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Improving the Regulation of Fracking Wastewater Disposal in BC

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INTRODUCTION

The Fort Nelson First Nation (FNFN) recently asked the University of Victoria Environmental Law Centre to develop recommendations for reform of BC's laws governing disposal wells for fracking wastewater. This report is the result.

The Nation's territory encompasses three of the province's four major shale gas plays, the prime sources of BC natural gas. Extensive gas fracking operations already exist in this area; however, the FNFN expect BC LNG development will lead to a 600% increase in fracking operations in their territory in the near future.

The FNFN is concerned about the impacts of fracking activity in their territory on groundwater and human health. Fracking operations use massive amounts of water that are contaminated with a variety of toxic substances. Operators dispose of flowback water and produced water from fracking operations into underground disposal wells. These wells are typically old wells whose integrity and operation are poorly monitored. Because the quality of the seal placed on such wells can degrade over time, there are concerns that these wells may contaminate aquifers used for drinking water, as well as the surface water systems the aquifers connect to.

Therefore, the FNFN asked us to address the following questions:

- How are fracking wastewater disposal wells currently regulated in BC?
- What regulatory best practices exist in other jurisdictions and authorities?
- How can these best practice examples be incorporated into BC disposal well regulations to better protect health and the environment?

This memo is divided into four parts. The first part of the memo tersely identifies the key broad legal issues. The second part provides an overview of the current regulatory framework governing disposal wells in BC. This part also briefly discusses concerns raised by the history of lax disposal well regulation – and the fact that most waste water has been injected into very old wells that may be subject to failure. The third part of this memo provides four "best practice" case studies from the International Energy Agency, the Canadian Association of Petroleum Producers, the United States and Natural Resources Defence Council, and the European Commission. The fourth and final part of the memo is perhaps the most important. It synthesizes the best practice case studies to make key recommendations to strengthen the BC regulatory framework and better protect environment and health.

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Part I: Preliminary considerations

1.1 Issues

We have identified the following issues:

1. How does BC currently regulate fracking wastewater disposal wells?

2. What regulatory best practices for disposal wells exist from other jurisdictions and authorities?

3. What key principles can we derive from best practice examples to strengthen BC's regulatory framework for disposal wells?

Part II: Regulation of disposal wells in BC

This part provides an overview of how disposal wells are currently regulated in BC. It is divided into four sections. The first section gives a general overview of how fracking wastewater is produced, BC's method of disposing of wastewater in underground disposal wells, and concerns associated with wastewater disposal in underground wells. The second section provides an overview of the current regulatory framework for BC disposal wells. The third section describes the lax early regulation of disposal wells in BC, and the concerns raised by the current use of disposal wells that were built and operated under those lax historical standards.

2.1 General overview of the production and disposal of fracking wastewater, and associated concerns

The fracking process produces large quantities of wastewater that can be disposed of in a variety of ways. This section aims to give a general overview of the production and disposal of fracking wastewater, and includes:

- A description of how fracking produces flowback water and produced water, collectively known as fracking wastewater;
- A brief overview of the different methods used to dispose of fracking wastewater: notably, BC uses only the disposal well method;
- A brief discussion of concerns associated with disposal of wastewater in underground disposal wells.

Hydraulic fracturing and the production of wastewater

Hydraulic fracturing, or "fracking," is a method industry uses to increase the flow of hydrocarbons in a natural gas well. It is typically used to increase production of "unconventional" types of gas like shale gas, because gas from shale formations does not flow as freely as conventional sources of gas.[1] Fracking was developed in the 1940s; however, the last twenty years have seen a massive increase in shale gas production due to the development of hydraulic fracturing technology, and technological advances that enable horizontal well drilling.[2] Fracking involves

[1] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 12.

