended practice.

Legislation

Hazardous Products Act (Canada)

Individual ingredients in the fluids are subject to the federal *Hazardous Products Act (HPA)*. The HPA requires that suppliers of controlled products provide detailed information about the hazards of the ingredients through the use of material safety data sheets (MSDSs), including “all hazardous ingredients in the product, its toxicological properties, any safety precautions workers need to take when using the

product and the first aid treatment required in the case of exposure."[39] The HPA provides a list of controlled product ingredients that are subject to disclosure through MSDSs[40] and outlines the labeling requirements of all hazardous materials as part of the Workplace Hazardous Materials Information System (WHMIS). All fracture fluid additives used in Canada that fall under the definition of a controlled product must follow the MSDS and WHMIS disclosure and labeling requirements.

- Section 16 of the HPA allows suppliers to include generic chemical names on the MSDSs for any ingredients for which they have received a disclosure exemption under the federal *Hazardous Materials Information Review Act* (see below for more information)
- Section 15 (j) requires that the supplier disclose information about chemicals that have been granted a confidential business information disclosure exemption to "any physician or other medical professional specified in the regulations who requests that information for the purpose of making a medical diagnosis of, or rendering medical treatment to, a person in an emergency."

Hazardous Materials Information Review Act (Canada)

Section 11 of the federal *Hazardous Materials Information Review Act* allows suppliers of controlled products to claim an exemption from disclosure requirements if they consider the information to be confidential business information. If a claim is granted by Health Canada, the supplier is exempt from the disclosure rules for three years. At the end of the three year period, the supplier must reapply for an exemption. The HPA requires that suppliers disclose exempted MSDS information to medical professionals who may require that information to treat or diagnose a person in an emergency.

Regulation

Controlled Products Regulation

Sections 34 to 66 of the *Controlled Products Regulation* provide detailed and specific criteria for defining controlled products. If an additive to fracturing fluid meets the definition of a controlled product according to these criteria, then any ingredients in that additive that are included on the HPA Ingredients Disclosure List are subject to WHMIS labeling requirements and hazard disclosure through the use of MSDSs.

Hazardous Materials Information Review Regulation

Section 3 of the *Hazardous Materials Information Review Regulation* outlines the criteria for a controlled product to be considered confidential business information. Specifically, it considers these criteria:

- "whether the information is confidential to the claimant;
- whether the claimant has taken measures that are reasonable in the circumstances to maintain the confidentiality of the information; and

[39] http://www.hc-sc.gc.ca/ewh-semt/occup-travail/whmis-simdut/hmira-lcrmd/exemption-derogation/index-eng.php
[40] The "Ingredients Disclosure List" http://laws-lois.justice.gc.ca/eng/regulations/SOR-88-64/FullText.html

- whether the information has actual or potential economic value to the claimant or to the claimant's competitors because it is confidential and the disclosure of the information would result in a material financial loss to the claimant or a material financial gain to the claimant's competitors."

Industry standards, principles, and recommended practices

API HF2: Water Management Associated with Hydraulic Fracturing

The American Petroleum Institute has produced a document providing guidelines and recommended practices to industry around water use in hydraulic fracturing operations. It recommends that "in developing plans for hydraulic fracturing, operators should strive to minimize the use of additives" and that "when necessary, operators should assess the feasibility of using more environmentally benign additives."[41] It also recommends that companies explore the possibility of beneficial reuse of flowback water from previous hydraulic fracturing activities, and notes that doing so "requires the selection of compatible additives, with focused efforts on the use of environmentally benign constituents that do not impede water treatment initiatives."

CAPP Operating Practices

CAPP has developed a fracturing fluid additive risk assessment and management operating practice.[42] This practice supports CAPP's commitment to "support the development of fracturing fluid additives with the least environmental risks… [and] continue to advance, collaborate on and communicate technologies and leading practices that reduce the potential environmental risks of hydraulic fracturing."[43] The operating practice document asks companies to:

- Identify the chemical ingredients and information regarding the chemical characteristics to be used though the use of materials safety data sheets
- Assess the potential health and environmental risks of additives used
- Manage potential health and environmental risks through the use of appropriate operational procedures and controls
- Create written risk management plans

It is not mandatory that companies follow this operating practice.

7.1.2.2.3. Chemical mix opportunities and observations

Chemicals added to hydraulic fracturing fluid are governed by federal hazardous materials legislation and regulation. While a regulatory incentive to develop greener chemicals doesn't currently exist, the Commission has expressed a desire to encourage companies to use "greener" fracturing fluid, which would reduce the level of contamination in the event of a spill, leak, or wellbore integrity issue. Requiring the use of such chemicals would be matter of policy and is outside the purview of the regulator. The

[41] American Petroleum Institute, 2010
[42] Canadian Association of Petroleum Producers, 2012d
[43] Canadian Association of Petroleum Producers, 2012d

Commission is working with UBC Okanagan to review the toxicity of hydraulic fracturing chemicals and flowback water. Initial conversations have also taken place with several companies and with the Alberta Energy Regulator (AER). **No opportunities within the control of the BCOGC have been identified.**

7.1.2.3. Chemical storage and transportation

The chemicals added to hydraulic fracturing fluid are typically transported and stored separately on the well pad. During the hydraulic fracturing of a well, chemicals are mixed into the water along with proppant immediately before being injected into the well at high pressure.

7.1.2.3.1. Chemical storage and transportation risks and issues

The use of chemicals in hydraulic fracturing poses a risk to surface and groundwater during the storage or transportation of those chemicals. Spills of chemicals during transportation or while being stored on the well pad could lead to contamination of fresh water or soil, and could result in public health issues.

7.1.2.3.2. Chemical storage and transportation regulatory instruments

Table 7.1-12: Chemical storage and transportation regulatory instruments summary

Instrument type	Instrument	Coverage
Legislation	Hazardous Products Act (Canada)	▸ Contains general information about safe storage precautions and conditions of the controlled products that are detailed in MSDSs
Legislation	Transportation of Dangerous Goods Act (Canada)	▸ Outlines the transportation, containment, documentation, and safety requirements for transporting dangerous goods
Legislation	Environmental Management Act	▸ Sections 6 through 10 describe the requirements for storing, transporting, and disposing of hazardous waste. ▸ Section 6 prohibits the introduction of hazardous waste from an oil and gas activity into the environment without an explicit permit or approval
Regulation	Occupational Health and Safety Regulation (OHS Regulation)	▸ Outlines the containment, storage, and labeling requirements for storing hazardous chemicals in the workplace in B.C.
Regulation	Drilling and Production Regulation	▸ Section 20 requires that proper provisions for fracturing fluid management have been made before well completion activity occurs ▸ Section 51 prohibits chemicals from contaminating water or creating hazards to public health
Regulation	Transportation of Dangerous Goods Regulation (Canada)	▸ Outlines the specific requirements for transporting dangerous goods including identifying, packing and labeling, containment according to class, training for transporters and handlers, emergency response action plan and reporting in the event of an accident

Chemical storage and transportation is covered by legislation and regulation.

Legislation

Hazardous Products Act (Canada)

The HPA requires that suppliers of controlled products disclose detailed information about the hazards of the ingredients through the use of MSDSs. These MSDSs contain general information about the safe storage precautions and conditions of the controlled product that they describe.

Transportation of Dangerous Goods Act (Canada)

For additives used in hydraulic fracturing that are classified as dangerous goods under the *Transportation of Dangerous Goods Act* (TDG Act), the TDG Act governs their safe handling and transportation. The *TDG Act* requires that a person transporting dangerous goods must:

- Comply with all safety requirements under the TDG Act regulations
- Ensure that the goods are accompanied by all required documentation
- Ensure that the goods are stored and transported in an approved means of containment
- Ensure that "the means of containment and means of transport comply with all safety standards that apply under the regulations and display all applicable safety marks in accordance with the regulations"

The TDG Act requires that the transporter of dangerous goods have an approved emergency response assistance plan. That plan must "outline what is to be done to respond to an actual or anticipated release of the dangerous goods in the course of their handling or transporting that endangers, or could endanger, public safety."

- Section 18 of the act requires the person in charge of transporting dangerous goods to report any actual or anticipated release of the goods if the release could endanger the public and to take all reasonable emergency measures

Environmental Management Act

Sections 6 through 10 describe the requirements for storing, transporting, and disposing of hazardous waste. In particular, section 6 prohibits the introduction of hazardous waste from an oil and gas activity into the environment without an explicit permit or approval.

Regulation

Occupational Health and Safety Regulation (OHS Regulation)

Sections 5.20 to 5.47 of the *OHS Regulation* provide detailed requirements for the storage of hazardous substances under WHMIS. Specifically,

- Chemicals must be stored in a container that is designed, constructed, and maintained in good condition for the storage of that particular substance
- Containers must be made of appropriate material that is resistant to the substance it contains
- Containers must be kept sealed or covered when not in use
- The amount of substance in a work area must not exceed the amount reasonably needed for the current work in progress. Bulk or reserve quantities should be stored elsewhere

- A hazardous substance must be stored in a designated area, in a manner which ensures that it will not readily fall, become dislodged, suffer damage, or be exposed to conditions of extreme temperature
- The designated storage area for a hazardous substance must be designed and constructed to provide for the safe containment of the contents

Drilling and Production Regulation

Section 20 of the *Drilling and Production Regulation* requires that a permit holder ensure that proper provisions have been made for the management of fracturing fluid chemicals before any well completion activity occurs.

Likewise, chemicals stored at a well site are subject to the same section 51 requirements as flowback water or other waste products. Specifically, chemicals must be stored in such a way that they will not:

- Create a hazard to public health
- Contaminate any water supply well, usable aquifer, or any other body of water or remain in a place where it might cause contamination
- Pollute or damage any public road
- Pass into or, on ice, over any water body that is frequented by fish or wildlife or that flows into any such water body

Transportation of Dangerous Goods Regulation (Canada)

The *Transportation of Dangerous Goods Regulation* (TDG Regulation) outlines the specifics of the requirements under the TDG Act, including:

- Determining which goods are dangerous goods
- The packing and labeling requirements for dangerous goods
- The proper means of containment for different classes of dangerous goods, including the requirement that the "means of containment is designed, constructed, filled, closed, secured and maintained so that under normal conditions of transport, including handling, there will be no accidental release of the dangerous goods that could endanger public safety"
- The training requirements for a person transporting or handling dangerous goods
- The requirements of an emergency response action plan
- The reporting requirements in the event of an accidental release or imminent accidental release
- An alphabetical listing of 2,823 specified dangerous goods

7.1.2.3.3. Chemical storage and transportation opportunities and observations

Federal regulations provide strict control over the transportation of dangerous goods, including the requirement to notify responsible authorities in the event of a spill and to have an approved emergency response plan. The storage of chemicals is covered both by provincial occupational and safety regulation as well as the *Drilling and Production Regulation*. **Consequently, there are no identified opportunities within the control of the BCOGC.**

7.1.2.4. Public disclosure of the composition of fracturing fluid

Currently, the contents of fracturing fluids used in B.C. are partially disclosed on fracfocus.ca. Disclosure is relevant from a regulatory perspective insofar as it forces companies to be transparent about their chemical use.

7.1.2.4.1. Fracturing fluid disclosure regulatory instruments

Table 7.1-13: Fracturing fluid disclosure regulatory instruments summary

Instrument type	Instrument	Coverage
Legislation	Hazardous Products Act (Canada)	▸ Requires the disclosure of hazard information for controlled products in MSDSs
Legislation	Hazardous Materials Information Review Act (Canada)	▸ Allows suppliers of controlled products to claim an exemption from public disclosure ingredient information if those ingredients are considered confidential business information
Regulation	Drilling and Production Regulation	▸ Requires that permit holders record and submit detailed information about the composition of fracturing fluid within 30 days of well completion
Regulation	OGAA General Regulation	▸ Section 17 requires that the Commission release submitted well reports and well data from confidential status
Regulation	Hazardous Materials Information Review Regulation	▸ Describes the criteria considered when evaluating claims for disclosure exemptions under the Hazardous Materials Information Review Act
BCOGC-issued guidance and advice	Fracture Fluid Report Upload Manual	▸ Reiterates the disclosure requirements of section 37 of the Drilling and Production Regulation, and that also stipulates that the Health Canada registry number must be included for any chemicals granted a disclosure exemption
Industry recommended practice	CAPP Operating Practice	▸ Encourages the disclosure of the trade name of each additive, the general purpose of each additive in the mixture, the name and chemical abstract number of each chemical ingredient listed on the MSDS, and the concentration of each ingredient

Fracturing fluid disclosure is covered by legislation, regulation and industry recommended practice.

Legislation

Hazardous Product Act (Canada)

The HPA requires that suppliers of controlled products provide detailed information about the hazards of the ingredients through the use of material safety data sheets (MSDSs), including "all hazardous ingredients in the product, its toxicological properties, any safety precautions workers need to take when using the product and the first aid treatment required in the case of exposure."[44] The HPA provides a list of controlled product ingredients that are subject to disclosure through MSDSs.[45] All fracture fluid

[44] http://www.hc-sc.gc.ca/ewh-semt/occup-travail/whmis-simdut/hmira-lcrmd/exemption-derogation/index-eng.php
[45] The "Ingredients Disclosure List" http://laws-lois.justice.gc.ca/eng/regulations/SOR-88-64/FullText.html

additives used in Canada that fall under the definition of a controlled product must follow the MSDS and WHMIS disclosure and labeling requirements.

Section 16 of the HPA allows suppliers to include generic chemical names on the MSDSs for any ingredients for which they have received a disclosure exemption under the federal *Hazardous Materials Information Review Act* (see below for more information).

Hazardous Materials Information Review Act (Canada)

Section 11 of the federal *Hazardous Materials Information Review Act* allows suppliers of controlled products to claim an exemption from disclosure requirements if they consider the information to be confidential business information. If a claim is granted by Health Canada, then the supplier is exempt from the disclosure rules for three years. At the end of the three year period, the supplier must reapply for an exemption. The HPA requires that suppliers disclose exempted MSDS information to medical professionals who may require that information to treat or diagnose a person in an emergency.

Regulation

Drilling and Production Regulation

Section 37 of the *Drilling and Production Regulation* requires that the permit holder of a well must maintain detailed records of the composition of all fracturing fluids used at that well. Specifically, a permit holder must record the following information for each fracture activity:

- The well authorization number
- The fracture date
- An identification of the fluid ingredients and a description of the purpose of each
- An identification of the ingredient concentration in the additive and in the hydraulic fracturing fluid
- The chemical abstract service number of each ingredient
- An identification of the total volume of water injected with the ingredients
- The trade name and supplier of each ingredient

Section 37 also requires that the permit holder submit those records to the Commission within 30 days of completing the well.

Oil and Gas Activities Act General Regulation

Section 17 (1) of the *OGAA General Regulation* requires that the Commission release submitted well reports and well data from confidential status, enabling their public disclosure.

Hazardous Materials Information Review Regulation

Section 3 of the *Hazardous Materials Information Review Regulation* outlines the criteria for a controlled product to be considered confidential business information. Specifically, it considers these criteria:

- “whether the information is confidential to the claimant;
- whether the claimant has taken measures that are reasonable in the circumstances to maintain the confidentiality of the information; and

- whether the information has actual or potential economic value to the claimant or to the claimant's competitors because it is confidential and the disclosure of the information would result in a material financial loss to the claimant or a material financial gain to the claimant's competitors"

BCOGC-issued guidance and advice

Fracture Fluid Report Upload Manual

The Commission publishes a Fracture Fluid Report Upload Manual that reiterates the disclosure requirements of section 37 of the Drilling and Production Regulation, and that also stipulates that the Health Canada registry number must be included for any chemicals granted a disclosure exemption under the federal *Hazardous Materials Information Review Act.*

Industry standards, principles and recommended practice

CAPP Hydraulic Fracturing Operating Practice

CAPP has developed a fracturing fluid additive disclosure operating practice.[46] Under this practice, "companies will disclose, either on their own websites or on a third-party website, those chemical ingredients in their fracturing fluid additives which are identified on the MSDS."[47] Information that should be disclosed includes:

- The trade name of each additive
- The general purpose of each additive in the mixture
- The name and chemical abstract number of each chemical ingredient listed on the MSDS
- The concentration of each ingredient

It is not mandatory that companies follow this operating practice, but CAPP does "support action by provincial governments to make fracturing fluid disclosure a mandatory component of shale gas, tight gas and tight oil development."[48]

7.1.2.4.2. Fracturing fluid disclosure opportunities and observations

Disclosure requires companies to be transparent about their chemical use. In B.C., proprietary chemical blends are protected under trade secret laws. There is a risk that the ability to avoid disclosure under these laws could undermine the benefits of the FracFocus disclosure system, though this risk appears to be low: BCOGC staff note that complaints and questions about chemical use and disclosure have decreased since the introduction of FracFocus. Moreover, the BCOGC has reached an agreement with the Petroleum Services Association of Canada (PSAC) to have the association's member companies provide their emergency contact information directly to the Commission to expedite any necessary

[46] Canadian Association of Petroleum Producers, 2012c
[47] Canadian Association of Petroleum Producers, 2012c
[48] Canadian Association of Petroleum Producers, 2012c

response in the event of an emergency. All hydraulic fracturing service providers in B.C. are members of PSAC.

Trade secret exemptions are governed by Federal legislation and administered by the hazardous material information review committee (HMIRC), a Crown corporation under Health Canada. This issue is outside of the control of the BCOGC. Accordingly, **no opportunities within the control of the BCOGC related to fracturing fluid disclosure have been identified.**

7.1.2.5. Short-term surface storage of flowback water

Flowback (or produced) water is hydraulic fracturing fluid that has returned from the well after fracturing has occurred. Typically some amount of fluid is recovered (usually up to approximately 40%) while the rest remains in the formation. Flowback water contains the original substances in the fluid as well as additional contaminants picked up from the formation. Flowback water is usually stored on-site for the short-term in various different tanks or containment vessels that are either enclosed or open, and is commonly stored over the long-term in excavated containment ponds.

7.1.2.5.1. Short-term flowback water storage risks and issues

Leakage from flowback water storage ponds and tanks is considered to be a high-priority risk, given the large volumes of flowback water stored in these vessels or ponds and the large number of surface storage tanks and ponds in the northeast.[49] Water that returns to the surface after conducting a hydraulic fracturing operation tends to be more contaminated than the initial hydraulic fracturing fluid. In addition to any chemical additives present in the initial fluid, flowback water contains dissolved solids present in the formation that has been fractured. These dissolved solids can contain naturally occurring radioactive materials (NORM) as well as trace metals such as arsenic and barium. The water can also be saline, presenting a risk to any potable surface water or ground water it may come in contact with. There is a risk of groundwater contamination from leaks or spills of surface storage vessels and ponds as well as a risk to vegetation. There is also a risk to wildlife and waterfowl from open storage vessels.

In B.C., only flowback water from slickwater[50] fracturing operations can be stored in lined earthen ponds or open-top containment tanks. All other forms of flowback water must be stored in closed tanks.[51, 52]

7.1.2.5.2. Short-term flowback storage regulatory instruments

Table 7.1-14: Short-terms flowback storage regulatory instruments summary

Instrument type	Instrument	Coverage
Legislation	Oil and Gas Activities Act	▸ OGAA gives the Commission the authority to require and issue permits to operate oil and gas facilities. The Commission has begun regulating earthen storage pits using facilities permits under OGAA rather than *Land Act* permits ▸ Section 37 prohibits spillage of harmful substances and outlines the reporting, containment, elimination, and remediation requirements in the event of a spill
Legislation	Land Act	▸ The *Land Act* was used in the past to regulate earthen storage pits through Crown land use approvals

[49] Interview with BCOGC staff

[50] Slickwater fracturing fluids largely water-based (generally around 99% by volume) with friction reducing additives added

[51] B.C. Oil and Gas Commission, 2009

[52] The current guidance regarding storage of flowback water is provided by Information letter # OGC 09-07. The BCOGC is participating in an ongoing initiative with the Western Regulators' Forum to develop updated guidance regarding storage of flowback water. This updated guidance is set to be released in 2015 and will replace the guidance contained in Information letter # OGC 09-07

Instrument type	Instrument	Coverage
Legislation	Environmental Management Act	▸ Section 6 prohibits the introduction of hazardous waste from an oil and gas activity into the environment without an explicit permit or approval
Regulation	Drilling and Production Regulation	▸ Prohibits flowback water from contaminating water or creating hazards to public health
Regulation	Environmental Protection and Management Regulation	▸ Section 10 states that “a person carrying out an oil and gas activity on an operating area on top of an aquifer must ensure that the activity does not cause a material adverse effect on the quality, quantity or natural timing of flow of water in the aquifer"
Regulation	Waste Discharge Regulation	▸ Schedule 1 defines the oil and gas industry as a prescribed industry for the purposes of section 6 of the Environmental Management Act
BCOGC-issued guidance and advice	Information letter # OGC 09-07	▸ Provides prescriptive guidance over the design, containment, monitoring, and reporting requirements of surface storage vessels (earthen storage pits and tanks). This guidance is enforceable through permit conditions ▸ This guidance is in the process of being updated
Industry recommended practice	CAPP Operating Practice	▸ Encourages operators to store fluid and flowback water in accordance with laws and regulation and in such a way that wildlife are restricted from accessing it

Short-term flowback storage is covered by legislation, regulation, BCOGC-issued guidance and advice, and industry recommended practice.

Legislation

Oil and Gas Activities Act

OGAA gives the Commission the authority under the *Land Act* to issue temporary land use permits or long-term land use licenses for earthen storage pits. Historically, earthen storage pits were regulated by the Commission using *Land Act* permits, but in 2014 the Commission began regulating these pits as oil and gas facilities by issuing facilities permits under OGAA.

Section 37 of OGAA regulates the spilling of substances that could be a risk to the environment or public safety. Specifically, it requires that people carrying out oil and gas activities “prevent spillage and promptly report to the Commission any damage or malfunction likely to cause spillage….” In the event that spillage does occur, it requires that the permit holder or person carrying out the activity “remedy the cause or source of the spillage”, “contain and eliminate the spillage”, and “remediate any land or body of water affected by the spillage”. If there is a risk to the environment or public safety because of a spillage, the permit holder or person doing the activity must also report the location and severity of the spill as well as any “damage or malfunction causing or contributing to the spillage.”

Finally, section 37 also states that “a person who is aware that spillage is occurring or likely to occur must make reasonable efforts to prevent or assist in containing or preventing the spillage.”

Land Act

Historically, earthen storage pits were regulated by the Commission using *Land Act* permits, but in 2014 the Commission began regulating these pits as oil and gas facilities by issuing facilities permits under OGAA.

Environmental Management Act

Section 6 prohibits the introduction of waste from an oil and gas activity into the environment without an explicit permit or approval. Specifically, it states that: “a person must not introduce or cause or allow waste to be introduced into the environment in the course of conducting a prescribed industry, trade or business.”

Regulation

Drilling and Production Regulation

Section 51 of the *Drilling and Production Regulation* governs the short-term storage of flowback water prior to reuse or disposal. It mandates that permit holders ensure that flowback water does not:

- Create a hazard to public health
- Contaminate any water supply well, usable aquifer, or any other body of water or remain in a place where it might cause contamination
- Pollute or damage any public road
- Pass into or, on ice, over any water body that is frequented by fish or wildlife or that flows into any such water body

Environmental Protection and Management Regulation

Section 10 of the EPMR states that “a person carrying out an oil and gas activity on an operating area on top of an aquifer must ensure that the activity does not cause a material adverse effect on the quality, quantity or natural timing of flow of water in the aquifer."

Waste Discharge Regulation

Schedule 1 of the *Waste Discharge Regulation* defines the oil and gas industry as a prescribed industry for the purposes of section 6 of the *Environmental Management Act*, which means that the provisions of that section apply to oil and gas operators.

BCOGC-issued guidance and advice

Information letter # OGC 09-07 provides specific requirements for the storage of flowback water in earthen pits and tanks. Specifically, it dictates that:

- Flowback fluid may be stored in open or closed tanks or lined, earthen excavations
- Only flowback fluid from slickwater fracture operations may be stored in lined pits or open tanks. All other forms of flowback water must be stored in closed tanks
- Storage systems on Crown land require that the operator have long-term tenure of the site under the *Land Act*
- All lined storage ponds must be registered with the BCOGC
- Storage in open and closed-top tanks is limited to 90 days unless otherwise authorized. Fluid can be stored in lined pits for as long as the operator has tenure to the site and the design life of the liner has not been exceeded
- All sites containing tanks must be bermed to protect the surrounding site from a tank failure
- Open top tanks and earthen pits must be filled no higher than 1 meter from the overflow point

- Primary containment for an open-top tank can be provided by a synthetic liner as long as the design is certified by a professional engineer in B.C.
- Open top tanks must be inspected monthly for evidence of damage or leaks and leaks must be reported to the BCOGC as soon as possible once they have been discovered
- All earthen storage pits "must be constructed with a primary containment device, a secondary containment device, a leak detection system between the primary and secondary containment devices, adequate fencing to prevent wildlife access and unauthorized dumping, and signage at the access point identifying the operator and location"[53]
- Lined pits must include measures to ensure that the lining is not damaged during operations and must be able to contain spills that occur during loading and unloading
- Measures must be taken to mitigate the risk of harm to waterfowl
- The design of all earthen pits must be certified by a professional engineer licensed in B.C.

The information letter also gives specific details about the nature of an acceptable leak detection system, inspection and monitoring requirements, and acceptable material for synthetic liners. The information letter is provided to permit holders as guidance and leading practice, but it is not included in regulation and does not have the force of law, making it difficult to enforce unless the requirements are included in permit conditions. It is generally included in facilities permit conditions issued for earthen storage pits, but open tanks, such as containment rings, do not require permits.

The BCOGC is also participating in an ongoing initiative with the Western Regulators' Forum to develop updated guidance regarding storage of flowback water. This updated guidance is set to be released in 2015 and will replace the guidance contained in Information letter # OGC 09-07.

Industry standards, principles, and recommended practices

CAPP Operating Practices

CAPP provides an "operating practice" document for fluid transport, storage, and disposal in hydraulic fracturing. This operating practice supports the following CAPP industry guiding principle: "We will continue to advance, collaborate on and communicate technologies and leading practices that reduce the potential environmental risks of hydraulic fracturing."[54]

The storage-related requirements of the operating practice include the following:

- Storage of fluids and flowback water must meet all applicable laws and regulations
- Fluids and flowback water must be stored in such a way that wildlife are restricted from accessing it

Adherence to the operating practice is voluntary but encouraged by CAPP.

[53] B.C. Oil and Gas Commission, 2009
[54] Canadian Association of Petroleum Producers, 2012b

7.1.2.5.3. Short-term flowback water storage opportunities and observations

Table 7.1-15: Short-term flowback water storage opportunities and observations summary

Aspect	Observations	Opportunities
Flowback water storage requirements	▸ Leakage from flowback water storage vessels is considered to be a high-priority risk, given the large volumes of flowback water stored in these facilities and the lack of prescriptive regulation ▸ Current initiative: The BCOGC is in the process of developing revised guidelines for storage of flowback water ▸ Earthen pits are now governed as facilities under OGAA and are regulated prescriptively using permit conditions	▸ The BCOGC's current guidance for flowback water storage is outlined in information letter # OGC 09-07. Adding these requirements into regulation would give them the force of law and would provide the BCOGC better C&E options to protect against water contamination due to leaks or spills
C-Rings and other open surface storage tanks	▸ Open surface storage tanks such as C-Rings are common and are currently not explicitly regulated or inventoried ▸ New initiative: Work is underway to add additional regulation to the DPR	▸ Regulation of Open tanks, such as containment rings, could benefit from more specific regulation to better protect against leaks or spills
Lined earthen pits/storage ponds	▸ Ponds/pits are currently small in number (<30) ▸ Permit conditions require that Leak detection systems be in place ▸ Some pits exist that were permitted under the Land Act. Since mid-2014, pits are being regulated as oil and gas facilities with permit conditions attached	

Short-term surface storage of flowback water in B.C. is largely regulated using results-based regulations, with few prescriptive regulations. This is especially true for open surface tanks, such as containment rings used on well sites.

The *Drilling and Production Regulation* forbids permit holders from contaminating potable water or harming wildlife with flowback water. It does not, however, contain comprehensive regulations addressing the engineering of flowback water storage facilities in relation to environmental protection. While earthen storage pits are currently (as of mid-2014) being regulated as oil and gas facilities under OGAA and can have prescriptive permit conditions attached to their construction and operation, surface storage tanks, such as containment rings used on well pads, are not currently regulated using permits and are therefore subject to few explicit requirements over their engineering, construction, and operation. **These storage vessels could benefit from more specific regulation to better protect against leaks or spills.**

Information Letter #OGC 09-07 does provide some prescriptive guidance regarding the design, containment, monitoring, and reporting of surface storage vessels, but it is not a part of regulation and does not have the force of law. While Information Letter #OGC 09-07 dictates that lined storage pits have a leak detection system that is monitored on a monthly basis, that requirement is not enforceable unless requirements are included as permit conditions. The BCOGC's current guidance for flowback water

storage is outlined in information letter # OGC 09-07**. Adding these requirements into regulation would give them the force of law and would provide the BCOGC better C&E options to protect against water contamination due to leaks or spills.** It should be noted that prescriptive permit conditions are generally added to permits issued for lined earthen pits.

The BCOGC is currently engaged in a collaborative process with the Western Regulators' Forum to update its guidance around flowback water storage tanks and pits. However, hydrologists with the BCOGC consider leakage from flowback water storage ponds and tanks to present a large possible risk to ground and surface water. Given that assessment, there is an opportunity to review this topic and consider amendments to regulation to include more prescriptive requirements, especially with regards to surface tanks such as containment rings.

7.1.2.6. Treatment of flowback water prior to disposal

In some jurisdictions it is legal to treat flowback water to make it safe for disposal on the surface or in waterways. In these jurisdictions, inadequate treatment presents a risk of groundwater contamination during disposal on the surface or in a waterway.

In B.C., companies are prohibited from disposing of flowback water on the surface or in waterways without being granted explicit permission by the relevant Ministry. No company has applied for permission to dispose of flowback water on the surface due to the prohibitive cost to treat water to surface release standards using current technology. Accordingly, all disposal of flowback water occurs in deep disposal injection wells (see section 7.1.3.5 for more information about the regulation of disposal wells).

7.1.2.7. Transportation of flowback water

The large volume of water required to hydraulically fracture a well (5 million cubic meters in 2013) must be transported to the well site. Much of this water is transported by truck, though transporting water by pipeline is becoming more common.

7.1.2.7.1. Transportation of flowback water risks and issues

As the use of recycled flowback water increases, the risk of groundwater contamination from a truck or pipeline spill increases as well. To the extent that water for hydraulic fracturing is transported by truck, issues and risks associated with traffic exist. For discussion of issues relating to traffic, see section 7.3.2.

7.1.2.7.2. Transportation of flowback water regulatory instruments

Table 7.1-16: Transportation of flowback water regulatory instruments summary

Instrument type	Instrument	Coverage
Legislation	Oil and Gas Activities Act	▸ Gives the BCOGC the authority to regulate pipelines as an oil and gas activity and requires that a permit be issued to construct or operate a pipeline (Sections 23,25,49,111) ▸ Section 37 prohibits spillage of harmful substances and outlines the reporting, containment, elimination, and remediation requirements in the event of a spill
Regulation	Pipeline Regulation	▸ Provides detailed regulation of the construction, operation, and maintenance of pipelines to carry flowback water ▸ Requires that applicants provide a detailed proposed route mapping showing compliance with all boundaries and hazards ▸ Requires that construction and safety inspections and measures are in accordance with industry standard CSA Z662 ▸ Requires that a pipeline operator have an integrity management program and a damage prevention program ▸ Details the testing, monitoring, and reporting requirements for pipelines carrying flowback water
Regulation	Drilling and Production Regulation	▸ Section 51 prohibits flowback water from contaminating water or creating hazards to public health
BCOGC-issued guidance and advice	Pipeline Application Manual	▸ Provides instruction and context into the information that must be supplied with a pipeline application and the activities that must be undertaken prior to applying for a pipeline permit
BCOGC-issued guidance and advice	Pipeline Operations Manual	▸ Provides extensive detail into the notification, reporting, construction, testing, and operations requirements of pipeline permit holders
BCOGC-issued guidance and advice	Self-Assessment Protocol – Integrity Management Programs for Pipeline Systems	▸ Provides guidance to pipeline permit holders to self-assess their pipeline integrity management programs
BCOGC-issued guidance and advice	Integrity Management Self-Assessment (IMP) Report Internal Form	▸ Guides permit holders to more effectively develop their pipeline integrity management programs
BCOGC-issued guidance and advice	Recommended Practice for Damage Prevention Programs	▸ Gives guidance around program planning and development, public awareness programs, hazard management, surveillance and monitoring, crossings/proximity work, and program evaluation and audit
Industry standards	CSA Z662	▸ Provides technical standards for the design, construction, operation, and maintenance of pipeline systems
Industry recommended practice	CAPP Operating Practice	▸ Encourages operators to conform to applicable law and regulation and to reduce transportation of fluids and flowback water by road where practical

Transportation of flowback water is covered by legislation, regulation, BCOGC-issued guidance and advice, and industry standards and recommended practice. Flowback water is frequently transported by pipeline between storage facilities and well pads. The BCOGC administers a detailed and comprehensive regulatory regime for pipelines; while this section discusses the regulation of oil and gas pipelines, it is not intended to be a complete and comprehensive review of pipeline regulation, and therefore, discussion is limited to elements that are particularly relevant to the risk of contamination of fresh water during the transportation of flowback water by pipeline.

Legislation

Oil and Gas Activities Act

OGAA expressly defines "water produced in relation to the production of petroleum or natural gas or conveyed to or from a facility for disposal into a pool or storage reservoir" as an oil and gas activity. Therefore, construction or operation of a pipeline designed to transport hydraulic fracturing flowback water is subject to permitting requirements by the BCOGC.

- Sections 23 and 25 of OGAA require that a person must apply to the BCOGC for a permit to construct a pipeline and must supply with their application a preliminary plan of the proposed route of the pipeline. Section 25 gives the BCOGC the power to attach conditions to a pipeline permit
- Section 37 regulates the spilling of substances that could be a risk to the environment or public safety. Specifically, it requires that people carrying out oil and gas activities "prevent spillage and promptly report to the Commission any damage or malfunction likely to cause spillage…." In the event that spillage does occur, it requires that the permit holder or person carrying out the activity "remedy the cause or source of the spillage", "contain and eliminate the spillage", and "remediate any land or body of water affected by the spillage". If there is a risk to the environment or public safety because of a spillage, the permit holder or person doing the activity must also report the location and severity of the spill as well as any "damage or malfunction causing or contributing to the spillage"
- Section 49 gives the BCOGC the ability to issue orders relating to oil and gas activities, including "that a person control or prevent the escape of petroleum, natural gas, water, waste or other substances from a well, pipeline or facility" or that a person divert their pipeline if required
- Section 111 expressly gives the Commission the power to regulate the construction and operation of a pipeline, including the ability to regulate the measures that must be taken "to monitor and maintain the integrity of the pipeline and equipment"

Regulation

Pipeline Regulation

Pipelines constructed and operated for the purpose of transporting flowback water for reuse or disposal must meet the requirements of the *Pipeline Regulation.* In particular:

- Section 2 of the regulation requires that a detailed map must be submitted with an application for a pipeline permit. That map must detail the proposed route, the boundaries of any private land that the pipeline will cross, surface and environmental features and structures including streams

and lakes, and "the right of way of a highway, road, railway, underground communication or power line or other pipeline to be crossed or within 500 metres of the proposed pipeline"
- Section 3 requires that any pipeline, including a flowback water pipeline, must be constructed in accordance with CSA standard Z662
- Prior to beginning operation of a pipeline, the permit holder must "test the pipeline in accordance with CSA Z662; inspect and test all control and safety devices to ensure that the devices are in good working order; and take any other steps reasonably necessary to ensure that the pipeline is safe for use"
- Section 7 requires that a pipeline permit holder must have an integrity management program that complies with CSA Z662 and a damage prevention program for the purpose of anticipating and preventing damage. The permit holder must ensure that the pipeline is operated in accordance with those programs and must make a copy of the programs available to an official upon request
- Section 12 requires a permit holder to "maintain records of any spillage and any damage or malfunction likely to cause spillage that could be a risk to public safety or the environment"

Drilling and Production Regulation

Section 51 of the *Drilling and Production Regulation* mandates that permit holders ensure that flowback water does not:

- Create a hazard to public health
- Contaminate any water supply well, usable aquifer, or any other body of water or remain in a place where it might cause contamination
- Pollute or damage any public road
- Pass into or, on ice, over any water body that is frequented by fish or wildlife or that flows into any such water body

BCOGC-issued guidance and advice

Pipeline Application Manual

The Commission has produced a Pipeline Application Manual that provides instruction and context into the information that must be supplied with a pipeline application and the activities that must be undertaken prior to applying for a pipeline permit.[55]

Pipeline Operations Manual

The Commission has produced a Pipeline Operations Manual that provides extensive detail into the notification, reporting, construction, testing, and operations requirements of pipeline permit holders.[56]

[55] B.C. Oil and Gas Commission, 2014b
[56] B.C. Oil and Gas Commission, 2014c

Self-Assessment Protocol – Integrity Management Programs for Pipeline Systems

This Commission produced document provides guidance to pipeline permit holders to self-assess their pipeline integrity management program. Section 7 of the *Pipeline Regulation* requires that each pipeline operator have a pipeline integrity management program in place.

Integrity Management Self-Assessment (IMP) Report Internal Form

This document is the template used by the Commission to evaluate pipeline integrity management programs submitted to the Commission by pipeline permit holders. It is provided for the information of permit holders to allow them to more effectively develop their integrity management programs.

Recommended Practice for Damage Prevention Programs

Recommended Practice for Damage Prevention Programs is a document developed by the B.C. Common Ground Alliance and made available by the BCOGC on their website. It outlines leading practices for developing a damage prevention program in accordance with section 7 of the *Pipelines Regulation*. It gives guidance related to:

- Program planning and development
- Public awareness programs
- Hazard management
- Surveillance and monitoring
- Crossings/proximity work
- Program evaluation and audit

Industry standards, principles, and recommended practice

CSA Z662

Canadian Standards Association standard Z662 provides technical standards for the design, construction, operation, and maintenance of pipeline systems that carry oil and gas products and flowback water.[57] The *Pipeline Regulation* requires that pipelines used to carry flowback water conform to this standard.

CAPP Operating Practices

CAPP provides an "operating practice" document for fluid transport, storage, and disposal in hydraulic fracturing. This operating practice supports the following CAPP industry guiding principle: "We will continue to advance, collaborate on and communicate technologies and leading practices that reduce the potential environmental risks of hydraulic fracturing."[58]

[57] http://shop.csa.ca/en/canada/petroleum-and-natural-gas-industry-systems/z662-11-package/invt/27024912011
[58] Canadian Association of Petroleum Producers, 2012b

Meeting the transportation-related requirements of the operating practice involves:

- All transportation of fluids or flowback/produced water must conform to all applicable laws and regulations
- On large-scale projects, mechanisms or procedures to reduce transportation by road should be implemented where practical
- Industry must follow applicable regulations for constructing and developing pipelines

Adherence to the operating practice is voluntary but encouraged by CAPP.

7.1.2.7.3. Transportation of flowback water opportunities and observations

Transport of fresh water by truck or pipeline presents no risk of contamination. A spill or leak of flowback water, however, could lead to contamination of fresh water sources or interference with wildlife. Flowback water is not currently considered a dangerous or controlled product, and accordingly is not governed by legislation or regulation concerning the storage or transportation of dangerous goods.

The Commission administers a comprehensive set of legislation, regulation, and guidance/advice around constructing and operating pipelines, and industry standards and recommended practices provide additional regulatory instruments. Accordingly**, the Commission has ample tools at its disposal for mitigating the risks from transporting flowback water by pipeline**. However, fewer tools exist for regulating the transportation of flowback water by truck. The *Oil and Gas Road Regulation* allows the BCOGC to ensure that proper infrastructure is in place on roads constructed by the oil and gas industry, but beyond that, there is little regulatory control over transportation by truck. It is unclear, however, how significant this risk is as spills during transportation by truck appear to be rare. Moreover, **the regulation of transportation on public roads is outside of the purview of the Commission; to the extent that there are opportunities around the transportation of flowback water, they are outside of the Commission's control.**

While transportation of flowback water for reuse in other wells presents a contamination risk, it should also be noted that encouraging the reuse of flowback water reduces the need to withdraw fresh water from surface or groundwater sources.

7.1.3. Surface or groundwater contamination from below

Below-surface risks to fresh water may include compromises in well casing or cement integrity, communication with other nearby wells, and migration of gas or fluids from deeper zones along natural fractures and faults. Regulators rely on:

- Well casing and cement integrity to protect against contamination through or along the wellbore
- Notification requirements to minimize the risk of inter-wellbore communication

Migration of contaminants, particularly dissolved hydrocarbon gases, from below to above the base of groundwater protection (BGWP) along natural fractures and faults is a hypothetical possibility; it has not been scientifically analyzed or assessed.[59]

7.1.3.1. Base of groundwater protection

The DPR requires that the deepest porous zone containing non-saline groundwater that is usable for domestic or agricultural purposes be isolated from contaminants such as drilling mud or natural gas, or that hydraulic isolation exist to a minimum depth of 600 m.

The fresh groundwater zone (FGWZ) is the uppermost geological zone in the context of groundwater. The depth to which groundwater must be protected is referred to as “base of groundwater protection” (BGWP), “depth of usable groundwater” or other terms in different jurisdictions (BGWP is the term adopted for this report). BGWP is defined differently in different jurisdictions, but is generally the base above which it is possible to find an aquifer containing usable water (100-600m below surface). In B.C, the *Environmental Protection and Management Regulation* defines an aquifer as a formation or group of formations “that contains water with up to 4,000 milligrams per litre of total dissolved solids and is capable of storing, transmitting and yielding that water”. While protection of aquifers is regulated in a general sense, the provisions of the DPR related to the protection of fresh groundwater specify that protection measures be implemented above the base of “all porous zones containing usable groundwater”. There are, however, no specific definitions of ‘usable’ or ‘porous zones’ in legislation or regulation.

Protecting the fresh groundwater zone from contamination involves determining a base of groundwater protection and isolating it from lower formations.