[2] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 12; see also International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy*

injecting a fluid, known as fracking fluid, through wells and down into the rock formation at high pressures.[3] Fracking fluid is a mixture of chemical additives and proppant (particles like sand or ceramic beads).[4] This pressurized injection of fracking fluid creates small fissures in the target rock beneath the well. If left alone, these fissures would eventually close – however, the proppant particles help "prop" the fissures open to allow more natural gas to flow from the target rock into the well.[5]

The process of hydraulically fracturing a well using a repeated, multi-stage process can use between a thousand and twenty thousand cubic metres of water (one million to five million gallons).[6] Once the operator injects the fracking fluid into the well and releases the pressure, some of the injected fracking fluid will flow back up the well as "flowback water." This "flowback water" will continue to return for about ten to fourteen days, until the well begins producing natural gas.[7] However, the majority of fracking fluid stays in the well – between 80% and 50% of the fluid stays bound to clays in the rock; the total amount varies with the composition of the formation.[8]

Once the well begins producing gas, water will continue to come out of the well along with the emerging gas.[9] This wastewater is referred to as "produced water." Produced water is a mixture of water; chemicals from the fracking process; metals, minerals, and hydrocarbons from the target rock; and very old water also present in the target zone and in bedrock formations above or below it that may be highly saline and contain naturally occurring radioactive material (NORM).[10]

The main difference between the two types of water is that flowback water occurs at the beginning of the process and its composition is primarily determined by the chemicals used in the fracking operation; produced water occurs after the well has begun producing gas and its composition is influenced by the geochemistry of the shale gas formation.[11] Both flowback water and produced water may cause serious harm to people and the environment if spilled or disposed of improperly.[12]

This subsection defined the two types of wastewater to avoid confusion in terminology. However, it important to note that in practice, the two are often managed the same way. In addition, flowback water is technically considered

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Outlook Special Report on Unconventional Gas, online: <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 24, 25.

[3] International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*, online: <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 25, 26.

[4] International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*, online: <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 25, 26.

[5] International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*, online: <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 26.

[6] International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*, online: <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 27, 30.

[7] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 13.

[8] International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*, online: <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 27, 32.

[9] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 13.

[10] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 3, 13.

[11] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 13.

[12] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 13.

a type of produced water, and both types of water may be referred to as "produced water." Therefore, in this paper both produced water and flowback water are referred to simply as "wastewater."[13]

Disposal of wastewater

The safe disposal of wastewater is an essential consideration given the massive amounts of contaminated water fracking produces, and the harm this wastewater can cause to people and the environment if disposed of improperly.

Initially, wastewater is often stored in ponds or other containment vessels at the fracking site.[14] Wastewater may be transported from these ponds to further wastewater management options via pipelines or trucks.[15] It should be noted that, although outside the scope of this memo, such wastewater ponds can also pose serious environmental hazards if a spill or tear in the lining occurs and contaminates soil or water; transportation methods such as pipelines and trucks may also have associated environmental hazards if there is a rupture or spill.[16] In a recent communication with Scott Anderson, the US Environmental Defence Fund's Senior Policy Advisor, US Climate and Energy Program, Mr. Anderson gave us a list of fracking wastewater disposal well issues that merit close attention (though these issues are mentioned throughout the document, for a complete list, see Appendix B). One key issue was whether there are sufficient safeguards against surface leaks and spills at these well sites (for example from truck accidents; lack of proper liners under ponds; or lack of proper leak detection with regard to ponds.)[17] This may be an important area for future research.

Following storage, there are four ways industry typically disposes of fracking wastewater in North America: recycling it for further use; treating it at an industrial waste facility and then discharging it into local water sources such as rivers; injecting it deep underground; and "beneficial reuse" as a dust control or de-icing agent on roads.[18] For a detailed analyses of the advantages and drawbacks of these various methods of fracking wastewater disposal, you may wish to consult the Natural Resources Defence Council's 2012 report "*In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater.*"[19]

In BC, companies are prohibited from disposing of wastewater in water bodies or on land.[20] This precludes treatment options that may be used in other parts of the world such as treatment and discharge to surface water systems. Therefore, BC disposes of produced water in underground disposal wells.[21]

Concerns about underground disposal of wastewater

There are numerous concerns about disposal of wastewater in underground wells. For example, there is concern that spills of wastewater at the surface will lead to water contamination; that fluids will leak through improperly sealed

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[13] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 13.

[14] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 56.

[15] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 56-58.

[16] Lauren Williams, "Wastewater Impoundments 101" (Powerpoint and Presentation delivered at the Public Interest Environmental Law Conference, University of Oregon School of Law, 1 March 2014), [unpublished].

[17] Email communication with Scott Anderson, Senior Policy Advisor, US Climate and Energy Program, EDF (31 March, 2014).

[18] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 5; see also International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*, online: IEA - Goldenrules <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 33.

[19] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf>.

[20] *Drilling and Production Regulation*, BC Reg 282/2010, s 51.