7.1.3.1.1. Base of groundwater protection zone risks and issues

There is a risk that hydraulic fracturing at shallow depths could generate connections between the hydraulically fractured zone and overlying aquifers, creating the possibility of contamination by:

- Dissolved hydrocarbon gases (e.g., methane)
- Liquid phase hydrocarbons
- Hydraulic fracturing fluids or flowback water

[59] Canadian Council of Academies, 2014, p. 74

This risk decreases as the depth of hydraulic fracturing increases; deep hydraulic fracturing does not pose a scientifically acknowledged risk of groundwater contamination from below. The Canadian Council of Academies accepts that, at depths greater than one kilometer below the surface, "there is no method by which a fracture is going to propagate through the various rock layers and reach the surface."[60]

7.1.3.1.2. Base of groundwater protection regulatory instruments

Table 7.1-17: Base of groundwater protection regulatory instruments summary

Instrument type	Instrument	Coverage
Legislation	▸ Oil and Gas Activities Act	▸ Section 37 prohibits spillage of harmful substances and outlines the reporting, containment, elimination, and remediation requirements in the event of a spill. Accordingly, it regulates contaminants entering fresh water aquifers
Regulation	▸ Drilling and Production Regulation	▸ Section 22 requires that companies establish and maintain hydraulic separation between porous zones ▸ Section 18 requires that a sufficiently strong casing string be cemented to the surface from the base of any porous strata containing usable groundwater ▸ Section 18 additionally requires that non-toxic drilling fluids be used until porous strata containing usable groundwater have been isolated from the drilling fluid by a cemented casing string ▸ Section 21 dictates that an operator must not conduct hydraulic fracturing operations at depths less than 600m from the surface unless specifically authorized to do so in the permit
Regulation	▸ Environmental Protection and Management Regulation	▸ Section 4 outlines the Government's environmental objectives as they relate to oil and gas activities ▸ Section 10 defines the requirements to not cause a material adverse effect on the quality, quantity or natural timing of flow of water in the aquifer ▸ Section 34 allows the Minister of the Environment to identify an aquifer

Subsurface oil and gas activities that are conducted above the "base of groundwater protection" are regulated through OGAA, the *Drilling and Production Regulation,* and the *Environmental Protection and Management Regulation*.

Legislation

Oil and Gas Activities Act

Section 37 of OGAA regulates the spilling of substances that could be a risk to the environment or public safety, and accordingly regulates contaminants entering fresh water aquifers. Specifically, it requires that people carrying out oil and gas activities "prevent spillage and promptly report to the Commission any damage or malfunction likely to cause spillage…." In the event that spillage does occur, it requires that the permit holder or person carrying out the activity "remedy the cause or source of the spillage", "contain and eliminate the spillage", and "remediate any land or body of water affected by the spillage". If there is a risk to the environment or public safety because of a spill, the permit holder or person doing the activity must also report the location and severity of the spill as well as any "damage or malfunction causing or contributing to the spillage."

[60] Fisher and Warpinski 2011, as cited in Canadian Council of Academies 2014, p. 79

Finally, section 37 also states that “a person who is aware that spillage is occurring or likely to occur must make reasonable efforts to prevent or assist in containing or preventing the spillage.”

Regulation

Drilling and Production Regulation

Section 18 of the *Drilling and Production Regulation* states that “a well permit holder must use non-toxic drilling fluids during the drilling of a well until, in the opinion of a qualified professional, all porous strata that are less than 600 m below ground level, and contain non-saline groundwater that is usable for domestic or agricultural purposes have been isolated from the drilling fluid.” Additionally, section 18 requires that either:

- The surface casing string extend below the base of all porous strata containing usable groundwater; or, if the surface casing does not extend below the base of all porous strata that contain usable groundwater,
- The next casing string (generally the intermediate string) must be cemented completely to the surface

Section 21 requires a well permit holder to obtain an additional approval (as an original condition or amendment to the well permit) to conduct a hydraulic fracturing operation shallower than 600m.

Section 22 requires that “a well permit holder must establish and maintain hydraulic isolation between all porous zones in a well.”

Environmental Protection and Management Regulation

Section 4 outlines the Government’s environmental objectives as they relate to oil and gas activities, including “that operating areas not be located

i. within an identified ground water recharge area,
ii. within a designated watershed, or
iii. on top of an identified aquifer

unless the operating area will not have a material adverse effect on the quality and quantity of water and the natural timing of water flow”

Section 10 defines the requirements to “not cause a material adverse effect on the quality, quantity or natural timing of flow of water in the aquifer.”

Section 34 gives the Minister responsible for administering the *Water Act* the authority to identify aquifers and groundwater recharge areas. No such areas have been identified as of yet.

7.1.3.1.3. Base of groundwater protection opportunities and observations

Table 7.1-18: Base of groundwater protection opportunities and observations summary

Aspect	Observations	Opportunities
Definition of usable water	► Well permit holders are required to maintain hydraulic separation between porous zones and to ensure that a fully cemented casing string extends from the surface to the "base of all porous strata that contain usable groundwater or to a minimum depth of 600m" ► Current initiative: Hydrogeologists with the BCOGC are in the process of drafting guidelines for the determination of the BGWP	► While the DPR requires that porous zones containing usable water be isolated, there are no regulatory definitions of "usable" groundwater or "porous zones." Clearer definitions would reduce the likelihood of interpretation errors and allow the BCOGC to more consistently apply the regulation and evaluate compliance
Determination of base of fresh groundwater		► Specific data collection and submission requirements related to the characterization of shallow aquifers in Northeast B.C. would allow for more informed decisions related to the isolation of porous zones containing usable groundwater and determinations for the base of all porous zones containing usable groundwater. Such data collection efforts may also inform any future BGWP mapping initiatives ► Guidance on the criteria or methodology for identifying porous zones containing useable groundwater would provide consistency with respect to interpretations by qualified professionals
Depth of drilling	► No one has applied to HF at a depth above 600m for the purposes of shale gas extraction	► Permit holders are allowed to conduct hydraulic fracturing operations to depths of close to 600 meters without additional permit conditions. As future knowledge regarding the BGWP and hydraulic fracture propagation distances is developed, a review of this prescribed depth limit may be advisable

In B.C., well permit holders are required by the DPR to maintain hydraulic separation between porous zones, to ensure that a fully cemented casing string extends from the surface to the "base of all porous strata that contain usable groundwater or to a minimum depth of 600 meters", and to use non-toxic drilling fluids above 600m and across all strata containing usable groundwater.

While the DPR requires that porous zones containing usable water be isolated, there are no regulatory definitions of "usable" groundwater or "porous zones." Clearer definitions would reduce the likelihood of interpretation errors and allow the BCOGC to more consistently apply the regulation and evaluate compliance.

With respect to identification and isolation of porous zones containing usable groundwater **specific data collection and submission requirements related to the characterization of shallow aquifers in Northeast B.C. would allow for more informed decisions related to the isolation of porous zones containing usable groundwater and determinations for the base of all porous zones containing usable groundwater.** Moreover, guidance on the criteria or methodology for identifying porous zones

containing useable groundwater would provide consistency with respect to interpretations by qualified professionals.

Permit holders are allowed to conduct hydraulic fracturing operations at depths close to 600 meters without additional permit conditions. The potential for hydraulic fractures to connect with usable water aquifers increases as the depth of activity decreases; **as future knowledge regarding the BGWP and hydraulic fracture propagation distances is developed, a review of this prescribed depth limit may be advisable.**

7.1.3.2. Well casing construction and string depth

As wells are drilled, strings of steel casing are run into the hole and cemented in place. Cascading layers of casing to varying depths are cemented in place as the well depth increases. In B.C., all production wells will start with a conductor casing (10-15 meters in depth), followed by a surface casing, and finally by a production casing that extends to the top of the section of the well that will be hydraulically fractured. In cases where it is required to manage drilling hazards, an intermediate casing string may also be run between the surface casing and the production casing. Generally the surface casing extends below the lowest zone of usable groundwater (see section 7.1.3.1 for discussion on the base of groundwater protection); however, if it cannot extend that deeply, the next string must be cemented to below the lowest zone of usable groundwater. Each casing string is cemented into place immediately after it is set and before the next casing string is run. The cement must either extend to the surface or to at least 200 meters above the shoe of the previous casing string.

7.1.3.2.1. Well casing construction and string depth risks and issues

The integrity of the barriers as well as the cement between them is essential for ensuring that gas or contaminated fluids do not cross into the fresh groundwater zone and come into contact with usable water. The Canadian Council of Academies suggests that the most probable pathway for leakage of contaminants is leakage "along the annulus between the cement seal and the rock."[61] The integrity of the casing prevents gas and fluid from escaping the wellbore, while the integrity of the cement prevents gas from migrating along gaps in the space between casing layers. The flow of gas between the surface casing and the next casing string is known as surface casing vent flow (SCVF).

The depth of well casing is also critical to the protection of groundwater from contamination. Casing that does not descend deeply enough to isolate the intermediate zone[62] and the fresh groundwater zone could lead to contamination. In B.C., essentially all unconventional gas wells are cased to the total depth of the well.[63]

[61] Canadian Council of Academies, 2014, p. 70
[62] The Canadian Council of Academies defines the intermediate zone as the formations between the fresh groundwater zone and the deep zone containing the targeted gas-bearing formations
[63] Interview with BCOGC staff

7.1.3.2.2. Well casing construction and string depth regulatory instruments

Table 7.1-19: Well casing construction and string depth regulatory instruments summary

Instrument type	Instrument	Coverage
Regulation	▸ Drilling and Production Regulation	▸ Section 22 requires hydraulic separation be maintained between porous zones ▸ Section18 outlines the requirements for casing depth, durability, and cementing. It also outlines what must occur if a casing or cementing failure is detected ▸ Section 32 requires that permit holders record and report casing and cementing activity information during well drilling and completion ▸ Section 41 requires that wells be checked for SCVF during well completion, abandonment, and as a part of routine maintenance throughout the life of the well
BCOGC-issued guidance and advice	▸ Well Drilling Guideline	▸ Provides additional context around the casing and cementing requirements in the Drilling and Production Regulation
BCOGC-issued guidance and advice	▸ Well Completion, Maintenance and Abandonment Guideline	▸ Mandates that it is expected that SCVF tests will occur at least annually for the first five years of the life of the well ▸ Defines the difference between SCVFs and "serious" SCVFs ▸ Specifies that gas migration testing is only required if there is visible evidence that gas migration is occurring ▸ Outlines the proper process for testing for SCVF and gas migration
Industry recommended practice	▸ American Petroleum Institute (API) HF1	▸ Provides recommended practices for well construction and integrity, including casing and cementing recommendations
Industry recommended practice	▸ CAPP Operating Practice	▸ Outlines recommended practices for well construction, casing design, cementing and evaluation of cementing, and SCVF management

Well casing construction and string depth is currently covered by regulations, guidelines and industry practice.

Regulation

Drilling and Production Regulation

Section 22 of the *Drilling and Production Regulation* requires that well permit holders must "establish and maintain hydraulic isolation between all porous zones in a well".

Section 18 outlines the casing requirements for wells. Several elements are specifically relevant:

- All casing must be designed to not fail under the maximum loads and conditions that can reasonably be expected during the life of the well
- The annulus surrounding the surface casing must be filled completely to the surface
- It effectively mandates that there must be complete isolation to the deeper of 600 meters below the surface or "below the base of all porous strata that contain usable groundwater." If the surface casing is not set below that level, then the next layer of casing (typically the intermediate casing) must be cemented completely to the surface
- All reasonable efforts must be "taken to cement all intermediate and production casing to the surface or a minimum of 200 m above the shoe *[bottom]* of the previous casing string"
- If there is any reason to believe that a casing string was not effectively cemented, then the permit holder must conduct a survey to evaluate the integrity of the cement and take any remedial measures
- If a leak or failure in the casing is detected, then the permit holder must notify the Commission and repair the leak "without unreasonable delay"

Section 32 mandates that data about casing and cementing must be recorded on a daily basis while the well is being drilled and must be submitted to the Commission within 30 days of the well being drilled.

Section 41 regulates fugitive emissions and SCVF. It requires that wells must be checked for SCVF during well completion, abandonment, and during routine maintenance throughout the life of the well. In the event that a SCVF "presents an immediate safety or environmental hazard or an occurrence of gas migration", the operator must notify the Commission, take steps to eliminate the issue, and submit a report to the Commission outlining the steps that were taken.

BCOGC-issued guidance and advice

Well Drilling Guideline

The BCOGC has published a *Well Drilling Guideline* that gives additional guidance for the drilling and completion of wells. To the extent that it is relevant to wellbore integrity, it provides some additional context around the casing and cementing requirements in the *Drilling and Production Regulation*.

Well Completion, Maintenance and Abandonment Guideline

The Well Completion, Maintenance and Abandonment Guideline provides additional guidance around environmental considerations.

- It mandates that in addition to testing for SCVF during routine maintenance, it is expected that SCVF tests will occur at least annually for the first five years of the life of the well
- It defines the difference between SCVFs and "serious" SCVFs
- Specifies that gas migration testing is only required if there is visible evidence that gas migration is occurring
- Outlines the proper process for testing for SCVF and gas migration

Industry standards, principles, and recommended practice

American Petroleum Institute (API) HF1: Hydraulic Fracturing Operations — Well Construction and Integrity Guidelines

The API has produced a document providing guidelines and recommended practices to industry around well construction and integrity in hydraulic fracturing operations.

It contains several relevant recommendations:

- Casing used in wells that will be hydraulically fractured meet API Standard 5CT, which gives strict requirements for "compression, tension, collapse, and burst resistance, quality, and consistency"[64]

[64] American Petroleum Institute, 2009

- Cement used between casing strings should meet API standards and should be tested in advance to make sure that they meet the requirements of the well
- Cement should completely fill the annular space to an appropriate height to ensure zone isolation. There should be an absence of voids and a good bonding of cement between the casing and the drilled hole
- Operators should review the history of nearby wells to identify any cementing issues.
- Operators should use established and effective techniques
- Casing centralizers should be used to help center the casing
- Appropriate cement testing procedures should be undertaken by the service company pumping the cement
- The operator should ensure that the wellbore is properly prepared with wiper trips prior to cementing
- Rotation of the casing should be considered where appropriate
- Service providers should ensure that cement is properly mixed, blended, and pumped in the field.
- The document does not specifically recommend situations when logging or testing should occur, but it does discuss appropriate techniques to conducting logging (e.g., cement bond logs)
- After cement is set, "the cement surrounding the casing shoe should have a compressive strength of at least 500 psi and should achieve 1200 psi in 48 hours at bottomhole conditions" before drilling commences again
- Pressure testing of each casing string should occur prior to "drill-out"
- Surface casing and conductor casing should both be drilled using air, fresh water, or a fresh water-based fluid
- Surface casing should extend below fresh groundwater aquifers and be cemented to the surface.
- It does not require that the intermediate casing be cemented to the surface, only that "at a minimum the cement should extend above any exposed USDW [underground sources of drinking water] or any hydrocarbon bearing zone"[65]
- At a minimum, the tail of cement for production casing should extend at least 500 meters above where hydraulic fracturing will occur
- Before drilling commences, "water samples from any source of water located nearby should be obtained and tested in accordance with applicable regulatory requirements" in order to establish baseline conditions in the surface and groundwater

CAPP Operating Practices

CAPP provides an "operating practice" document for wellbore construction and quality assurance. This operating practice supports two CAPP industry guiding principles:

- "We will safeguard the quality and quantity of regional surface and groundwater resources, through sound wellbore construction practices, sourcing fresh water alternatives where appropriate, and recycling water for reuse as much as practical
- We will continue to advance, collaborate on and communicate technologies and best practices that reduce the potential environmental risks of hydraulic fracturing"[66]

[65] American Petroleum Institute, 2009

Meeting the requirements of the operating practice involves:

- Designing wellbores using good engineering practice in conformance with regulation and under competent supervision
- Installing surface casing and cementing it to the surface and ensuring that the final casing string is cemented from the top of the target zone back into the next casing string
- Running a cement evaluation log in the event that cement returns are not obtained at the surface or if the cement level drops below the next casing string and taking appropriate action
- Designing the wellbore to withstand the maximum burst and collapse loads anticipated during hydraulic fracturing
- In the event of SCVF or gas migration, managing the flow in accordance with regulatory requirements

Adherence to the operating practice is voluntary but encouraged by CAPP.

7.1.3.2.3. Well casing construction and string depth opportunities and observations

Aspect	Observations	Opportunities
Prescriptive regulation of cementing and pressure testing	▸ The Canadian Council of Academies notes that "proper isolation in this intermediate depth region may be the most important factor in preventing contamination of fresh groundwater resources"	▸ Enhanced regulation related to pressure testing, casing centralization, and submission of cement bond logs would provide additional tools to protect against uncontrolled fluid flow occurring behind well casing

Well casing depth and integrity is essential for ensuring that:

- Gas or contaminated fluid traveling through the wellbore do not escape and enter the FGWZ
- Gas or saline water in the intermediate and deep zones do not travel along the well casing once their containing formations have been perforated by the wellbore

Indeed, the Canadian Council of Academies notes that "proper isolation in this intermediate depth region may be the most important factor in preventing contamination of fresh groundwater resources." [67]

The Commission has a very comprehensive set of prescriptive regulations in place to prevent these issues. Well permit holders are required to maintain complete separation between porous zones and to ensure that sufficient casing is in place to prevent seepage from the wellbore into the surrounding formations. As well, surface casing integrity must be tested as part of blowout prevention practices. Communication between deep formations in a poorly cemented section can lead to a loss of producible hydrocarbon reserves due to communication crossflow, H_2S, or saline water. The requirement to cement the surface casing to the surface and the intermediate casing to at least 200 meters above the shoe of

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[66] Canadian Association of Petroleum Producers, 2012f
[67] Canadian Council of Academies, 2014, p. 44

the surface casing is intended to mitigate the risk of contaminants migrating between the casing and the formation.

There is, however, room to improve the Commission's prescriptive regulations regarding casing and cementing: **enhanced regulation related to pressure testing, casing centralization, and submission of cement bond logs would provide additional tools to protect against uncontrolled fluid flow occurring behind well casing**.

7.1.3.3. Communication with other wells

Communication between wells occurs when fractures extend outward from the well being fractured and connect with other wells, either by connecting with the fractures of a previously fractured well or by communicating directly with the wellbore of another well.

7.1.3.3.1. Communication with other wells risks and issues

Connections between wells could provide a pathway for contaminants to cross zones, especially in the event of communication with older, less well-designed or improperly abandoned wells. During the hydraulic fracturing process the fluid in the well is under significant pressure. There is a risk of connections developing to existing or abandoned wells when hydraulic fracturing is conducted in proximity to other wells. Opening a connection to a nearby well could potentially force that high pressure fluid into that well and provide a pathway for fluid or gas to cross zones. Several instances of communication between wells resulting in well-control issues have been recorded, including 18 in B.C.[68] Of these 18, all were communicating within the same geologic formation.

Contacted wells may be in the process of being drilled, producing, suspended, or abandoned. Each scenario has safety, environmental, and equipment damage risks. Wells undergoing drilling are at risk of a blow-out, producing wells are at risk of damage to surface facilities due to the contact of high pressure fluids, and suspended or abandoned wells may provide pathways for contaminants to reach fresh water or the atmosphere.

Additionally, while the integrity of nearby wellbores may not fail due to hydraulic fracturing operations, improperly cemented nearby wells could provide an avenue for gas to migrate along the annulus of the wellbore between the casing and the outside of the borehole. Gas moving along these pathways could potentially migrate into ground or surface water or escape into the atmosphere. For further discussion of the issues around proper cementing of well casing, see section 7.1.3.2.

[68] B.C. Oil and Gas Commission, 2010

7.1.3.3.2. Communication with other wells regulatory instruments

Table 7.1-20: Communication with other wells regulatory instruments summary

Instrument type	Instrument	Coverage
Regulation	▸ Drilling and Production Regulation	▸ Section 7 exempts unconventional zones from the normal spacing requirements for efficient production ▸ Section 9 outlines the requirements for well control and requirements in the event of barrier failure ▸ Section 10 requires that adequate blowout prevention equipment exists on each production well and that the equipment is tested regularly ▸ Section 18 requires that well casing be designed to handle the maximum loads and service conditions that could reasonably be anticipated ▸ Casing failures must be reported to the Commission and repaired as soon as possible
Safety Advisory	▸ Safety Advisory 2010-03	▸ Recommends that operators of wells within 1,000 meters of a hydraulic fracturing activity be notified that the activity will be taking place
Industry Practice	▸ Enform Industry Recommended Practice (IRP) #24	▸ Outlines a recommended hazard management process for mitigating the risk of interwellbore communication during hydraulic fracturing, including between older or abandoned nearby wells

Communication with other wells is currently covered by regulations, industry practice and safety advisory.

Regulation

Drilling and Production Regulation

Conventional wells in B.C. are limited to a single well per pool without applying for a special exemption, but due to the nature of unconventional gas extraction, higher well density is generally required to efficiently extract gas from deep shale formations. Section 7 of the DPR exempts wells in unconventional zones from the normal spacing requirements outlined in the *Drilling and Production Regulation.*

Section 9 of the DPR outlines the requirements for well control. All operating wells in B.C. must ensure that appropriate well control equipment is in place “to control kicks, prevent blow-outs and safely carry out all well operations.” In the event that a well barrier fails, section 9 of the DPR requires that all well activity cease except the activity required to repair or replace the barrier.

Section 10 of the DPR requires that well permit holders ensure that blowout protection equipment is tested on installation and as often as necessary.

Section 18 of the DPR requires well permit holders “ensure that casing is designed so that it will not fail if subjected to the maximum loads and service conditions that can reasonably be anticipated during the expected service life of the well” and that “surface casing must be set in a competent formation at a depth sufficient to provide a competent anchor for blowout prevention equipment and to ensure control of anticipated well pressures.”

BCOGC-issued guidance and advice

Safety Advisory 2010-03

In May 2010, in response to a "kick"[69] experienced in a well adjacent to a well that was undergoing hydraulic fracturing nearby, the BCOGC-issued a safety bulletin recommending that well permit holders notify the operators of any wells within a 1,000 meter radius of a hydraulic fracturing operation that such an operation will be occurring.[70]

Industry standards, principles, and recommended practices

Enform Industry Recommended Practice (IRP) #24

Enform, the safety association for upstream oil and gas companies in Canada, has created an "industry recommended practice" document to establish recommended practices around mitigating the risk of interwellbore communication during hydraulic fracturing.[71] The practices included in the document are "intended to reduce the risk of well control events due to interwellbore communication between an offset energy well and a subject energy well as the result of fracture stimulation operations."[72]

IRP 24 outlines a recommended hazard management process for mitigating the risk of interwellbore communication during hydraulic fracturing. Process steps include:

- Model the "fracture planning zone" - the zone where it is expected that fractures will extent from the wellbore
- Identify any other wells within the fracture planning zone, as well as any nearby wells meriting special consideration
- Determine which wells may be at risk for interwellbore communication during fracturing
- Conduct a "barrier analysis" on each at-risk well. This analysis evaluates the combination of barriers intended to prevent or control flow
- Assess groundwater protection at at-risk wells
- Develop a well control plan. This plan could involve activities such as monitoring, installing additional barriers in at-risk wells, shutting in the at-risk well, or adjusting the parameters of the fracturing operation

[69] "A kick is an unintended entry of water, gas, oil, or other formation fluid into wellbore that is under control and can be circulated out. It occurs when the formation fluid is driven by a formation pressure that is greater than the pressure exerted on it by the column of drilling mud in the wellbore. If the formation fluid is not controlled a blowout may result" B.C. Oil and Gas Commission, 2010
[70] B.C. Oil and Gas Commission, 2010
[71] Enform, 2013
[72] Enform, 2013

7.1.3.3.3. Communication with other wells opportunities and observations

Table 7.1-21: Communication with other wells opportunities and observations summary

Aspect	Observations	Opportunities
Unintended communication with other wells	▸ Currently operating unconventional gas wells are designed to withstand the high pressure of hydraulic fracturing without losing casing integrity ▸ The risk is more acute for communication with older wells ▸ As a matter of good engineering, companies will evaluate the integrity of older or abandoned wells near where they are fracturing	▸ Requirements to evaluate the integrity of nearby wells, either active or abandoned, prior to hydraulic fracturing would protect against contamination of freshwater due to conduits created by other wells

In modern unconventional natural gas extraction activities, multiple wells are drilled from the same pad. The goal of both the well permit holders and the government is to achieve the most efficient use of B.C.'s natural resources by striving for the maximum possible depletion of a given reservoir. Accordingly, unconventional gas companies endeavour to space their wells in such a way that the fractures extending from the horizontal portion of a well spread as closely as possible to the fractures from the neighbouring well without touching them. While communication between wells in this context is possible and anticipated, the actual risks of contamination are low due as these neighbouring wells have been built to withstand the high pressures experienced during hydraulic fracturing.

The risk is more acute in the case of older wells. The *Drilling and Production Regulation* requires that operating wells be designed in such a way that their casings can withstand the high pressures of hydraulic fracturing without failing. Accordingly, the risk of communication with an operating well leading to failure of its barriers is low. Older wells, however, may not have been built to the same standards, may have been improperly shut-in or abandoned, or may have deteriorated over time. As the Canadian Council of Academies notes, "such abandoned wells could pose a risk to public health and safety if the formations that they penetrate become re-pressurized during… shale gas drilling or completion activities…."[73]

While an evaluation of nearby wells is generally done by industry as a matter of good engineering practice,[74] **requirements to evaluate the integrity of nearby wells, either active or abandoned, prior to hydraulic fracturing would provide additional tools to protect against contamination of freshwater due to conduits created by other wells.**

The upstream oil and gas industry safety association, Enform, has issued an "Industry Recommended Practice" document that recommends that interwellbore communication risk assessment and mitigation activities take place prior to hydraulic fracturing, including an assessment of nearby abandoned wells. Following these practices is recommended, but not required of oil and gas companies in B.C.

[73] Canadian Council of Academies, 2014, p. 80
[74] Personal communication with Ron Stefik

7.1.3.4. Natural pathways

Natural fractures and faults are conceptually the only non-anthropogenic mechanism for movement of contaminants through low permeability rock.[75] Migration of contaminants, particularly dissolved hydrocarbon gases, from below to the fresh groundwater zone (FGWZ) along natural fractures and faults is a hypothetical possibility; it has not been scientifically analyzed or assessed.[76]

7.1.3.4.1. Natural pathways risks and issues

If the fractures from a hydraulically fractured well intersect with a natural fault, it is theoretically possible that a pathway for contaminants to move between subsurface zones could emerge. There is a theoretical risk that connecting to a natural fracture during the hydraulic fracturing process could provide a potential pathway for gas or liquid to migrate above the base of groundwater protection.

The risk decreases as the depth of hydraulic fracturing increases; deep hydraulic fracturing does not pose a scientifically acknowledged risk of groundwater contamination from below. The Canadian Council of Academies accepts that, at depths greater than one kilometer below the surface, “there is no method by which a fracture is going to propagate through the various rock layers and reach the surface”.

7.1.3.4.2. Natural pathways regulatory instruments

Table 7.1-22: Natural pathways regulatory instruments summary

Instrument type	Instrument	Coverage
Legislation	▸ Oil and Gas Activities Act	▸ Section 37 prohibits spillage of harmful substances and outlines the reporting, containment, elimination, and remediation requirements in the event of a spill. Accordingly, it regulates contaminants entering fresh water aquifers

Contamination from below along natural pathways is regulated through OGAA.

Legislation

Oil and Gas Activities Act

Section 37 of OGAA regulates the spilling of substances that could be a risk to the environment or public safety, and accordingly regulates contaminants entering fresh water aquifers. Specifically, it requires that people carrying out oil and gas activities “prevent spillage and promptly report to the Commission any damage or malfunction likely to cause spillage….” In the event that spillage does occur, it requires that the permit holder or person carrying out the activity “remedy the cause or source of the spillage”, “contain and eliminate the spillage”, and “remediate any land or body of water affected by the spillage”. If there is a risk to the environment or public safety because of a spillage, the permit holder or person doing the

[75] Canadian Council of Academies, 2014, p. 72
[76] Canadian Council of Academies, 2014, p. 74

activity must also report the location and severity of the spill as well as any “damage or malfunction causing or contributing to the spillage.”

Finally, section 37 also states that “a person who is aware that spillage is occurring or likely to occur must make reasonable efforts to prevent or assist in containing or preventing the spillage.”

7.1.3.4.3. Natural pathways opportunities and observations

The risk of fluid moving along natural pathways and contaminating the FGWZ appears to be very low and largely academic. The Canadian Council of Academies notes that it is not enough for a conduit to merely exist; there must also be “sufficient and sustained pressure to push the contaminating fluid to a height where it could overcome the hydraulic head of the fresh water zone.”[77] The majority of the energy used in a hydraulic fracturing operation is consumed by the fracturing process and would “not be available to drive a sustained flow of water to the shallow subsurface.”[78] A hydraulic fracture operation time period is measured in hours. Moreover, as soon as fluid being injected into a well during hydraulic fracturing found a natural fault or other pathway, the pressure would drop and the operator would likely shut down the hydraulic fracturing operation as it would no longer be effective.

Gas migrating along natural faults may be more likely to reach the FGWZ compared to fluids due to the buoyant nature of gas, though as with fluid migration, the risk is generally highest while hydraulic fracturing is occurring. Once the pressure of the hydraulic fracturing activity is relieved, gas will “tend to migrate towards the wellbore rather than to the surface along some undefined pathway.”[79] A producing well is a pressure-sink; gas flowing from high to low pressure is produced up the well as the point of draw. **The risks of contamination from below along natural pathways are theoretical and no evidence exists to suggest that it is occurring in reality.** The Canadian Council of Academies notes that migration of “natural gas through fractured sedimentary rock following its release by hydraulic fracturing has not been rigorously analyzed or assessed.”[80] Given the largely theoretical nature of the risk of contamination from below along natural pathways, **no evidence-based opportunities have been identified.**

[77] Canadian Council of Academies, 2014, p. 73
[78] Canadian Council of Academies, 2014, p. 73
[79] Canadian Council of Academies, 2014, p. 74
[80] Canadian Council of Academies, 2014, p. 76

7.1.3.5. Disposal of flowback water in deep wells

In B.C., companies are prohibited from disposing of flowback water on the surface or in waterways without being granted explicit permission by the Ministry responsible. No company has applied for permission to dispose of flowback water on the surface due to the prohibitive cost to treat water to surface release standards using current technology. Accordingly, the de-facto method for disposing of flowback water that will not be reused is injection into deep disposal wells within the earth (permeable, porous formations capable of holding and containing large volumes of water and other fluids). These reservoirs may be depleted oil and gas pools, or, more commonly, saline water saturated reservoirs. They can be shallower than production wells, but are deeper than fresh water aquifers.[81] The industry is currently reusing flowback water for additional hydraulic fracturing operations, either by storing it on the surface or recycling it back from the disposal formation; however, the flowback water must eventually be disposed of permanently.

7.1.3.5.1. Disposal of flowback water in deep wells risks and issues

The largest risk is potential groundwater contamination. There are three potential avenues for groundwater contamination from disposal injection wells:

1. The well casing is compromised
2. Fluid migrates away from the well into the FGWZ
3. Potential for interference with deep saline water source wells or production wells

Injection wells are subject to the same casing and wellbore integrity risks as production wells. Flowback fluid and other waste is pumped into wells at high pressure over long periods of time, and compromises in the integrity of the wellbore could provide a pathway into groundwater. The pressure in this process differs from that of the pressure during hydraulic fracturing operations because, while fluid is pumped in at lower rates and lower pressure, it is sustained over significantly longer periods of time (typically months or years, rather than hours).

There is a risk of groundwater contamination if the fluid being disposed of migrates up to the FGWZ. While the operators of disposal wells are required to keep the total pressure below the amount required to cause hydraulic fracturing, pathways created by natural fractures could conceivably provide a path between zones. As well, if the fluid in the reservoir communicates with other nearby wells, these other wellbores could provide a pathway between zones. However, the Council of Canadian Academies report on the environmental impacts of shale gas extraction in Canada notes that, “the risk to the FGWZ should not be significant when best practices are followed because the low injection pressures and rates should not result in significant upward displacement through abandoned wells or leaky well seals.”[82]

The Commission has also begun investigating the potential for disposal of flowback water in deep reservoirs to interfere with the use of saline water from nearby deep saline reservoirs. This investigation is

[81] Canadian Council of Academies, 2014
[82] Canadian Council of Academies, 2014, p. 95

at an early stage and the BCOGC will be evaluating the need for future regulation of use of deep saline aquifers.

7.1.3.5.2. Disposal of flowback water in deep wells regulatory instruments

Table 7.1-23: Disposal wells regulatory instruments summary

Instrument type	Instrument	Coverage
Legislation	▸ Oil and Gas Activities Act	▸ Section 75 allows the Commission to regulate oil and gas activities as "special projects"
Legislation	▸ Environmental Management Act	▸ Allows the Commission and the Ministry responsible to regulate the disposal of other non-hazardous materials in disposal wells through a permitting process
Regulation	▸ Oil and Gas Act General Regulation	▸ Section 10 specifically prescribes disposal of flowback water into disposal wells as a special project under section 75 of OGAA
Regulation	▸ Drilling and Production Regulation	▸ Section 51 prohibits flowback water from being disposed of in surface or groundwater ▸ Section 74 requires that disposal well operators record the volume of fluid injected into the well
Regulation	▸ Oil and Gas Waste Regulation	▸ Explicitly enumerates the oil and gas waste that can be disposed of on the ground. Flowback water is not included in that list
Permit Conditions	▸ Permits	▸ Dictates the injection pressure, and total pressure of fluid that can be injected into the well ▸ Provides requirements for ensuring and testing wellbore and casing integrity ▸ Dictates additional notification and reporting requirements
BCOGC-issued guidance and advice	▸ Application Guideline	▸ Dictates the activities that must be completed and information that must be submitted with a permit application ▸ Ensures that the integrity of wells within a 5km radius is taken into consideration when permit decisions are made
BCOGC-issued guidance and advice	▸ Water Source, Injection and Disposal Service Wells Summary	▸ Provides further clarification around the requirements for wellbore integrity testing, injectivity testing, seismicity measurement, notification and reporting, and packer isolation testing
Industry recommended practice	▸ CAPP Operating Practices	▸ Encourages operators to dispose of all spent fluid and flowback water in a safe and legal manner

Disposal of flowback water is currently covered by legislation, regulation, permit conditions, guidelines, standards and industry practices.

Legislation

Oil and Gas Activities Act

Permits for deep disposal wells are granted under section 75 of OGAA, the "special projects" provision. Specifically, section 75 (1) (d) gives the Commission the authority to designate "any… prescribed oil and gas activity or method of carrying out an oil and gas activity" as a special project, and therefore attach conditions to permits or orders associated with that activity.

Environmental Management Act

Disposal wells intended to inject flowback water or recovered completion or workover fluids require a permit under section 75 of OGAA in addition to the initial well permit. Wells that are intended to inject any waste other than flowback water or recovered completion or workover fluids require both a section 75

permit as well as a permit under the *Environmental Management Act (*EMA)[83]*.* Non-hazardous materials that require an EMA permit include: "boiler blowdown water, tank wash water, rig wash, spent glycols, [and] drilling waste leachate."[84]

Regulation

Oil and Gas Activities Act General Regulation

Section 10 of the *OGAA General Regulation* expressly prescribes "the operation or use of a storage reservoir, including the disposal of produced water or acid gases" as a special project under section 75 (1) (d) of OGAA.

Drilling and Production Regulation

Section 51 of the *Drilling and Production Regulation* requires that a well permit holder must ensure that formation water does not "run into or contaminate any water supply well, usable aquifer or water body or remain in a place from which it might contaminate any water supply well, usable aquifer or water body". Companies are therefore prohibited from disposing of flowback water into bodies of surface water.

Section 74 of the regulation states that "a well permit holder must ensure that the quantity and rate of water, gas, air or any other fluid injected through a well to an underground formation is metered", ensuring that the volume of fluid injected into the well is recorded.

Oil and Gas Waste Regulation

Section 7 of the *Oil and Gas Waste Regulation* specifies the oil and gas wastes that can be discharged onto land. Flowback water is not among those that may be discharged on land.

Permit Conditions

BCOGC decision makers issuing permits for wells that will be used as disposal wells insert the following condition into well permits:

> The Oil and Gas Commission, under section 25(1) of the Oil and Gas Activities Act, hereby permits the holder to drill and operate well number WA XXXXX for the purpose of injecting or disposal of fluids, subject to the following conditions:
>
> - Prior to disposal operation of the well, the Permit holder must acquire a Special Project Order under section 75 of the *Oil and Gas Activities Act* from the Reservoir Engineering Department of the Commission. Application Guideline for the Special Project Order can be found on the B.C. Oil and Gas Commission Website at: http://www.bcogc.ca/node/8206/download

[83] B.C. Oil and Gas Commission, 2014a
[84] B.C. Oil and Gas Commission, 2014a

This condition requires that the permit holder receive an additional permit prior to operating the well as a disposal well.

A number of permit conditions are included in all special projects Orders issued under section 75 of OGAA for disposal injection wells: [85]

- The maximum wellhead injection pressure may not exceed 90% of the formation fracture pressure
- The total pressure is limited to a calculated formation fill up pressure. Typically "based on 120% of the virgin reservoir pressure, prior to any production or injection within the reservoir"[86]
- The reservoir pressure must be measured periodically to ensure that the pressure remains below the ultimate pressure limit
- A monthly record of the volume of fluid disposed into the well must be submitted to the Commission no later than the 25th day of the following month[87]

In addition, injection wells are subject to the same well-integrity requirements as other oil and gas wells (see section 7.1.3.2 for more detail about wellbore and casing integrity), including:

- For wells that are being converted to injection wells, "all porous zones, in addition to the disposal zone, must be isolated by cement"[88]
- New wells must ensure that the surface casing be set "below the deepest usable water zone and cemented to surface or, if surface casing is not set below the deepest usable water zone, the next casing string is cemented to surface, and that hydraulic isolation is established between all porous zones"[89]
- A pressure integrity test must be done before beginning operations
- Per section 16 (3) of the *Drilling and Production Regulation*, annual packer isolation tests must be done

BCOGC-issued guidance and advice

The Commission has published two documents that provide guidance on submitting an application for a disposal well:

1. *Application Guideline for: Deep Well Disposal of Produced Water / Non-Hazardous Waste*[90]
2. *Water Source, Injection and Disposal Service Wells Summary*[91]

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[85] B.C. Oil and Gas Commission, 2014d
[86] B.C. Oil and Gas Commission, 2014d
[87] For example, http://www.bcogc.ca/node/8935/download
[88] B.C. Oil and Gas Commission, 2014d
[89] B.C. Oil and Gas Commission, 2014d
[90] http://www.bcogc.ca/industry-zone/documentation/Subsurface-Disposal
[91] B.C. Oil and Gas Commission, 2014d

The application guideline document provides a comprehensive list of requirements that must conducted prior to applying, or submitted along with the application. These include:

- A detailed map of the tenure and registered owners, in the disposal formation, within a 3km radius of the proposed well, as well as a map illustrating the status and completion zones of all wells within the same 3km radius
- Detailed information about the geology and history of the reservoir
- Summary of any well events that occurred prior to or during the preparation of the disposal zone
- Pressure values and calculations, including the initial pressure, proposed wellhead and bottom injection pressures, and the formation fracture pressure
- "A detailed report of: 1) a step-rate injectivity test performed to ascertain fracture pressure of the formation, if available, or 2) hydraulic stimulation of proposed well or comparable."
- Expected performance and life of the well
- Proposed testing schedule
- Radius and shape of the injection migration plume
- Analysis of water in the disposal formation
- Analysis of the water that will be disposed of in the well
- A diagram of the proposed well completion
- Wellbore integrity testing results and interpretation
- "A list of wellbore casing ages, sizes, types, collapse strength and depth within a 5 km radius of the proposed disposal well is required. The maximum collapse strength of wellbores intersecting the disposal formation in the area must be considered."
- The method by which the wellhead injection pressures will be continuously measured and recorded

The disposal wells summary document provides further clarification around the requirements for wellbore integrity testing, injectivity testing, seismicity measurement, notification and reporting, and packer isolation testing.

Industry standards, principles, and recommended practices

CAPP Operating Practices

The Canadian Association of Petroleum Producers (CAPP) provides an "operating practice" document for fluid transport, storage, and disposal in hydraulic fracturing. This operating practice supports the following CAPP industry guiding principle:

- "We will continue to advance, collaborate on and communicate technologies and best practices that reduce the potential environmental risks of hydraulic fracturing"[92]

[92] Canadian Association of Petroleum Producers, 2012b

The disposal-related requirements of the operating practice include the following.

- Spent fluids and flowback water will be disposed of safely and in an approved facility or disposal well
- Disposal well design and construction will adhere to all applicable laws and regulation

Adherence to the operating practice is voluntary but encouraged by CAPP.

It should be noted that disposal of flowback water in deep wells can be expensive, upwards of $70 per cubic meter.[93] This high cost has the benefit of providing a financial incentive for companies to reuse flowback water in additional hydraulic fracturing activities as much as possible.

Disposal wells may be operated by either disposal service companies, accepting fluids from a range of operators, or by producing companies that dispose of their own produced fluid. All wells permitted for the disposal of non-hazardous waste are owned by disposal service companies.

7.1.3.5.3. Disposal well opportunities and observations

Table 7.1-24: Disposal well opportunities and observations summary

Aspect	Observations	Opportunities
Baseline and ongoing water testing	▸ The risks around deep disposal wells are fairly well known and understood ▸ The regulatory framework addresses each of the major contamination vectors ▸ In addition to regulatory requirements specific to disposal wells, these wells are also subject to the same regulatory requirements around construction and integrity as production wells ▸ The operation of a well for disposal service is subject to a through application and review process by professional engineers and geologists ▸ Disposal wells are subject to rigorous operating, monitoring, testing and reporting requirements as conditions of individual approvals, appropriate to the specific circumstances	▸ Baseline and ongoing testing of water quality near disposal wells is currently done on a case-by-case basis using permit conditions. Including these requirements in regulation and applying them more broadly would provide an additional tool to measure compliance with results-based regulatory requirements

As the Canadian Council of Academies notes, “deep-well disposal is a long-standing practice for disposal of saline fluids and acid gases in the oil and gas industry in western Canada”[94], and the risks are fairly well known and understood. The major vectors for groundwater contamination are fluid migration through

[93] Per discussions with John Nurkowski
[94] Canadian Council of Academies, 2014

the breaches in the casing, fluid migration through nearby wells, and fluid migration through fractures and other natural pathways. The regulatory framework addresses each of these issues:

- In addition to requirements specific to disposal wells, these wells are also subject to the same regulatory requirements around construction and integrity as production wells. Permit conditions specify the requirements for testing and measuring wellbore integrity
- As a condition of an application to drill or operate a disposal well, any wells within a 5km radius must be examined for adequate integrity
- As a condition of an application, “detailed geologic mapping and analysis of the disposal and overlying formations” must take place to ensure that the reservoir is able to competently store the injected fluids

The Commission has a comprehensive set of tools in place to prescriptively regulate disposal wells. There is no broadly applied requirement to conduct baseline testing or ongoing monitoring of groundwater or surface water near these wells; however, the Commission does have the ability to include these requirements as permit conditions, and has done so in the past for those wells that are deemed to pose an elevated risk. While it should be considered a low priority, including these requirements in regulation and applying them more broadly would provide an additional tool to measure compliance with results-based regulatory requirements, as well as a broader range of compliance and enforcement options.