[21] *Oil and Gas Waste Regulation*, BC Reg 254/2005, s 7(1).

cement columns surrounding the well's casing into shallow aquifers; or that wastewater from the deep rock layer will move into shallow aquifers and surface water systems by travelling through the rock between the two.[22] These concerns make it vital that disposal wells are properly constructed, maintained, and that there is adequate monitoring throughout the lifetime of the well.

There are also concerns that hydraulic fracturing and disposal well injection may increase the potential for earthquakes.[23] Hydraulic fracturing creates cracks in the target rock, and this typically generates small seismic events. For example, a recent OGC report noted events of up to 3.8 on the Richter scale in the Horn River Basin; such events were recorded from 2009-2011 when operators were fracking at even lower pressures than they are now.[24] Disposal well injection occurs at lower pressures: therefore, while disposal operations may also induce seismicity, such seismic events are usually too small to be detected at the surface.[25] However, if wells or fractures intersect with and reactivate existing deep faults, it can cause a larger seismic event. This happened recently with the Cuadrilla shale gas operations in the UK, which triggered two earthquakes.[26] Finally, while induced seismicity itself is troubling, seismic events are also relevant to wastewater disposal – earthquakes may result in the creation of more fractures in deep bedrock horizons, generating new pathways for wastewater to move between layers of rock.[27]

To sum up, this section has provided an overview of how fracking wastewater is produced, discussed fracking wastewater disposal methods, and noted that BC only disposes of fracking wastewater in underground disposal wells. It also discussed concerns associated with the disposal well method.
The next section discusses how disposal wells are currently regulated in BC.

2.2 How BC currently regulates disposal wells

In BC, the bulk of disposal well regulation occurs at the permitting stage. Following permitting, there appear to be minimal regulatory requirements. This section describes how disposal wells are permitted and regulated.

The first subsection below describes the legislation, guidelines, and procedures that govern disposal wells. The second subsection discusses disposal well permitting. The third and final subsection outlines conditions for additional monitoring that may be attached to disposal well permit approvals.

The legislation, guidelines, and procedures that govern disposal wells in BC

In BC, the legislation and regulations that govern disposal wells are the *Oil and Gas Activities Act*[28] and two regulations made pursuant to this act: the *Environmental Protection and Management Regulation,*[29] and the *Drilling and Production Regulation.*[30] The *Oil and Gas Waste Regulation*,[31] made pursuant to the *Environmental Management Act*,[32] is also relevant.

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[22] International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*, online: IEA - Goldenrules <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 36.
[23] International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*, online: IEA - Goldenrules <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 26.
[24] BC Oil and Gas Commission, *Investigation of Observed Seismicity in the Horn River Basin, August 2012,* online: <http://www.bcogc.ca/node/8046/download>; Note that while operators fracked at 50 MPa during 2009-2011, they are now fracking at even higher pressures (approximately 65 MPa); Email communication with Dr. Gilles Wendling, President of GW Solutions, (17 April, 2014).
[25] International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*, online: IEA - Goldenrules <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 26.
[26] International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*, online: IEA - Goldenrules <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 26.
[27] Email communication with Dr. Gilles Wendling, President of GW Solutions, (17 April, 2014).
[28] *Oil and Gas Activities Act,* SBC 2008, c 36.
[29] *Environmental Protection and Management Regulation,* BC Reg 200/2010.
[30] *Drilling and Production Regulation*, BC Reg 282/2010.
[31] *Oil and Gas Waste Regulation,* BC Reg 254/2005.
[32] *Environmental Management Act,* SBC 2003, c 53.

There are also Oil and Gas Commission (OGC) and BC Ministry of Environment (MOE) guidelines and procedures regarding disposal wells. These include the MOE Procedure for Authorizing Deep Well Disposal of Wastes ("MOE Procedure") and the OGC Application Guideline for: Deep Well Disposal of Produced Water/Non-Hazardous Waste ("OGC Application Guideline").[33]

[Preliminary Note: The MOE Procedure may appear somewhat confusing because it uses the terminology "Class 1b" and "Class 1a" wells, specifically stating that "Class 1b wells means deepwell disposal wells used for the disposal of produced water, specific common oilfield waste streams, and waste streams meeting specific criteria; and constructed and operated in accordance with the requirements for class 1b wells as specified by the Oil and Gas Commission." This is notable because the language "Class 1b" and "Class 1a" is not used anywhere else, including Oil and Gas Commission guidelines.