7.1.4. Water jurisdictional review

In our review of the six jurisdictions, we found that the water lifecycle was well regulated within the key issue areas of scarcity management, groundwater and aquifer protection, hydraulic fracturing fluid composition and chemical disclosure and produced water storage, disposal, and reuse. There were several instances where we could not find a more robust or even comparable regulation in other jurisdictions thus signalling that B.C. may be leading in some aspects of this area. Nonetheless, we did identify a few regulations that may improve coverage of an existing and identified issue. This section will discuss those instances.

Transparency around the quantity and all sources of water (including off-book sources)

In Pennsylvania, within 30 days of completing a well, the operator must report the following data points: A list of water sources used and the volume of water used from each source; and the total volume of any recycled water used.

Similarly, in Alberta, after every hydraulic fracturing operation, licensees must submit a comprehensive report of their fracture fluid water source.[95]

Managing the cumulative effects and long-term impacts of water use

In Pennsylvania, water management plans are required that identify from where water will be withdrawn and the corresponding volume. These plans are evaluated by the regulator for upstream and downstream impacts and cumulative effects. The approval is subject to the requirement to register any water withdrawals greater than 300,000 gallons over a 30 day period (including location and volume).

In Colorado, permit application for a groundwater wells are denied if the proposed withdrawal will exceed a 40% depletion rate within a three-mile radius over 25 years. This regulatory instrument appears to protect the long-term impact of the removal of groundwater.

Short-term surface storage of flowback water

In North Dakota, storage in open pits is prohibited. Similarly, in Saskatchewan, storage in pits is only allowed in an emergency, and the contents must be disposed of in 48 hours. Such a restriction is likely not feasible in B.C., given the large volumes of water used.

In Pennsylvania, there is a standard for groundwater monitoring wells around the impoundment of flowback water.

[95] Alberta Energy Regulator, 2012

Disclosure of chemical contents and trade-secret exemptions

Most jurisdictions require disclosure of chemical contents with some protection of companies under trade-secret exemptions. However, in Pennsylvania, any information claimed as a trade secret must still be disclosed to the regulator.

Base of groundwater protection

In Alberta, the regulator has developed a map of the base of groundwater protection (BGWP) and an online query tool. Additionally, there exists a process to submit BGWP measurement data in the permitting process. This data is then used to confirm or improve the BGWP map that Alberta has developed. Furthermore, saline is defined as having >4,000 mg/L total dissolved solids.

Well casing construction and string depth

In Alberta, surface casing must be adequately centralized. Furthermore, on production and intermediate casing, centralizers must be placed at the top and bottom of all productive formations and at 50 meter intervals to the required cement top.

Communication with other wells

In Alberta, licensees must manage the risk of interwellbore communication through the use of a hydraulic fracture risk plan that includes a risk assessment of each offset well in the fracture planning zone using a methodology such as that described by IRP 24.

7.2. Induced seismicity

Hydraulic fracturing is a controlled process that injects pressurized solutions into geological formations, such as shale, where natural gas is otherwise locked. As the fluid is injected into deep shale formations, it fractures the rock, increasing the permeability of the formation and allowing gas to flow into the wellbore. There have been recorded instances where the injected fluids have increased pore pressure along critically stressed faults. This increased pore pressure reduces normal stresses along the fault, and can result in fault movement. These events generally occur either within the targeted zone or in a deeper horizon and have been recorded from about 1800 to 2800 metres below the surface.[96]

The Commission continues to conduct research on induced seismicity. In 2012, the Commission undertook an investigation in response to several incidents of anomalous seismicity in the Horn River Basin recorded by Natural Resources Canada (NRCan).[97] The Canadian data from this report focuses exclusively on the Horn River Basin in northeastern B.C. It points out that none of the seismic events associated with hydraulic fracturing have caused any injury, property damage or posed any risk to public safety or the environment. The largest seismic events in the BCOGC report are described as “minor”.

7.2.1. Induced seismicity due to hydraulic fracturing

During the hydraulic fracturing process, thousands of microseismic events occur as the rock is fractured. These events are typically between magnitude -3.0 to 0.5. Some higher magnitude events, ranging from magnitude 1.0 to magnitude 4.4 and linked to fluid injection during hydraulic fracturing have been recorded. Since January 2013, approximately 15 of these events were large enough to be felt on the surface and have begun to give rise to public concern over the risk for human safety and infrastructure integrity.

7.2.1.1.1. Induced seismicity due to hydraulic fracturing risks and issues

The potential for anomalous induced seismicity from hydraulic fracturing has raised the following risks**:**

- Compromising well integrity: Well integrity is currently measured during completion and prior to production. There is a perceived risk that seismicity from the hydraulic fracturing process could compromise the integrity of the vertical portion of the wellbore, opening pathways for gas and water contamination from below.

  However, the risk to wellbore integrity due to induced seismicity appears to be low. The BCOGC’s 2012 report notes that of 93 wells examined after seismic events, 91 reported no issues. The remaining two reported deformations along their horizontal portions that presented no risk “with respect to safety, containment or fluid migration”.[98]

[96] B.C. Oil and Gas Commission, 2012
[97] B.C. Oil and Gas Commission, 2012
[98] B.C. Oil and Gas Commission, 2012

- Injury or property damage due to induced seismicity: There have been a small number of documented cases where these triggered microseismic events have resulted in minor seismic events felt on the surface. The BCOGC's 2012 report into seismic events in the Horn River Basin attributed all 38 events recorded by NRCan to the injection of fracturing fluid near existing faults.[99]

7.2.1.1.2. Induced seismicity due to hydraulic fracturing regulatory instruments

Table 7.2-1: Induced seismicity due to hydraulic fracturing regulatory instruments

Instrument type	Instrument	Coverage
Permit conditions	Well operations permit conditions	▸ Require that the Commission be notified if an earthquake measuring greater than magnitude 4.0 is recorded or if any seismicity is felt on the surface within a 3km radius of the drilling pad. Wellbores identified as the cause of the magnitude 4.0 or greater events must be suspended ▸ Suspended operations may only continue after a mitigation plan is created, approved and adopted
Industry standards, principles and recommended practices	CAPP Operating Practice	▸ Appropriately evaluate wellbore placement and drilling design to account for geologic conditions ▸ Communicate and prepare onsite personnel for the possibility of anomalous induced seismicity ▸ Have procedures established to monitor for induced seismicity ▸ Have procedures to mitigate and respond to anomalous induced seismicity

Currently, induced seismicity is covered by permit conditions and industry recommended practices.

Regulation

Currently, induced seismicity is regulated using permit conditions, but the Commission is considering elevating those conditions into the *Drilling and Production Regulation*.

Permit Conditions

Induced seismicity is currently regulated by conditions included in all well permits in Northeast B.C. These conditions require that:

- Permit holders report any seismic event within 3km of the drilling pad recorded by the permit holder or any source available to the permit holder as being greater than magnitude 4.0 or that is felt on the surface
- If a wellbore is identified as the source of a magnitude 4.0 or greater seismic event, fracturing activities on that pad must be suspended immediately
- In order to resume fracturing, the permit holder must present a plan for mitigating seismicity or eliminating the operations related to the seismicity, the Commission must be satisfied with this plan, and the permit holder must implement the plan

[99] B.C. Oil and Gas Commission, 2012

Industry standards, principles and recommended practices

CAPP Operating Practice[100]

CAPP has published guidance on minimum requirements for assessing, monitoring, responding to, and mitigating anomalous induced seismicity for hydraulic fracturing. The objective of the CAPP operating practice is "to continue to advance, collaborate on, and communicate technologies and best practices that reduce the potential environmental risks of hydraulic fracturing." To meet this requirement, companies must meet or exceed the following:

- For hydraulic fracturing projects, companies should assess the potential for anomalous induced seismicity by considering the public interest, well type, local surface conditions and geology, past operating experience, historical seismicity, and the anticipated scope of operations. The assessment approach should draw from available data, communication with the regulator and other operators in the area, and understanding of local context
- If the assessment determines that a risk of induced seismicity exists, that risk should be accounted for in wellbore placement and drilling design, onsite personnel should be notified of the risk and authorized to suspend operations if a seismic event occurs, and a proper monitoring procedure should be established
- If a seismic event is detected, mitigation procedures should be undertaken, up to and including suspending operations

7.2.1.1.3. Induced seismicity due to hydraulic fracturing opportunities and observations

Table 7.2-2: Induced seismicity due to hydraulic fracturing opportunities and observations summary

Aspect	Observations	Opportunities
Regulation of induced seismicity	▸ Permit conditions outlining notification and suspension requirements and are added to every permit ▸ Current initiative: the BCOGC is considering adding seismicity conditions into the Drilling and Production Regulation	▸ Regulation of induced seismicity caused by hydraulic fracturing is currently done through permit conditions. There is an opportunity to improve transparency and effectiveness by moving these requirements into regulation to be more consistently applied and enabling access to a broader set of C&E tools

[100] Canadian Association of Petroleum Producers, 2012a

Aspect	Observations	Opportunities
Seismicity research and monitoring	► The Commission continues to conduct research on induced seismicity and in 2012, investigated in response to several incidents of anomalous seismicity in the Horn River Basin that were recorded by Natural Resources Canada (NRCan) ► Current initiative: The Commission continues to improve its monitoring capability: six new seismograph stations were added to the Canadian National Seismograph Network (CNSN) with two more installations scheduled for 2014 ► Current initiative: The Commission has just released a second report on induced seismicity that builds on the findings of the 2012 investigation	

The BCOGC's 2012 report noted that the risk of damage due to induced seismicity caused by hydraulic fracturing is relatively low. While the NRCan stations recorded 38 events, the Commission noted "that more than 8,000 high-volume hydraulic fracturing completions have been performed in Northeast British Columbia with no associated anomalous seismicity."[101] As well, "none of the NRCan reported events caused any injury, property damage or posed any risk to public safety or the environment."[102] In fact, only one of the events was felt on the surface.

The Commission continues to study induced seismicity issues and improve its monitoring capability:

- Working with the Commission, Geoscience B.C. has organized funding for a five year project to install and operate six additional seismograph stations for the CNSN. Six new seismograph stations were added to CNSN with two more installations scheduled for 2014
- The Commission has just released a second report on induced seismicity that builds on the findings of the 2012 investigation

While seismic events are rare, the occurrence of a large event triggered by hydraulic fracturing, whether in B.C. or in another jurisdiction, could lead to increased public concern. There is currently no legislation or regulation around induced seismicity caused by hydraulic fracturing, but conditions added to every natural gas well permit require that the Commission be notified and that fracturing operations of the causal wellbore be suspended if an earthquake measuring greater than magnitude 4.0 is recorded. The risk to wellbore integrity due to induced seismicity also appears to be low. The BCOGC's 2012 report notes that of 93 wells examined after seismic events, 91 reported no issues. The remaining two reported deformations along their horizontal portions that presented no risk "with respect to safety, containment or fluid migration".[103]

[101] B.C. Oil and Gas Commission, 2012
[102] B.C. Oil and Gas Commission, 2012
[103] B.C. Oil and Gas Commission, 2012

7.2.2. Induced seismicity due to deep well disposal

Currently in B.C., companies are prohibited from disposing of flowback water on land or in bodies of water, regardless of any treatment it may undergo. Accordingly, the de-facto method for disposing of flowback water that will not be reused is injection into deep disposal wells – permeable, porous formations capable of holding large volumes of water and other fluids. These wells are often depleted oil and gas reservoirs and can be shallower than production wells, but are still significantly deeper than fresh water aquifers.[104]

7.2.2.1.1. Induced seismicity due to deep well disposal risks and issues

Flowback water is injected into disposal wells at a pressure below the threshold for creating fractures in the rock. There is some risk that this sustained, high-pressure injection of fluid into wells could result in induced seismic events that could lead to injury or property damage on the surface. There is also the potential that a seismic event could damage the integrity of other wells in the area.

7.2.2.1.2. Induced seismicity due to deep well disposal regulatory instruments

Table 7.2-3: Induced seismicity due to deep well disposal regulatory instruments summary

Instrument type	Instrument	Coverage
Permit conditions	Well operations permit conditions	► Require that the Commission be notified and that fracturing operations be suspended if an earthquake measuring greater than magnitude 4.0 is recorded or if any seismicity is felt on the surface within a 3km radius of the drilling pad
Permit conditions	Special project permit conditions	► Dictates the volume, injection pressure, and total pressure of fluid that can be injected into the well

Currently, induced seismicity in deep disposal wells is governed by permit conditions.

Permit Conditions

Induced seismicity is currently regulated by conditions included in all well permits in Northeast B.C. These conditions require that:

- Permit holders report any seismic event within 3km of the drilling pad recorded by the permit holder or any source available to the permit holder as being greater than magnitude 4.0 or that is felt on the surface
- If a well pad is identified as the source of a magnitude 4.0 or greater seismic event, fracturing activities on the causal wellbore must be suspended immediately
- In order to resume fracturing, the permit holder must present a plan for mitigating seismicity or eliminating the operations related to the seismicity, the Commission must be satisfied with this plan, and the permit holder must implement the plan

[104] Canadian Council of Academies, 2014

7.2.2.1.3. Induced seismicity due to deep well disposal opportunities and observations

Table 7.2-4: Induced seismicity due to deep well disposal opportunities and observations summary

Aspect	Observations	Opportunities
Regulation of induced seismicity	▸ Two disposal wells in Northeast B.C. are known to be causing seismic events. ▸ The Canadian Council of Academies notes that more than 140,000 disposal wells have been drilled in the United States with very few seismic issues ▸ In addition to the notification and suspension permit conditions placed in all well permits, disposal wells are also required to maintain pressure below the level that would result in hydraulic fracturing	▸ Regulation of induced seismicity caused by injection wells is currently done through permit conditions. There is an opportunity to improve transparency and effectiveness by moving these requirements into regulation to be more consistently applied and enabling access to a broader set of C&E tools

Induced seismicity caused by disposal wells is subject to many of the same opportunities and observations as induced seismicity triggered by hydraulic fracturing. While more than 140,000 disposal wells have been drilled in the United States with very few seismic issues[105], two disposal wells in Northeast B.C. are known to be causing seismic events and felt and/or damaging events have been triggered by disposal wells in Ohio and Oklahoma.[106] The BCOGC has also increased its seismic monitoring capabilities since the 2012 Horn River Basin report was released. Using CNSN monitoring stations as well as a number of dense arrays deployed in areas that are at high-risk of induced seismicity, the Commission has good monitoring coverage of relevant areas of the province.

There is currently no legislation or regulation around induced seismicity caused by hydraulic fracturing, but conditions outlining notification and suspension requirements are added to every permit. In addition to the notification and suspension permit conditions placed in all well permits, disposal wells are also required to maintain pressure below the level that would result in hydraulic fracturing.

[105] Zoback 2012, qtd in Canadian Council of Academies 2014, 132
[106] Nicholson & Wesson 1990, qtd in Canadian Council of Academies 2014, 132

7.2.3. Induced seismicity jurisdictional review

In our review of the six jurisdictions we found that most jurisdictions that are concerned about induced seismicity focus on disposal wells rather than from hydraulic fracturing activities.

Uniquely, in Pennsylvania, these Class II (disposal wells) are regulated by the Environmental Protection Agency (EPA) which has developed a decision model that defines and uses the three components necessary for significant injection induced seismicity: “1) pressure buildup from disposal activities, 2) faults of concern, and 3) a pathway for the increased pressure to communicate with the fault.”

In Texas, applicants for disposal well permits must include the results of a review of United States Geological Survey information regarding any seismic information within a circular area of 100 square miles around the well location. If the results indicate that there is a history of seismic events, applicants may be required to provide additional information, including logs, geologic cross-sections, pressure front boundary calculations or structure maps.

7.3. Quality of life

The hydraulic fracturing process involves significant industrial activity at the well site and the related transportation activities to and from the well site. As the number of unconventional wells in B.C. grows, the amount and duration of this activity increases. A well is typically only hydraulic fractured prior to initial production, however there may be cases where a well will require an additional fracture treatment during its productive life to increase total reserves recovery.

The area surrounding a large, multi-well pad undergoing multi-stage hydraulic fracturing may experience an increase in light, noise, air pollution and area traffic that could be sustained over many months. For well-pads located near populated areas, these issues could lead to significant disturbances to the local population. Public concerns for the quality of life of communities in nearby areas fall under the following categories:

1. Issues resulting from the **surface footprint** of the well pad including peripheral land use for equipment.
2. Issues resulting from the **transportation** of materials and equipment to and from the well sites (increased traffic) including the creation of airborne dust, noise, and human safety
3. **Production disturbances** related to the well pad operating activities, including concern over local air quality

7.3.1. Surface footprint

Shale gas development requires high density wells spacing to efficiently develop a resource play. Since land is an asset to British Columbians, the surface footprint of oil and gas activity is important from many perspectives, including the opportunity cost of other uses such as recreational space for the community; and the impact on the surrounding habitat. In 2013, the BCOGC reported that 2.14 percent of the land in north east B.C. is used for oil and gas activities.[107]

In addition to the number and size of well pads and facilities, the surface footprint includes linear land use such as access roads and pipelines. While most pipelines in B.C. are buried underground, the land above remains clearer and is not available for most other uses.[108]

7.3.1.1.1. Surface footprint risks and Issues

The surface footprint of hydraulic fracturing activities generates the following public concerns:

1. Adverse impacts on neighbouring habitats or wildlife migration
2. Loss of ability to use the land for other purposes such as hunting, forestry, agriculture, or outdoor recreation areas

[107] B.C. Oil and Gas Commission, 2013a
[108] B.C. Oil and Gas Commission, 2013a

7.3.1.1.2. Surface footprint regulatory instruments

Table 7.3-1: Surface footprint regulatory instruments

Instrument type	Instrument	Coverage
Legislation	Oil and Gas Activities Act	▸ Gives the Commission the authority to issue temporary land use permits or long-term land use licenses under the Land Act and to permit or deny the use of certain areas under the Heritage Conservation Act
Legislation	Land Act	▸ Sections 11 and 38 allow the BCOGC to issue long-term leases of Crown land and attach terms and conditions ▸ Sections 11 and 39 allow the BCOGC to issue long-term licenses to Crown land and attach terms and conditions ▸ Section 14 allows the BCOGC to issue short term permits to use Crown land for up to two years
Legislation	Heritage Conservation Act	▸ Gives the Commission the ability to permit or deny the use of areas of land that are considered heritage property in B.C.
Legislation	Water Act	▸ Section 9 gives Regional Water Managers the authority to authorize changes in an about a stream. A person or company may only make changes in an about a stream in accordance with an approval under section 9
Regulation	Environmental Protection and Management Regulation	▸ Governs several aspects of land use, including location of activities relative to bodies of water, preservation of natural range barriers for livestock, activities in culturally protected areas and old growth management areas, and location of activities relative to wildlife and their habitat ▸ Section 19 outlines oil and gas site restoration requirements

Land use and the corresponding surface footprint are currently regulated with multiple pieces of legislation and regulation.

Legislation

Oil and Gas Activities Act

OGAA gives the Commission the authority to issue temporary land use permits or long-term land use licenses under the *Land Act* and to permit or deny the use of certain areas under the *Heritage Conservation Act.*

Land Act

Section 11 of the *Land Act*, in conjunction with OGAA, allows the BCOGC to lease Crown land, grant a license to Crown land, or grant a right of way over Crown land.

Section 14 allows the Commission to issue a temporary permit (less than two years) for the use of Crown land.

Section 38 allows the BCOGC to lease Crown land and attach any terms or reservations it feels are advisable.

Section 39 allows the BCOGC to grant a license to use Crown land and attach any terms or reservations it feels are advisable.

Heritage Conservation Act

Section 12 of the *Heritage Conservation Act* gives the Commission the ability to permit or deny the use of areas of land that are considered heritage property in B.C.

Water Act

Section 9 gives Regional Water Managers the authority to approve changes in an about a stream. A person or company may only make changes in an about a stream in accordance with an approval under section 9.

Regulation

Environmental Protection and Management Regulation

Section 4 of the *Environmental Protection and Management Regulation* outlines the Government's environmental objectives as they relate to oil and gas activities. This regulation governs several aspects of land use, including:

- Location of activities relative to bodies of water
- Preservation of natural range barriers for livestock
- Activities in culturally protected areas and old growth management areas
- Location of activities relative to wildlife and wildlife habitat

Section 19 of the regulation outlines the requirements for site restoration activities and timing.

7.3.1.1.3. Surface footprint opportunities and observations

Table 7.3-2: Surface footprint opportunities and observations summary

The Commission has the power, using its authority under the *Land Act*, to regulate the use of Crown land, including granting a right of way over Crown land, for the purposes of oil and gas activities. While surface footprint as it relates to oil and gas activities is an important issue, hydraulic fracturing activities themselves do not pose significant surface footprint issues, and accordingly, issues related to surface footprint are largely outside of the scope of this report.

7.3.2. Increased traffic

Hydraulic fracturing requires that tens of thousands of cubic meters of fluids, chemicals, and proppants be transported to and from the well pad. Currently, the bulk of this material is transported by truck, resulting in significant traffic.

7.3.2.1.1. Increased traffic risks and Issues

Increased traffic presents the following public concerns:

1. Increased wear and tear/damage to local infrastructure, primarily roads;
2. Disturbances from airborne dust created by both traffic along unpaved roads as well as from the transportation of sand and other proppant material; and
3. Safety concerns for the potential for increased risk of motor vehicle incidents.

7.3.2.1.2. Increased traffic regulatory instruments

Table 7.3-3: Increased traffic regulatory instruments summary

Instrument type	Instrument	Coverage
Legislation	Motor Vehicle Act	▸ The primary piece of legislation governing activities on roads in B.C.

Currently the Commission does not have the authority to regulate traffic, dust, or road use outside of specified oil and gas roads.

Legislation

Motor Vehicle Act

B.C.'s *Motor Vehicle Act* is the primary piece of legislation governing activities on roads in B.C. The Commission does not have any authority to regulate under the *Motor Vehicle Act*.

7.3.2.1.3. Increased traffic opportunities and observations

While the Commission does govern activities that take place on oil and gas roads, **it currently does not have the power to implement traffic, dust, or road use regulation** outside of these areas and **any gaps in the regulation of traffic must be addressed by bodies outside of the BCOGC.**

The Commission does use a number of non-regulatory tools to mitigate issues related to increased traffic. For example, it acts as a liaison between the public and industry and works closely with industry to help resolve complaints from residents in Northeast B.C. Many oil and gas companies have also begun to take proactive steps to limit traffic during times when children are traveling to and from school and to implement road dust management strategies along certain roads.

7.3.3. Operational disturbances

Well drilling, hydraulic fracturing, and other related operational activities can cause temporary disturbances to surrounding neighbours in the form of lights, noise, odours and ground level air quality.

7.3.3.1.1. Operational disturbances risks and Issues

The operating activities of hydraulic fracturing can generate the following public concerns for the neighbours within sight and earshot:

1. Noise created by drilling equipment and from running diesel equipment engines.
2. Light from flood lights used to illuminate well pads at night to run 24 hour operations.
3. Ground level air quality contamination, such as ground level ozone, and odors due to diesel engines (pollution caused by transportation traffic is addressed in section 6.3.2)

7.3.3.1.2. Operational disturbances regulatory instruments

Table 7.3-4: Operational disturbances regulatory instruments summary

Instrument type	Instrument	Coverage
Regulation	Drilling and Production Regulation	▸ Section 5 outlines the separation distances required between oil and gas activities and other infrastructure ▸ Section 40 requires that operators not make excessive noise
Regulation	Consultation and Notification Regulation	▸ Outlines the requirements for consulting and notifying
Regulation	Oil and Gas Waste Regulation	▸ Outlines the specific requirements for handling waste produced by oil and gas activities. The regulation does not place limits on the fumes generated by hydraulic fracturing activities
BCOGC-issued guidance and advice	School exclusion zone policy	▸ The Commission does not approve permit applications to drill a well within one kilometer of a school
BCOGC-issued guidance and advice	British Columbia Noise Control Best Practices Guideline	▸ Provides guidelines for noise impact assessment, noise management, and noise complaint handling

Operational disturbances are covered by regulation and BCOGC-issued guidance and advice.

Regulation

Drilling and Production Regulation

Section 5 of the *Drilling and Production Regulation* outlines the separation distances that must be maintained between oil and gas activities and other infrastructure. Specifically, the regulation states that "a permit holder must not drill a well within the following minimum distances:

a) 40 m of the right of way or easement of any road allowance or public utility,
b) 100 m of a permanent building, installation or works,
c) 100 m of a place of public concourse, or
d) 100 m of a reservation for national defence."

Section 40 requires that operations do not cause excessive noise.

Consultation and Notification Regulation

The *Consultation and Notification Regulation* outlines the requirements for consulting and notifying different classes of people. Sections 7 to 9 outline the distance requirements for consultation and notification:

- For wells on pads smaller than 5 hectares in size or containing fewer than 9 wells, the notification distance is the larger of 1,500 meters or the distance required by the Emergency Management Regulation and the consultation distance is the larger of 1,000 meters or the distance required by the Emergency Management Regulation
- For wells on pads smaller than 5 hectares in size or containing more than 9 wells, the notification distance is the larger of 1,800 meters or the distance required by the Emergency Management Regulation and the consultation distance is the larger of 1,300 meters or the distance required by the Emergency Management Regulation
- For pipelines, the notification and consultation distances are the larger of 200 meters or the distance required by the Emergency Management Regulation
- For roads, the notification and consultation distances are 200 meters

Oil and Gas Waste Regulation

The *Oil and Gas Waste Regulation* outlines the specific requirements for handling waste produced by oil and gas activities. The regulation does not place limits on the fumes generated by hydraulic fracturing activities.

BCOGC-issued guidance and advice

School exclusion zone policy

In 2014, the Commission created an exclusion zone policy that prohibits drilling activity within one-kilometre of schools in B.C.[109]

British Columbia Noise Control Best Practices Guideline

The BCOGC's Noise Control Best Practices Guidelines provides guidelines to oil and gas operators, including:

- Acceptable sound levels at different periods in the day and during different seasons
- Adjustments to reflect ambient noise levels
- Requirements for conducting and reporting noise impact assessments
- Handling noise complaints and developing noise management plans

[109] http://www2.news.gov.bc.ca/news_releases_2013-2017/2014MNGD0040-000856.htm

7.3.3.1.3. Operational disturbances opportunities and observations

Table 7.3-5: Operational disturbances opportunities and observations summary

Aspect	Observations	Opportunities
Regulation of light, noise, emissions, and fumes		▸ Light emissions, fumes from diesel engines and other air quality issues such as ground level ozone are currently addressed through industry best practice, but given that this is an emerging issue, there is an opportunity to consider increased guidance/permit conditions/regulations in cases where hydraulic fracturing occurs near occupied buildings or populated areas
Setback distances	▸ While the Drilling and Production Regulation does outline minimum separation distances, at the time when these requirements were brought into force, the oil and gas industry in the province was largely drilling conventional wells. A conventional well pad might see three to four weeks of drilling, by contrast, the large increase in size and density of unconventional well pads is resulting in drilling and fracturing periods that can stretch for six months or longer	▸ There is an opportunity to improve public awareness related to the Commission's use of minimum separation requirements (setbacks) in decision-making

While the BCOGC does provide regulation and guidelines to govern noise levels and to require consultation with nearby residents, it does not place any restrictions on light emissions, fumes from diesel engines or other sources, or other air quality concerns such as ground level ozone.

The most effective method for mitigating these issues is to ensure that there is sufficient separation between the location of hydraulic fracturing activities and other private or municipal infrastructure. **While the *Drilling and Production Regulation* does outline minimum separation distances, there is an opportunity to improve public awareness related to the Commission's use of minimum separation requirements (setbacks) in decision-making.** At the time that the current requirements were brought into force the oil and gas industry in the province was largely drilling conventional wells. While a conventional well pad might see a single well go through three to four weeks of drilling and then another few days of hydraulic fracturing or other completion activities, the large increase in size and density of unconventional well pads is resulting in drilling and fracturing periods that can stretch for six months or longer. Moreover, the larger fluid volumes and pressures required to fracture unconventional wells results in more and larger pumping trucks.

That said, the 100 meter minimum distance is only a minimum. BCOGC decision makers integrate local information as well as findings from the consultation and notification processes and avoid approving permit applications for activities that occur too closely to occupied areas. Care must be taken when considering increasing statutory minimum distances, as larger minimum could result in significant areas of "sterilized" land – i.e., land that is unavailable for development. Sterilization is a reciprocal concern; sterilizing areas from development can reduce the value of the land to the landowner. Accordingly, this is primarily a communications opportunity. The Commission can better communicate the role of the permit process in ensuring adequate separation between activity and occupied land.

7.3.4. Quality of life jurisdictional review

In our review of the six jurisdictions, we found that all six jurisdictions primarily regulate quality of life disturbances though the use of setbacks. At 100 meters, B.C.'s setback requirements are similar to those in other jurisdictions. It is important to note that setback distances between jurisdictions are not necessarily a relevant comparison. With the exception of distances required for health and safety reasons, these separation requirements are generally not based on scientific analysis, but are rather determined through political processes.

- **Alberta**: 200 meters from public dwellings
- **Saskatchewan**: 100m of an occupied dwelling; a public facility; or an urban centre
- **Colorado**: 1,000 feet (approximately 305 meters) from a building and 350 feet (approximately 106 meters) from a designated outside activity area
- **North Dakota**: 500 feet (approximately 152 meters) from an occupied dwelling
- **Pennsylvania**: 500 feet (approximately 152 meters) from an occupied dwelling
- **Texas**: 467 feet (approximately 142 meters) from any property line or lease line

Community engagement

Alberta has developed a unique model for conducting stakeholder engagement in areas near oil and gas activities. Synergy Alberta is a not-for-profit organization that operates as a partnership between the regulator, the government, and industry. Synergy Alberta provides support to "synergy groups": community- based groups that serve as a forum for local residents, industry operators, and government officials to discuss impacts to local quality of life caused by oil and gas activities.

There are more than 25 synergy groups across the province, with memberships ranging from 10 people to several hundred.

7.4. Additional opportunities

An additional opportunity that exists outside of the categories of water, induced seismicity, and quality of life was identified during interviews with BCOGC staff: access to microseismic monitoring data.

Microseismic monitoring data

Microseismic analysis is the primary monitoring tool for evaluating hydraulic fracturing, including understanding the area and location of the fractures and the success of the fracturing operation. By placing sensitive geophones either on the surface or downhole near where the fractures are propagating, microseismic analysis allows operators to understand fracture development, fluid movement, and if the fractures are staying in the desired zone. Microseismic monitoring is a different concept from seismic monitoring, which is concerned with measuring induced seismicity.

Microseismic analysis is necessary to prove that the fractures are staying in the deep zones, which is necessary for maintaining public confidence in the Commission's oversight of hydraulic fracturing operations in the province. The data from microseismic monitoring provides information about the potential effectiveness of a specific hydraulic fracture technique to create an effective stimulated rock volume for efficient hydrocarbon recovery. **Disclosure of this information would support continuous improvement and ensure that B.C.'s natural gas resources are being extracted efficiently and effectively.**

Currently, operators do not consider microseismic data to be well completion data and do not submit the results of monitoring that does occur to the BCOGC. In B.C. companies will typically conduct microseismic monitoring when fracturing wells in a new geological formation or refining well completion and hydraulic fracture techniques, but due to the high cost of collecting microseismic data, companies do not do so for most wells. Additionally, companies consider the microseismic data that they collect to have economic value and may object to any requirement to submit such data to the Commission for fear of sharing a learned advantage with their competitors.

In our jurisdictional scan, we noted that Alberta requires that in cases where microseismic testing is performed, the results must be included in daily drilling and completion reports.

7.4.1.1.1. Additional opportunities and observations

Table 7.4-1: Additional opportunities and observations summary

Aspect	Observations	Opportunities
► Microseismic monitoring data		► Requirements to collect and submit microseismic monitoring data around hydraulic fracturing activities would allow the BCOGC to better understand the behavior of hydraulic fracturing in different formations, maintain confidence that fractures are not migrating outside of their intended zones, and support efficient resource extraction by encouraging industry adoption of best practices

8. Appendix B: Detailed opportunities

Table 7.4-1: Identified opportunities

ID#	Opportunity	Priority rationale
Opportunities related to: Surface fresh water use		
O1	▸ Increased regulatory authority over the use of water obtained on private land would allow the BCOGC to better manage water use, particularly in periods of drought	▸ **2:** While a relatively small percentage of water use in hydraulic fracturing is taken from sources on private land, those sources are exempt from suspension orders issued by the Commission in times of drought. Control of surface water use from private land is important to be able to comprehensively ensure sustainable management of water sources
O2	▸ The ability to issue higher penalties for violations of the Water Act would allow the BCOGC to more effectively enforce compliance with the Act	▸ **2:** The *Water Act* ticketing process is a convenient process for issuing penalties, but with a maximum penalty of $230 for most offenses, *Water Act* tickets may not be a sufficient deterrent
Opportunities related to: Subsurface fresh water use		
O3	▸ Requiring limits on pumping rates for water source wells would give the BCOGC the ability to more comprehensively manage the sustainable use of groundwater	▸ **3:** The BCOGC is preparing a new water source well permitting framework that will introduce pumping limits and realize this opportunity
O4	▸ The upcoming *Water Sustainability Act* will include provisions related to groundwater thereby addressing the gaps in *the Water Act* concerning the protection of groundwater in B.C. Successful implementation of the Act and its regulations will support the sustainable management of groundwater in B.C.	▸ **2:** Groundwater is under-regulated in the province, but the updated B.C. *Water Sustainability Act* will govern groundwater upon its coming into force with groundwater regulation(s). Groundwater regulation(s) under this act are expected to be developed in 2015, with the act tentatively expected to begin coming into force in 2016
Opportunities related to: Alternative sources of water		
O5	▸ Requiring operators to report the use of water obtained from alternative sources, such as municipal grey water or water purchased from municipal water supplies would allow the BCOGC to more accurately report on water use related to hydraulic fracturing, thereby improving transparency	▸ **3:** Use of water from municipalities and water treatment facilities is relatively low. As well, use of this water is low risk relative to the overall hydrogeological context in B.C. This opportunity is limited to gathering additional information
Opportunities related to: Water use disclosure		
O6	▸ Requiring operators to report the use of water obtained from sources on private land would allow the BCOGC to more accurately report on water use related to hydraulic fracturing, thereby improving transparency	▸ **2:** Use of water from private sources is estimated to account for 20% of water used in hydraulic fracturing in the province. The BCOGC is an acknowledged leader in water-use disclosure; however, not being able to disclose complete information about water use could impact the public's confidence in the disclosure process
Opportunities related to: Site locations relative to water sources and aquifer recharge zones		
O7	▸ The EPMR allows for enhanced management to protect aquifers should the Ministry responsible designate an aquifer; no aquifers have yet been designated. There is an opportunity for the BCOGC to collect and provide the Ministry with the data necessary to identify high-risk aquifers. Should an aquifer be designated, additional mitigation requirements could be implemented by the BCOGC related to the protection of the aquifers and associated recharge zones	▸ **2:** The Ministry does not have the information necessary to designate aquifers or aquifer recharge zones. Additional research and an appropriate framework for designation would provide an additional tool for protecting potentially sensitive areas

ID#	Opportunity	Priority rationale
O8	▸ Requirements to conduct baseline testing or ongoing monitoring of surface or groundwater quality around production zones would provide an additional tool to measure compliance with results-based regulatory requirements	▸ **1:** Protection of B.C.'s water resources from contamination is a key concern for the public and other stakeholders. The BCOGC has results-based regulation in place, but additional tools to support the results-based regulatory approach and for measuring the effectiveness of those requirements would support maintaining public confidence in the effectiveness of regulation. This information is also helpful for making regulatory decisions and monitoring for cumulative effects
O9	▸ Development of appropriate requirements related to baseline testing and ongoing monitoring of domestic water well quality around production wells would provide an additional data to support results-based regulatory requirements and to monitor compliance	▸ **3:** To the extent that the public is concerned about domestic water well contamination, baseline testing could support the Commission in measuring the impact of nearby oil and gas activities. However, domestic water well testing is just one aspect of a larger need to collect baseline water quality data
Opportunities related to: Short-term surface storage of flowback water		
O10	▸ The BCOGC's current guidance for flowback water storage is outlined in information letter # OGC 09-07. Adding these requirements into regulation would give them the force of law and would provide the BCOGC better C&E options to protect against water contamination due to leaks or spills	▸ **1:** Protection of B.C.'s water resources from contamination is a key concern for the public and other stakeholders. Storage pits and tanks are a large source of potential water contaminants and a failure to properly regulate them could result in a significant impact to the environment in the event of a spill or leak. Lined pits can be regulated using permit conditions, but open tanks such as c-rings are not regulated using any kind of permit process
O11	▸ Open tanks, such as containment rings, could benefit from more specific regulation to better protect against leaks or spills	▸ **1:** There is currently no permitting process in place to regulate open storage tanks such as c-rings, and the DPR does not provide sufficient regulation over their engineering and use. Given the large number of these tanks in use, they pose a risk to the environment in the event of a spill or leak
Opportunities related to: Base of groundwater protection		
O12	▸ While the DPR requires that porous zones containing usable water be isolated, there are no regulatory definitions of "usable" groundwater or "porous zones." Clearer definitions would reduce the likelihood of interpretation errors and allow the BCOGC to more consistently apply the regulation and evaluate compliance	▸ **3:** A consistent definition is important for removing ambiguity, but most operators currently use the definition of an 'aquifer', which is similar to Alberta's definition of 'usable' groundwater
O13	▸ Specific data collection and submission requirements related to the characterization of shallow aquifers in Northeast B.C. would allow for more informed decisions related to the isolation of porous zones containing usable groundwater and determinations for the base of all porous zones containing usable groundwater. Such data collection efforts may also inform any future BGWP mapping initiatives	▸ **2:** Mapping of BGWP would support a scientifically based determination of the base of all porous zones containing usable groundwater (i.e., the BGWP). ▸ Collection of aquifer characterization data would support confirmation of the isolation of all porous zones containing usable groundwater
O14	▸ Guidance on the criteria or methodology for identifying porous zones containing useable groundwater would provide consistency with respect to interpretations by qualified professionals	▸ **3:** A consistent and approved methodology is important for removing ambiguity. The BCOGC is currently developing guidance for determining the BGWP
O15	▸ Permit holders are allowed to conduct hydraulic fracturing operations to depths of close to 600 meters without additional permit conditions. As future knowledge regarding the BGWP and hydraulic fracture propagation distances is developed, a review of this prescribed depth limit may be advisable	▸ **3:** Essentially all hydraulic fracturing activity in B.C. occurs at depths of more than 1,500 meters. The 600 meter threshold has historically been proven adequate, but may be worth revisiting with consideration of future knowledge regarding hydraulic fracture propagation distances in conjunction with future increased base of groundwater protection knowledge

ID#	Opportunity	Priority rationale
Opportunities related to: Well casing construction and string depth		
O16	▸ Enhanced regulation related to pressure testing and casing centralization would provide additional tools to protect against uncontrolled fluid flow occurring behind well casing	▸ **1:** Isolation of zones containing usable water is essential for protecting fresh water from contamination. Given the difficulty of conducting remediation work on cement found to be offering inadequate protection, strong regulations are good practice
Opportunities related to: Communication with other wells		
O17	▸ Requirements to evaluate the integrity of nearby wells, either active or abandoned, prior to hydraulic fracturing would protect against contamination of freshwater due to conduits created by other wells	▸ **2:** There is relatively low risk of occurrence, but the consequences are potentially high. As a matter of good engineering, most operators conduct a risk assessment of nearby offset wells, but such an assessment is a regulatory requirement in other jurisdictions such as Alberta
Opportunities related to: Disposal of flowback water in deep wells		
O18	▸ Baseline and ongoing testing of water quality near disposal wells is currently done on a case-by-case basis using permit conditions. Including these requirements in regulation and applying them more broadly would provide an additional tool to measure compliance with results-based regulatory requirements	▸ **3:** The BCOGC has recently used permit conditions to mandate ongoing water quality monitoring around disposal wells on a case by case basis. The BCOGC has considered this issue through the B.C. Disposal Well Working Group and has determined that adding requirements on a case-by-case basis is appropriate given the small number of these wells and the unique context of each individual well. As activity increases, however, the Commission should periodically evaluate the appropriateness of moving monitoring requirements into regulation to allow for more consistent application and a broader range of compliance and enforcement tools
Opportunities related to: Induced seismicity due to hydraulic fracturing		
O19	▸ Regulation of induced seismicity caused by hydraulic fracturing is currently done through permit conditions. There is an opportunity to improve transparency and effectiveness by moving these requirements into regulation to be more consistently applied and enabling access to a broader set of C&E tools	▸ **3:** Seismicity is currently controlled through permit conditions, but moving the conditions into regulation would allow for more consistent application and increase the range of compliance and enforcement tools available to the Commission
Opportunities related to: Induced seismicity due to deep well disposal		
O20	▸ Regulation of induced seismicity caused by injection wells is currently done through permit conditions. There is an opportunity to improve transparency and effectiveness by moving these requirements into regulation to be more consistently applied and enabling access to a broader set of C&E tools	▸ **3:** Seismicity is currently controlled through permit conditions, but moving the conditions into regulation would allow for more consistent application and increase the range of compliance and enforcement tools available to the Commission
Opportunities related to: Operational disturbances		
O21	▸ Light emissions, fumes from diesel engines and other air quality issues such as ground level ozone are currently addressed through industry best practice, but given that this is an emerging issue, there is an opportunity to consider increased guidance/permit conditions/regulations in cases where hydraulic fracturing occurs near occupied buildings or populated areas	▸ **2:** Most current hydraulic fracturing activity takes place in very remote locations, but as activity increases, so does the likelihood of activity occurring near occupied buildings. This is also a significant perceived issue for local residents in Northeast B.C.