However, in a phone interview, a MOE representative stated that this terminology is outdated, and the MOE Procedure simply has not been updated to reflect the change. When the procedure was first put in place in 1996, it attempted to mimic procedures from Alberta, including their language about classes of wells. This language is no longer used, and the criteria for what once would have been called "Class 1b wells" is actually the criteria for disposal well permitting set out in the OGC Application Guideline.[34]]

The permitting process for disposal of produced water

In BC, companies cannot dispose of wastewater into water bodies or on land.[35] This means they cannot pursue treatment options that may be used in other parts of the world, such as sending wastewater to municipal treatment plants then discharging it into rivers and streams. Instead, BC disposes of produced water in underground disposal wells.[36]

In general, there are some wastes that can be injected into disposal wells, and others that cannot. Wastes that can be injected into disposal wells include produced water and non-hazardous wastes, both of which are further defined in the OGC Application Guideline.[37] A complete list of wastes that cannot be disposed of in disposal wells is found in the MOE Procedure and includes wastes such as municipal sewage, lube oils or diesel invert drilling fluids, and hazardous wastes. However, the MOE Procedure states that it may be possible to dispose of hazardous waste via underground injection if it meets the criteria set out in Section 3.5 of the MOE Procedure; this would require an exemption from section 37 of the BC *Hazardous Waste Regulation* that prohibits disposal of hazardous waste by underground injection.[38]

Depending on what is disposed of in the well, either the MOE or the OGC issues the necessary *Environmental Management Act* permit that operators require to begin disposal operations.[39] If the operator is only using the disposal well for fluids generated by their own operations, the OGC handles the necessary permit under the *Environmental Management Act*.[40] This is the most common option for produced water disposal wells.[41]

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[33] BC Ministry of Environment, *Procedure for Authorizing Deepwell Disposal of Wastes*, online: British Columbia: Environment <http://www2.gov.bc.ca/gov/topic.page?id=CC13CEECAEAF48F0BF4DA4314F5690A3&title=Oil%20and%20Gas>; BC Oil and Gas Commission, *Deep Well Disposal of Produced Water / Non-Hazardous Waste Application Guideline*, online: BC Oil and Gas Commission <https://www.bcogc.ca/deep-well-disposal-produced-water-non-hazardous-waste-application-guideline>.
[34] Phone conversation with representative from BC Ministry of Environment, (21 March, 2014).
[35] *Drilling and Production Regulation*, BC Reg 282/2010, s 51.
[36] *Oil and Gas Waste Regulation*, BC Reg 254/2005, s 7(1).
[37] Produced water is defined to include recovered fluids from well completion or workover operations (including flowback fluids from fracture stimulations); Non-hazardous waste covers waste materials that are not classified as "hazardous" under the Hazardous Waste Regulation, for example boiler blowdown water, tank wash water, rig wash, spent glycols, and drilling waste leachate; for more information, see the OGC Application Guideline.
[38] *Hazardous Waste Regulation,* BC Reg 63/88, s 37.
[39] BC Oil and Gas Commission, *Deep Well Disposal of Produced Water / Non-Hazardous Waste Application Guideline*, online: BC Oil and Gas Commission <https://www.bcogc.ca/deep-well-disposal-produced-water-non-hazardous-waste-application-guideline>.
[40] BC Oil and Gas Commission, *Deep Well Disposal of Produced Water / Non-Hazardous Waste Application Guideline*, online: BC Oil and Gas Commission <https://www.bcogc.ca/deep-well-disposal-produced-water-non-hazardous-waste-application-guideline>.
[41] Phone conversation with representative from BC Ministry of Environment, (21 March, 2014).

However, if the disposal well accepts third party waste, the MOE must administer the *Environmental Management Act* permit.[42] In practice, the MOE almost exclusively issues the permits for non-hazardous waste wells because they fall under the category of disposal wells that accept third party wastes.[43]
They fall into this category because in practice, most companies do not want to build and operate disposal wells for non-hazardous waste. These wells are expensive and difficult to construct and operate properly, so this type of disposal is usually outsourced to commercial companies that operate non-hazardous waste disposal wells. Since these commercial wells accept wastes from various parties, that qualifies as accepting third party waste, and the MOE administers the permit.[44]