ID#	Opportunity	Priority rationale
O22	▸ There is an opportunity to improve awareness related to the use of minimum separation requirements (setbacks) in decision-making	▸ **1:** Most current hydraulic fracturing activity takes place in very remote locations, but as activity increases, so does the likelihood of activity occurring near occupied buildings. Adequate setback distances are an effective method for mitigating operational disturbances. This is especially important given the public perception of the importance of operational disturbance issues
Additional Opportunities		
O23	▸ Requirements to collect and submit microseismic monitoring data around hydraulic fracturing activities would allow the BCOGC to better understand the behavior of hydraulic fracturing in different formations, maintain confidence that fractures are not migrating outside of their intended zones, and support efficient resource extraction by encouraging industry adoption of best practices	▸ **2:** Microseismic monitoring information is an important oversight tool for the Commission to analyze and regulate hydraulic fracturing operations. It also provides valuable insight into the extent of resource extraction and can support the Commission's mandate to ensure that resource extraction is maximized

9. Appendix C: Hydraulic fracturing regulatory framework map

See accompanying regulatory framework map document

Appendix C: Hydraulic fracturing regulatory framework map

Issue category	Issue	Report reference	Sub-issue	Risks and issues	Protection objectives				Legislation	Regulation	Permit and license conditions	BCOGC issued guidance and advice	Industry standards, principles, and recommended practice	Observations	Improvement opportunities
					Environment	Public safety	Economic fairness	Resource conservation							
Water	**Water Sources/ Scarcity**	7.1.1.1	Surface fresh water use	Two potential risks exist surrounding the use of surface fresh water: ► The total amount of water withdrawn from a source over time, if not monitored and sustainably managed, could have adverse social, ecological, or economic impacts. ► A large amount of water being removed from a source over a short period of time, if not monitored and sustainably managed, could place stresses on the environment during particular times of the year.	X			X	Water Act ► Section 8 gives the BCOGC the authority to issue permits for short-term water use ► Section 8 allows the BCOGC to temporarily suspend short-term water withdrawal permits during drought or due to misuse ► Gives the authority to qualified BCOGC representatives designated as Regional Water Managers to issue long-term water licenses for oil and gas activities Land Act ► Provides the BCOGC with the authority to issue permits for borrow pits which are often used for fresh water storage ► Use of accumulated water in borrow pits requires a permit under Section 8 of the Water Act			Short Term Use of Water Application Manual ► Provides guidance for applying for a short term water use approval Water License Application Manual ► Provides guidance for applying for a long-term water license	Canadian Association of Petroleum Producers (CAPP) Operating Practice ► Outlines recommended practices for water use, including obtaining required licenses and permits, evaluating potential sources of water to ensure sustainability, monitoring appropriate parameters for water sources, collecting measurement data, basing water withdrawal on the amount of water actually available, and collaborating and sharing best practices American Petroleum Industry (API) HF2 ► Provides recommended practices for water use	► The Commission has a comprehensive ability to regulate the collection and use of surface water from sources on Crown land ► The use of surface water is governed by the Water Act, the BCOGC is limited to the administrative penalties available under that act, rather than the significantly larger penalties available under OGAA ► Water Act offers a quick and easy ticketing process but penalties not sufficiently high to change behavior. Process in OGAA is more burdensome, as no penalty under OGAA has been successfully applied ► The low Water Act penalties are offset by the fact that companies are sensitive to the press – regardless of monetary cost, there is a reputational cost that incentivizes compliance	**O1:** Increased regulatory authority over the use of water obtained on private land would allow the BCOGC to better manage water use, particularly in periods of drought **O2:** The ability to issue higher penalties for violations of the Water Act would allow the BCOGC to more effectively enforce compliance with the Act
		7.1.1.2	Subsurface fresh water use	The use of groundwater from water source wells presents the following potential risks: ► The total amount of wate withdrawn from a source over time, if not adequately monitored and sustainably managed, could have adverse social, ecological, or economic impacts. ► In cases where water source wells are hydraulically connected to surface water bodies, groundwater extractions during low flow periods could place short term/seasonal stresses on the aquatic environment.	X			X	Petroleum and Natural Gas Act ► Defines water source wells to ensure that the withdrawal of subsurface water for use in hydraulic fracturing is subject to regulation under the Oil and Gas Activities Act (OGAA) Oil and Gas Activities Act ► Expressly defines the drilling, operation, and abandonment of water source wells as oil and gas activities, requiring that companies apply for a permit	Drilling and Production Regulation ► Requires that water source well permit holders not injuriously affect the use of water for domestic or agricultural purposes ► Requires that permit holders report their monthly water withdrawal volume	Water Source Well Permit Conditions ► Water Source Well permit applications are reviewed by OGC hydrogeologists and conditions may be imposed (such as hydrogeological testing and monitoring requirements) to mitigate potential effects of groundwater pumping on groundwater availability		API HF2 ► Provides recommended practices for water use	► The Commission currently issues permits to drill and operate water source wells. In addition, volumes of water extracted from water source wells must be reported to the BCOGC within 25 days from the end of the month ► Water Source Well permit applications are reviewed by BCOGC hydrogeologists and conditions may be imposed to mitigate potential effects of groundwater pumping on groundwater availability ► New initiative: The BCOGC has developed a new Water Source Well Approval Framework that will incorporate pumping limits into well permits. Implementation is planned for February 2015 ► Current initiative: Changes under Water Sustainability Act should provide sufficient coverage. Goal of Provincial Government is implementation in 2016	**O3:** Requiring limits on pumping rates for water source wells would give the BCOGC the ability to more comprehensively manage the sustainable use of groundwater **O4:** The upcoming Water Sustainability Act will include provisions related to groundwater thereby addressing the gaps in the Water Act concerning the protection of groundwater in B.C. Successful implementation of the Act and its regulations will support the sustainable management of groundwater in B.C
		7.1.1.3	Alternative sources of water	Industry is exploring the potential use of other sources of water such as brackish/saline water from deep water aquifers, grey water from municipalities, and reused produced water from previous fractures. Use of these water sources can reduce the need for freshwater, but present extraction, transportation, and storage risks.	X	X	X	X	Petroleum and Natural Gas Act ► Defines water source wells (which includes deep saline wells) to ensure that subsurface water use for hydraulic fracturing is subject to regulation under OGAA OGAA ► Expressly defines the drilling, operation, and abandonment of water source wells as oil and gas activities, requiring that companies apply for a permit	Drilling and Production Regulation ► Requires that permit holders report their monthly water withdrawal volume from deep saline wells			API HF2 ► Recommends that potential opportunities for beneficial reuse of flowback and produced fluids from hydraulic fracturing be evaluated prior to treating for surface discharge or reinjection	► Technological improvements have been made in alternative water use: Progress has been made in the use of saline/brackish, grey and flowback water which reduces the requirement for fresh water ► Companies are economically incentivized to reuse flowback water because long-term disposal of flowback water in deep injection wells can cost as much as $70 per cubic meter	**O5:** Requiring operators to report the use of water obtained from alternative sources, such as municipal grey water or water purchased from municipal water supplies would allow the BCOGC to more accurately report on water use related to hydraulic fracturing, thereby improving transparencycy
		7.1.1.4	Water use disclosure	Water use disclosure covers volume of water licensed for use, volume of water actually used, and sources of fresh water. The large absolute amount of water used in hydraulic fracturing has led to concerns from the public over the effect of removing that water from ground and surface sources. Disclosure of industry water use provides an avenue for the Commission and industry to respond to public concerns. The Commission currently requires short-term surface water permit holders, water license holders, and water source well permit holders to report their monthly water withdrawal data. The Commission uses this data to produce quarterly and annual water reports.	X			X			Water Act long-term license ► Mandates that long-term license holders report monthly water usage (in cubic meters) to the Commission on a quarterly basis	Directive 2011-02 ► Mandates that short-term approval holders report monthly water usage (in cubic meters) to the Commission on a quarterly basis		► Representatives from both industry and the BCOGC consider the water reporting tools in the province to be leading practice ► The Commission has increased the regulatory requirements around reporting and disclosure of water use over the last two years, including requiring that long-term license holders begin reporting water use as of January 2014	**O6:** Requiring operators to report the use of water obtained from sources on private land would allow the BCOGC to more accurately report on water use related to hydraulic fracturing, thereby improving transparency

Appendix C: Hydraulic fracturing regulatory framework map

Issue category	Issue	Report reference	Sub-issue	Risks and issues	Protection objectives				Legislation	Regulation	Permit and license conditions	BCOGC issued guidance and advice	Industry standards, principles, and recommended practice	Observations	Improvement opportunities
					Environment	Public safety	Economic fairness	Resource conservation							
Water	**Surface/ Groundwater contamination from above**	7.1.2.1	Site locations relative to water sources and aquifer recharge zones	Fresh groundwater aquifers may receive recharge due to infiltration of precipitation at the ground surface, and therefore, some aquifers may be vulnerable to contamination due to spills or releases of contaminants at the ground surface. Using and storing contaminants of concern or conducting oil and gas activities on top of vulnerable fresh groundwater aquifers increases the risk of groundwater contamination in the event of a spill.	X	X			Land Act ► Gives the BCOGC the ability to regulate land use through the permitting process. The BCOGC has the option to reject the permit application or attach conditions or caveats to mitigate the impact of the oil and gas activity Heritage Conservation Act ► Gives the BCOGC the ability to permit or deny the use of areas of land that are considered heritage property in British Columbia	Environmental Protection and Management Regulation ► Section 4 outlines the Government's environmental objectives with respect to environmental setbacks and environmentally sensitive locations ► Section 10 defines the requirements to not cause a material adverse effect on the quality, quantity or natural timing of flow of water in the aquifer ► Section 13 requires that a person conducting oil and gas activities in a wetland "must, to the extent practicable, maintain natural flow of water" ► Sections 22 through 25 define the minimum riparian management and reserve distances ► Section 34 gives the Minister responsible for administering the Water Act the authority to identify aquifers and groundwater recharge areas			CAPP Operating Practices ► Provides recommendations for regional and domestic baseline water quality monitoring API HF2 ► Provides recommended practices for water use and the protection of fresh water sources	► The location of well pads is currently governed by the BCOGC through the permitting process: the proposed location is compared against known areas of concern, including potential wildlife-sensitive areas, surface water sources, and heritage conservation sites sources, and heritage conservation sites ► The Commission has the option to reject the permit application or attach conditions or caveats to mitigate the impact of the oil and gas activity ► Current initiative: The BCOGC has written a discussion paper on baseline testing and ongoing monitoring ► The provisions of the EPMR do not currently apply to private land due to a desire not to compromise land owners' rights	**O7:** The EPMR allows for enhanced management to protect aquifers should the Ministry responsible designate an aquifer; no aquifers have yet been designated. There is an opportunity for the BCOGC to collect and provide the Ministry with the data necessary to identify high-risk aquifers. Should an aquifer be designated, additional mitigation requirements could be implemented by the BCOGC related to the protection of the aquifers and associated recharge zones **O8:** Requirements to conduct baseline testing or ongoing monitoring of surface or groundwater quality around production zones would provide an additional tool to measure compliance with results-based regulatory requirements **O9:** Development of appropriate requirements related to baseline testing and ongoing monitoring of domestic water well quality around production wells would provide an additional data to support results-based regulatory requirements and to monitor compliance
		7.1.2.2	Contents of chemicals used in hydraulic fracturing fluid	Hydraulic fracturing fluids contain various chemicals designed to facilitate the fracturing process. While these chemicals make up a relatively small percentage of the total composition of fracking fluid (0.5-2%), the large total volume of fluid used in hydraulic fracturing (up to 80,000 cubic meters) means that on an absolute basis, significant amounts of potentially harmful chemicals are used. If proper separation between the fractured well and other porous zones is not maintained, there is a risk that the fracturing fluid could contaminate groundwater. Reducing the use of toxic or harmful chemicals in hydraulic fracturing fluids reduces the risk of groundwater contamination in the event of a failure during fracturing or a spill on the surface during fluid/chemical transportation, mixing, and storage.	X	X			Hazardous Products Act (Canada) ► Requires the disclosure of hazard information for controlled products in materials safety data sheets (MSDSs) ► Outlines the workplace hazardous materials information system (WHMIS) labeling requirements for controlled products ► Describes the conditions under which the MSDS information for ingredients that have been exempted from disclosure under the Hazardous Materials Information Review Act can be disclosed to medical professionals Hazardous Materials Information Review Act (Canada) ► Allows suppliers of controlled products to claim an exemption from public disclosure ingredient information if those ingredients are considered confidential business information	Controlled Products Regulation ► Outlines the specific criteria for defining controlled products whose ingredients are then subject to WHMIS labeling requirements and hazard disclosure through the use of MSDSs Hazardous Materials Information Review Regulation ► Describes the criteria considered when evaluating claims for disclosure exemptions under the Hazardous Materials Information Review Act			CAPP Operating Practice ► Outlines suggested analysis and risk management practices for chemical additives	► Chemicals added to hydraulic fracturing fluid are governed by federal hazardous materials legislation and regulation ► The Commission has expressed a desire to encourage companies to use "greener" fracturing fluid, which would reduce the level of contamination in the event of a spill, leak, or wellbore integrity issue. Mandating the use of "greener" additives would be a policy change and is outside the control of the BCOGC ► The Commission is working with UBC Okanagan to review the toxicity of hydraulic fracturing chemicals and flowback water. Initial conversations have also taken place with several companies and with the Alberta Energy Regulator (AER)	► No opportunities within the control of the BCOGC have been identified
		7.1.2.3	Chemical storage and transportation	The use of chemicals in hydraulic fracturing poses a risk to surface and groundwater during storage or transportation. Spills of chemicals during transportation or while being stored on the well-pad could lead to contamination of fresh water or soil, and could result in public health issues.	X	X			Environmental Management Act ► Sections 6 through 10 describe the requirements for storing, transporting, and disposing of hazardous waste. ► Section 6 prohibits the introduction of hazardous waste from an oil and gas activity into the environment without an explicit permit or approval Hazardous Products Act (Canada) ► Contains general information about safe storage precautions and conditions of the controlled products that are detailed in MSDSs Transportation of Dangerous Goods Act (Canada) ► Outlines the transportation, containment, documentation, and safety requirements for transporting dangerous goods	Occupational Health and Safety Regulation (OHS Regulation) ► Outlines the containment, storage, and labeling requirements for storing hazardous chemicals in the workplace in B.C. Drilling and Production Regulation ► Section 20 requires that proper provisions for fracturing fluid management have been made before well completion activity occurs ► Section 51 prohibits chemicals from contaminating water or creating hazards to public health Transportation of Dangerous Goods Regulation (Canada) ► Outlines the specific requirements for transporting dangerous goods including identifying, packing and labeling, containment according to class, training for transporters and handlers, emergency response action plan and reporting in the event of an accident				► Federal regulations provide strict control over the transportation of dangerous goods, including the requirement to notify responsible authorities in the event of a spill and to have an approved emergency response plan ► The storage of chemicals is covered both by provincial occupational and safety regulation as well as the Drilling and Production Regulation	► No opportunities within the control of the BCOGC have been identified

Appendix C: Hydraulic fracturing regulatory framework map

Issue category	Issue	Report reference	Sub-issue	Risks and issues	Protection objectives				Legislation	Regulation	Permit and license conditions	BCOGC issued guidance and advice	Industry standards, principles, and recommended practice	Observations	Improvement opportunities
					Environment	Public safety	Economic fairness	Resource conservation							
Water	**Surface/ Groundwater contamination from above**	7.1.2.4	Public disclosure of the composition of fracturing fluid	Currently, the contents of fracturing fluids used in B.C. are partially disclosed on fracfocus.ca. Disclosure is relevant from a regulatory perspective insofar as it forces companies to be transparent about their chemical use.	X	X			Hazardous Products Act (Canada) ► Requires the disclosure of hazard information for controlled products in MSDSs Hazardous Materials Information Review Act (Canada) ► Allows suppliers of controlled products to claim an exemption from public disclosure ingredient information if those ingredients are considered confidential business information	Drilling and Production Regulation ► Requires that permit holders record and submit detailed information about the composition of fracturing fluid within 30 days of well completion OGAA General Regulation ► Section 17 requires that the Commission release submitted well reports and well data from confidential status Hazardous Materials Information Review Regulation ► Describes the criteria considered when evaluating claims for disclosure exemptions under the Hazardous Materials Information Review Act		Fracture Fluid Report Upload Manual ► Reiterates the disclosure requirements of section 37 of the Drilling and Production Regulation, and that also stipulates that the Health Canada registry number must be included for any chemicals granted a disclosure exemption	CAPP Operating Practice ► Encourages the disclosure of the trade name of each additive, the general purpose of each additive in the mixture, the name and chemical abstract number of each chemical ingredient listed on the MSDS, and the concentration of each ingredient	► Disclosure requires companies to be transparent about their chemical use	► No opportunities within the control of the BCOGC have been identified
		7.1.2.5	Short-term surface storage of flowback water	Flowback (or produced) water is hydraulic fracturing fluid that has returned from the well after fracturing has occurred. Typically some amount of fluid is recovered (usually around 40%) while the rest remains in the formation. Produced water contains the original contaminants in the fluid as well as additional contaminants picked up from the formation. Flowback water is stored on-site for the short-term in various different tanks or containment vessels that are either enclosed or open. Leakage from produced water storage ponds is considered by many to be the greatest groundwater risk associated with unconventional gas development. Water that returns to the surface after conducting a hydraulic fracturing operation tends to be more contaminated than the initial hydraulic fracturing fluid. In addition to any chemical additives present in the initial fluid, flowback water contains dissolved solids present in the formation that has been fractured. These dissolved solids can contain naturally occurring radioactive materials (NORM) as well as trace metals such as arsenic and barium. The water can also be extremely saline, presenting a risk to any potable water it may come in contact with. There is a risk of groundwater contamination from leaks or spills of surface storage vessels as well as a risk to vegetation. There is also a risk to wildlife and waterfowl from open storage vessels.	X	X			OGAA ► OGAA gives the Commission the authority to require and issue permits to operate oil and gas facilities. The Commission has begun regulating earthen storage pits using facilities permits under OGAA rather than Land Act permits ► Section 37 prohibits spillage of harmful substances and outlines the reporting, containment, elimination, and remediation requirements in the event of a spill Land Act ► The Land Act was used in the past to regulate earthen storage pits through Crown land use approvals Environmental Management Act ► Section 6 prohibits the introduction of hazardous waste from an oil and gas activity into the environment without an explicit permit or approval	Drilling and Production Regulation ► Prohibits flowback water from contaminating water or creating hazards to public health Environmental Protection and Management Regulation ► Section 10 states that "a person carrying out an oil and gas activity on an operating area on top of an aquifer must ensure that the activity does not cause a material adverse effect on the quality, quantity or natural timing of flow of water in the aquifer." Waste Discharge Regulation ► Schedule 1 defines the oil and gas industry as a prescribed industry for the purposes of Section 6 of the Environmental Management Act.		Information letter # OGC 09-07 ► Provides prescriptive guidance over the design, containment, monitoring, and reporting requirements of surface storage vessels (earthen storage pits and tanks). This guidance is only enforceable to the extent that the requirements it outlines are reflected in permit conditions	CAPP Operating Practice ► Encourages operators to store fluid and flowback water in accordance with laws and regulation and in such a way that wildlife are restricted from accessing it	► Leakage from flowback water storage vessels is considered to be a high-priority risk, given the large volumes of flowback water stored in these facilities and the lack of prescriptive regulation ► Current initiative: The BCOGC is in the process of developing revised guidelines for storage of flowback water ► Earthen pits are now governed as facilities under OGAA and are regulated prescriptively using permit conditions ► Open surface storage tanks such as C-Rings are common and are currently not explicitly regulated or inventoried ► New initiative: Work is underway to add additional regulation to the DPR ► Ponds/pits are currently small in number (<30) ► Permit conditions require that Leak detection systems be in place ► Some pits exist that were permitted under the Land Act. Since mid-2014, pits are being regulated as oil and gas facilities with permit conditions attached	**O10:** The BCOGC's current guidance for flowback water storage is outlined in information letter # OGC 09-07. Adding these requirements into regulation would give them the force of law and would provide the BCOGC better C&E options to protect against water contamination due to leaks or spills **O11:** Open tanks, such as containment rings, could benefit from more specific regulation to better protect against leaks or spills
		7.1.2.6	Treatment of flowback water prior to disposal	In some jurisdictions it is legal to treat flowback water to make it safe for disposal on the surface or in waterways. In these jurisdictions, inadequate treatment presents a risk of groundwater contamination during disposal on the surface or in a waterway.	X									►In B.C., companies are prohibited from disposing of flowback water on the surface or in waterways without being granted explicit permission by the Ministry of the Environment. No company has applied for permission to dispose of flowback water on the surface due to the prohibitive cost to treat water to surface release standards using current technology. Accordingly, all disposal of flowback water occurs in deep disposal injection wells	► No opportunities have been identified
		7.1.2.7	Transportation of flowback water	The large volume of water required to hydraulically fracture a well (5 million cubic meters in 2013) must be transported to the well site. Currently, the majority of this water is transported by truck, though transporting water by pipeline is becoming more frequent. As the use of recycled produced water increases, the risk of groundwater contamination from a truck or pipeline spill increases as well. To the extent that water for hydraulic fracturing is transported by truck, issues and risks associated with traffic exist.	X	X			OGAA ► Gives the BCOGC the authority to regulate pipelines as an oil and gas activity and requires that a permit be issued to construct or operate a pipeline (Sections 23,25,49,111) ► Section 37 prohibits spillage of harmful substances and outlines the reporting, containment, elimination, and remediation requirements in the event of a spill	Pipeline Regulation ► Provides detailed regulation of the construction, operation, and maintenance of pipelines to carry flowback water ► Requires that applicants provide a detailed proposed route mapping showing compliance with all boundaries and hazards ► Requires that construction and safety inspections and measures are in accordance with industry standard CSA Z662 ► Requires that a pipeline operator have an integrity management program and a damage prevention program ► Details the testing, monitoring, and reporting requirements for pipelines carrying flowback water Drilling and Production Regulation ► Section 51 prohibits flowback water from contaminating water or creating hazards to public health		Pipeline Application Manual ► Provides instruction and context into the information that must be supplied with a pipeline application and the activities that must be undertaken prior to applying for a pipeline permit Pipeline Operations Manual ► Provides extensive detail into the notification, reporting, construction, testing, and operations requirements of pipeline permit holders Self-Assessment Protocol – Integrity Management Programs for Pipeline Systems ► Provides guidance to pipeline permit holders to self-assess their pipeline integrity management program Integrity Management Self-Assessment (IMP) Report Internal Form ► Guides permit holders to more effectively develop their integrity management programs Recommended Practice for Damage Prevention Programs ► Gives guidance around, program planning and development, public awareness programs, hazard management, surveillance and monitoring, crossings/proximity work, and program evaluation and audit	CSA Z662 ► Provides technical standards for the design, construction, operation, and maintenance of pipeline systems CAPP Operating Practice ► Encourages operators to conform to applicable law and regulation and to reduce transportation of fluids and flowback water by road where practical	► The Commission has ample tools for mitigating the risks from transporting flowback water by pipeline ► Governing transportation by truck is outside the purview of the Commission	► No opportunities within the control of the BCOGC have been identified

Appendix C: Hydraulic fracturing regulatory framework map

Issue category	Issue	Report reference	Sub-issue	Risks and issues	Protection objectives				Legislation	Regulation	Permit and license conditions	BCOGC issued guidance and advice	Industry standards, principles, and recommended practice	Observations	Improvement opportunities
					Environment	Public safety	Economic fairness	Resource conservation							
Water	**Surface/ Groundwater contamination from below**	7.1.3.1	Base of groundwater protection (BGWP)	The DPR specifies the depth of the FGWZ as the base of the deepest porous zone containing non-saline groundwater that is usable for domestic or agricultural purposes, or to a minimum depth of 600 m. The fresh groundwater zone is the uppermost geological zone in the context of groundwater (100-600m below surface, but typically 150m). The FGWZ is defined differently in different jurisdictions, but is generally the zone above which it is possible to find an aquifer containing potable water. In B.C., the Environmental Protection and Management Regulation defines an aquifer as a formation or group of formations "that contains water with up to 4,000 milligrams per litre of total dissolved solids and is capable of storing, transmitting and yielding that water." There is a risk that hydraulic fracturing at shallow depths could generate connections between the hydraulically fractured zone and overlying aquifers, creating the possibility of contamination by: ► Dissolved hydrocarbon gases (e.g., methane) ► Liquid phase hydrocarbons ► Hydraulic fracturing fluids ► Flowback water produced during hydraulic fracturing operations This risk decreases as the depth of hydraulic fracturing increases; deep hydraulic fracturing does not pose a scientifically acknowledged risk of groundwater contamination from below. "The Canadian Council of Academies accepts that, at depths greater than one kilometer below the surface, "there is no method by which a fracture is going to propagate through the various rock layers and reach the surface" .	X	X			OGAA ► Section 37 prohibits spillage of harmful substances and outlines the reporting, containment, elimination, and remediation requirements in the event of a spill. Accordingly, it regulates contaminants entering fresh water aquifers	Drilling and Production Regulation ► Sections 18 and 22 require hydraulic separation between porous zones, and require that a sufficiently strong casing string be cemented to the surface from the base of any porous strata containing usable groundwater. ► Section 18 additionally requires that non-toxic drilling fluids be used until porous strata containing usable groundwater have been isolated by a cemented casing string ► Section 21 dictates that an operator must not conduct hydraulic fracturing operations at depths less than 600m from the surface unless specifically authorized to do so in the permit Environmental Protection and Management Regulation ► Section 4 outlines the Government's environmental objectives as they relate to oil and gas activities ► Section 10 defines the requirements to not cause a material adverse effect on the quality, quantity or natural timing of flow of water in the aquifer ► Section 34 allows the Minister of the Environment to identify an aquifer				► Well permit holders are required to maintain hydraulic separation between porous zones and to ensure that a fully cemented casing string extends from the surface to the "base of all porous strata that contain usable groundwater or to a minimum depth of 600m" ► Current initiative: Hydrogeologists with the BCOGC are in the process of drafting guidelines for the determination of the BGWP ► No one has applied to HF at a depth above 600m for the purposes of shale gas extraction	**O12:** While the DPR requires that porous zones containing usable water be isolated, there are no regulatory definitions of "usable" groundwater or "porous zones." Clearer definitions would reduce the likelihood of interpretation errors and allow the BCOGC to more consistently apply the regulation and evaluate compliance **O13:** Specific data collection and submission requirements related to the characterization of shallow aquifers in Northeast B.C. would allow for more informed decisions related to the isolation of porous zones containing usable groundwater and determinations for the base of all porous zones containing usable groundwater. Such data collection efforts may also inform any future BGWP mapping initiatives **O14:** Guidance on the criteria or methodology for identifying porous zones containing useable groundwater would provide consistency with respect to interpretations by qualified professionals **O15:** Permit holders are allowed to conduct hydraulic fracturing operations to depths of close to 600 meters without additional permit conditions. As future knowledge regarding the BGWP and hydraulic fracture propagation distances is developed, a review of this prescribed depth limit may be advisable
		7.1.3.2	Well casing construction and string depth	As wells are drilled, strings of steel casing are run into the hole and cemented in place. Cascading layers of casing to varying depths are cemented in place as the well depth increases. In B.C., all production wells will start with a conductor casing (10-15 meters in depth), a surface casing extending below the lowest zone of potable groundwater; followed by an intermediate casing that extends from the surface to below the intermediate zone; followed by a production casing that extends to the top of the section of the well that will be hydraulically fractured. The annulus (empty space) between each layer of casing is then filled with cement. The integrity of the layers of casing as well as the cement between them is essential for ensuring that gas or contaminated fluids do not cross into the intermediate or fresh groundwater zones and come into contact with potable water. The Canadian Council of Academies suggests that the most probable pathway for leakage of contaminants is leakage "along the annulus between the cement seal and the rock." The integrity of the casing prevents gas and fluid from escaping the wellbore, while the integrity of the cement prevents gas from migrating along gaps in the space between casing layers. This flow of gas between casing layers is known as surface casing vent flow (SCVF). The depth of well casings is also critical to the protection of groundwater and the atmosphere from contamination. Casings that do not descend deeply enough to isolate the intermediate and fresh groundwater zones could lead to contamination.	X					Drilling and Production Regulation ► Section 22 requires hydraulic separation be maintained between porous zones ► Section18 outlines the requirements for casing depth, durability, and cementing. It also outlines what must occur if a casing or cementing failure is detected ► Section 32 requires that permit holders record and report casing and cementing activity information during well drilling and completion ► Section 41 requires that wells be checked for SCVF during well completion, abandonment, and as a part of routine maintenance throughout the life of the well		Well Drilling Guideline ► Provides additional context around the casing and cementing requirements in the Drilling and Production Regulation Well Completion, Maintenance and Abandonment Guideline ► Mandates that it is expected that SCVF tests will occur at least annually for the first five years of the life of the well ► Defines the difference between SCFVs and "serious" SCVFs ► Specifies that gas migration testing is only required if there is visible evidence that gas migration is occurring ► Outlines the proper process for testing for SCFV and gas migration	API HF1 ► Provides recommended practices for well construction and integrity, including casing and cementing recommendations CAPP Operating Practice ► Outlines recommended practices for well construction, casing design, cementing and evaluation of cementing, and SCVF management	► The Canadian Council of Academies notes that "proper isolation in this intermediate depth region may be the most important factor in preventing contamination of fresh groundwater resources"	**O16:** Enhanced regulation related to pressure testing and casing centralization would provide additional tools to protect against uncontrolled fluid flow occurring behind well casing
		7.1.3.3	Communication with other wells	Connections between wells could provide a pathway for contaminants to cross zones, especially in the event of communication with older, less well-designed or improperly abandoned wells. During the hydraulic fracturing process the fluid in the well is under significant pressure. There is a risk of connections developing to existing or abandoned wells when hydraulic fracturing is conducted in proximity to other wells. Opening a connection to a nearby well could potentially force that high pressure fluid into that well and provide a pathway for fluid or gas to cross zones. Several instances of unintended communication between wells have been recorded, including 18 in B.C. Additionally, while the integrity of nearby wellbores may not fail due to hydraulic fracturing operations, improperly cemented nearby wells could provide an avenue for gas to migrate along the annulus of the wellbore between the casing and the outside of the borehole.	X					Drilling and Production Regulation ► Section 7 exempts unconventional zones from the normal spacing requirements for efficient production ► Section 9 outlines the requirements for well control and requirements in the event of barrier failure ► Section 10 requires that adequate blowout prevention equipment exists on each production well and that the equipment is tested regularly ► Section 18 requires that well casing be designed to handle the maximum loads and service conditions that could reasonably be anticipated ► Casing failures must be reported to the Commission and repaired as soon as possible		Safety Advisory 2010-03 ► Recommends that operators of wells within 1,000 meters of a hydraulic fracturing activity be notified that the activity will be taking place	Enform Industry Recommended Practice (IRP) #24 ► Outlines a recommended hazard management process for mitigating the risk of interwellbore communication during hydraulic fracturing, including between older or abandoned nearby wells	► Currently operating unconventional gas wells are designed to withstand the high pressure of hydraulic fracturing without losing casing integrity ► The risk is more acute for communication with older wells ► As a matter of good engineering, companies will evaluate the integrity of older or abandoned wells near where they are fracturing	**O17:** Requirements to evaluate the integrity of nearby wells, either active or abandoned, prior to hydraulic fracturing would protect against contamination of freshwater due to conduits created by other wells
		7.1.3.4	Natural pathways	Natural fractures and faults are conceptually the only non-anthropogenic mechanism for movement of contaminants through low permeability rock. Migration of contaminants, particularly dissolved hydrocarbon gases, from below to the fresh groundwater zone (FGWZ) along natural fractures and faults is a hypothetical possibility; it has not been scientifically analyzed or assessed. If the fractures extend from a hydraulically fractured well intersect with a natural fault, it is theoretically possible that a pathway for contaminants to move between subsurface zones could emerge. There is a risk that connecting to a natural fracture during the hydraulic fracturing process could allow gas or liquid to migrate into the FGWZ. The risk decreases as the depth of hydraulic fracturing increases; deep hydraulic fracturing does not pose a scientifically acknowledged risk of groundwater contamination from below. The Canadian Council of Academies accepts that, at depths greater than one kilometer below the surface, "there is no method by which a fracture is going to propagate through the various rock layers and reach the surface".	X				OGAA ► Section 37 prohibits spillage of harmful substances and outlines the reporting, containment, elimination, and remediation requirements in the event of a spill. Accordingly, it regulates contaminants entering fresh water aquifers					► The Canadian Council of Academies accepts that, at depths greater than one kilometer below the surface, "there is no method by which a fracture is going to propagate through the various rock layers and reach the surface"	► Given the largely theoretical nature of the risk of contamination from below along natural pathways, no evidence-based opportunities have been identified
		7.1.3.5	Disposal of flowback water in deep wells	Currently in B.C., companies are prohibited from disposing of flowback water on land or in bodies of water, regardless of any treatment it may undergo. Accordingly, the de-facto method for disposing of flowback water that will not be reused is injection into deep disposal wells within the earth (permeable, porous formations capable of holding and containing large volumes of water and other fluids). These wells are often depleted oil and gas reservoirs and can be shallower than production wells, but are deeper than fresh water aquifers. The industry is currently reusing flowback water for additional hydraulic fracturing operations; however, the flowback water must eventually be disposed of. Regulations governing disposal wells are in place to protect groundwater quality.	X				Environmental Management Act ► Allows the Commission and the Ministry of the Environment to regulate the disposal of other non-hazardous materials in disposal wells through a permitting process Oil and Gas Activities Act (OGAA) ► Section 75 allows the Commission to regulate oil and gas activities as "special projects"	Drilling and Production Regulation ► Section 51 prohibits flowback water from being disposed of in surface or groundwater ► Section 74 requires that disposal well operators record the volume of fluid injected into the well Oil and Gas Act General Regulation ► Section 10 specifically prescribes disposal of flowback water into disposal wells as a special project under section 75 of OGAA Oil and Gas Waste Regulation ► Explicitly enumerates the oil and gas waste that can be disposed of on the ground. Flowback water is not included in that list	Special project permit conditions ► Dictates the injection pressure, and total pressure of fluid that can be injected into the well ► Provides requirements for ensuring and testing wellbore and casing integrity ► Dictates additional notification and reporting requirements	Application Guideline ► Dictates the activities that must be completed and information that must be submitted with a permit application ► Ensures that the integrity of wells within a 5km radius is taken into consideration when permit decisions are made Water Source, Injection and Disposal Service Wells Summary ► Provides further clarification around the requirements for wellbore integrity testing, injectivity testing, seismicity measurement, notification and reporting, and packer isolation testing	CAPP Operating Practices ► Encourages operators to dispose of all spent fluid and flowback water in a safe and legal manner	► The risks around deep disposal wells are fairly well known and understood ► The regulatory framework addresses each of the major contamination vectors ► In addition to regulatory requirements specific to disposal wells, these wells are also subject to the same regulatory requirements around construction and integrity as production wells ► The operation of a well for disposal service is subject to a through application and review process by professional engineers and geologists ► Disposal wells are subject to rigorous operating, monitoring, testing and reporting requirements as conditions of individual approvals, appropriate to the specific circumstances	**O18:** Baseline and ongoing testing of water quality near disposal wells is currently done on a case-by-case basis using permit conditions. Including these requirements in regulation and applying them more broadly would provide an additional tool to measure compliance with results-based regulatory requirements

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					Environment	Public safety	Economic fairness	Resource conservation							
Induced Seismicity	**Induced seismicity due to hydraulic fracturing**	7.2.1		During the hydraulic fracturing process, thousands of microseismic events occur as the rock is fractured. These events are typically between magnitude -3.0 to 0.5. Some higher magnitude events, ranging from magnitude 1.0 to magnitude 4.4 and linked to fluid injection during hydraulic fracturing have been recorded. Since January 2013, approximately 15 of these events were large enough to be felt on the surface and have begun to give rise to public concern over the risk for human safety and infrastructure integrity.	X	X					Well operations permit conditions ► Require that the Commission be notified if an earthquake measuring greater than magnitude 4.0 is recorded or if any seismicity is felt on the surface within a 3km radius of the drilling pad and further, if that well is identified as the cause, operations in the identified wellbore must be suspended ► Suspended operations may only continue after a mitigation plan is created, approved and adopted		CAPP Operating Practice ► Appropriately evaluate wellbore placement and drilling design to account for geologic conditions ► Communicate and prepare onsite personnel for the possibility of anomalous induced seismicity ► Have procedures established to monitor for induced seismicity ► Have procedures to mitigate and respond to anomalous induced seismicity	► Permit conditions outlining notification and suspension requirements and are added to every permit ► Current initiative: the BCOGC is considering adding seismicity conditions into the Drilling and Production Regulation	**O19:** Regulation of induced seismicity caused by hydraulic fracturing is currently done through permit conditions. There is an opportunity to improve transparency and effectiveness by moving these requirements into regulation to be more consistently applied and enabling access to a broader set of C&E tools
	Induced seismicity due to deep well disposal	7.2.2		Produced water is injected into disposal wells at a pressure below the threshold for creating fractures in the rock. There is some risk that this sustained, high-pressure injection of fluid into wells could result in induced seismic events that could lead to injury or property damage on the surface. There is also the potential that a seismic event could damage the integrity of other wells in the area.	X	X	X	X			Well operations permit conditions ► Require that the Commission be notified and that fracturing operations be suspended if an earthquake measuring greater than magnitude 4.0 is recorded or if any seismicity is felt on the surface within a 3km radius of the drilling pad Special project permit conditions ► Dictates the volume, injection pressure, and total pressure of fluid that can be injected into the well			► Two disposal wells in Northeast B.C. are known to be causing seismic events. ► The Canadian Council of Academies notes that more than 140,000 disposal wells have been drilled in the United States with very few seismic issues ► In addition to the notification and suspension permit conditions placed in all well permits, disposal wells are also required to maintain pressure below the level that would result in hydraulic fracturing	**O20:** Regulation of induced seismicity caused by injection wells is currently done through permit conditions. There is an opportunity to improve transparency and effectiveness by moving these requirements into regulation to be more consistently applied and enabling access to a broader set of C&E tools
Quality of Life	**Surface footprint**	7.3.1		Shale gas development requires high density wells spacing to efficiently develop a resource which creates a substantial surface footprint. Since land is an asset to British Columbians, its use is important from two perspectives: the opportunity cost of other uses such as recreational space for the community; and the impact on the surrounding habitat. In 2013, the BCOGC reported that 2.14 percent of the land in north east B.C. is used for oil and gas activities.	X		X	X	Oil and Gas Activities Act ► Gives the Commission the authority to issue temporary land use permits or long-term land use licenses under the Land Act and to permit or deny the use of certain areas under the Heritage Conservation Act Land Act ► Sections 11 and 38 allow the BCOGC to issue long-term leases of Crown land and attach terms and conditions ► Sections 11 and 39 allow the BCOGC to issue long-term licenses to Crown land and attach terms and conditions ► Section 14 allows the BCOGC to issue short term permits to use Crown land for up to two years Heritage Conservation Act ► Gives the Commission the ability to permit or deny the use of areas of land that are considered heritage property in B.C. Water Act ► Section 9 gives Regional Water Managers the authority to authorize changes in an about a stream. A person or company may only make changes in an about a stream in accordance with an approval under section 9	Environmental Protection and Management Regulation ► Governs several aspects of land use, including location of activities relative to bodies of water, preservation of natural range barriers for livestock, activities in culturally protected areas and old growth management areas, and location of activities relative to wildlife and their habitat ► Section 19 outlines oil and gas site restoration requirements				► Regulation of surface footprint has historically been on a well-by-well basis ► The Commission has recently been investigating incorporating "area-based analysis" in its land use permitting processes in order to incent companies to use land more efficiently	► No opportunities within the scope of this report have been identified
	Increased traffic	7.3.2		Hydraulic fracturing requires that tens of thousands of cubic meters of fluids, chemicals, and proppant be transported to and from the well pad. Currently, the bulk of this material is transported by truck, resulting in significant traffic. This traffic presents a risk of damage to local infrastructure as well as a risk of community disturbances and an increased risk of motor vehicle incidents.				X	Motor Vehicle Act ► The primary piece of legislation governing activities on roads in British Columbia					► The Commission does act as a liaison between the public and industry, and works closely with industry to help resolve complaints from residents in northeast British Columbia ► Many oil and gas companies have also begun to take proactive steps to limit traffic during times when children are traveling to and from school and to implement road dust management strategies along certain roads	► No opportunities within the control of the BCOGC have been identified
	Operational disturbances	7.3.3		Well drilling, hydraulic fracturing, and other related operational activities can cause temporary disturbances to surrounding neighbours in the form of lights, noise, odors and ground level air quality.	X	X				Drilling and Production Regulation ► Section 5 outlines the separation distances required between oil and gas activities and other infrastructure ► Section 40 requires that operators not make excessive noise Consultation and Notification Regulation ► Outlines the requirements for consulting and notifying different classes of people		School exclusion zone policy ► The Commission does not approve permit applications to drill a well within one kilometer of a school British Columbia Noise Control Best Practices Guideline ► Provides guidelines for noise impact assessment, noise management, and noise complaint handling		► While the Drilling and Production Regulation does outline minimum separation distances, at the time when these requirements were brought into force, the oil and gas industry in the province was largely drilling conventional wells. A conventional well pad might see three to four weeks of drilling, by contrast, the large increase in size and density of unconventional well pads is resulting in drilling and fracturing periods that can stretch for six months or longer	**O21:** Light emissions, fumes from diesel engines and other air quality issues such as ground level ozone are currently addressed through industry best practice, but given that this is an emerging issue, there is an opportunity to consider increased guidance/permit conditions/regulations in cases where hydraulic fracturing occurs near occupied buildings or populated areas **O22:** There is an opportunity to improve awareness related to the use of minimum separation requirements (setbacks) in decision-making
Additional Opportunities	**Microseismic monitoring data**	7.4.1		Microseismic analysis is necessary to prove that the fractures are staying in the deep zones, which is necessary for maintaining public confidence in the Commission's oversight of hydraulic fracturing operations in the province. The data from microseismic monitoring can also provide information about poor recovery in a reservoir. If this information is not shared, it is difficult to continuously improve and ensure that B.C.'s natural gas resources are being extracted efficiently.	X		X	X							**O23:** Requirements to collect and submit microseismic monitoring data around hydraulic fracturing activities would allow the BCOGC to better understand the behavior of hydraulic fracturing in different formations, maintain confidence that fractures are not migrating outside of their intended zones, and support efficient resource extraction by encouraging industry adoption of best practices

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