The permitting application for disposal well approval is treated as a Special Project under s. 75 of the Oil and Gas Activities Act.[45] This application needs to include the following information (what follows is a summary of a more detailed list found in the OGC Application Guideline):[46]

- Well name and location
- Well permit number, and general drilling, completion and activity history
- Maps showing tenure and registered owners in the disposal formation within a 3 km radius of the proposed well, and status and completion zones for wells within 3 km of the proposed well
- Information about the geology and reservoir history, including information about the geology and rock properties of the reservoir formation, details of any aquifers, and information about the producing history of the proposed disposal well and any other wells in the same pool
- Information about disposal operations such as initial reservoir pressure and other pressure values, calculations of maximum allowable wellhead injection pressure, details of the expected injectivity performance and well life, a proposed well testing schedule to monitor reservoir pressure in the disposal formation, the radius and shape of the injection migration plume based on geology and other factors, an analysis of water in the disposal formation, an analysis of the water to be disposed of, including a description of sources and compatibility, a diagram of the proposed disposal well, and results of wellbore integrity testing including evidence of hydraulic isolation of the disposal zone
- Written statements from subsurface tenure owners who may be affected, indicating their reaction to the proposed water-disposal scheme

The OGC Application Guideline also states that while not required at present, "pro-active monitoring of penetrated shallow aquifers is recommended practice… and it is advisable to include a monitoring plan in the application."

Approvals and requirements for continual monitoring

Disposal well approvals are granted by the OGC under Section 75 of the *Oil and Gas Activities Act*.[47] The disposal well approval order contains additional conditions that must be met. The OGC policy document "Water Source, Injection, and Disposal Service Wells" lists the requirements in detail, which may be summarized as:[48]

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[42] BC Oil and Gas Commission, *Deep Well Disposal of Produced Water / Non-Hazardous Waste Application Guideline*, online: BC Oil and Gas Commission <https://www.bcogc.ca/deep-well-disposal-produced-water-non-hazardous-waste-application-guideline>.
[43] Phone conversation with representative from BC Ministry of Environment, (21 March, 2014).
[44] Phone conversation with representative from BC Ministry of Environment, (21 March, 2014).
[45] *Oil and Gas Activities Act,* SBC 2008, c 75.
[46] BC Oil and Gas Commission, *Deep Well Disposal of Produced Water / Non-Hazardous Waste Application Guideline*, online: BC Oil and Gas Commission <https://www.bcogc.ca/deep-well-disposal-produced-water-non-hazardous-waste-application-guideline>.
[47] BC Oil and Gas Commission, *Deep Well Disposal of Produced Water / Non-Hazardous Waste Application Guideline*, online: BC Oil and Gas Commission <https://www.bcogc.ca/deep-well-disposal-produced-water-non-hazardous-waste-application-guideline>.

- The disposal injection pressure should not exceed the formation fracture pressure
- There is a limit on the maximum formation pressure a disposal well may reach
- There is a requirement for annual bottom hole pressure testing, which is a way of measuring pressure in the well reservoir to confirm that additional disposal is possible, confirm the well has not reached its maximum formation pressure, and forecast the remaining well life
- For existing wells, all potential hydrocarbon bearing zones and the disposal zone must be isolated by cement. A full-length casing inspection log is required for any existing well converted for disposal service
- New wells drilled for the purposes of disposal must ensure that: surface casing is 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; furthermore, hydraulic isolation must be established between all porous zones
- Operators must carry out a pressure integrity test before beginning operations
- During operation, operators must conduct annual packer isolation tests in accordance with section 16(3) of the *Drilling and Production Regulation*[49]
- The approval Order may require operators to submit additional information to the Commission to confirm the well remains suitable for continued service use. This information may include wellbore logging of casing integrity, cement bond and temperature, and the Order would specify how often the company should provide this additional information

In addition to any approval order requirements, the *Drilling and Production Regulation* requires that operators must, on a monthly basis, monitor and report the volume of fluid injected.[50] Operators must also make monthly reports of total injection hours and maximum wellhead pressure.[51]

Notably, there are no requirements for operators to conduct baseline testing of water systems surrounding the well, or conduct on-going monitoring of these water systems. There are also no requirements to monitor or disclose the quality or characteristics of the fluid being disposed of in the well.

In addition, it seems companies may not be complying with the annual packer isolation test requirement. During an interview, an Oil and Gas Commission engineer stated annual packer isolation tests are their main way of ensuring wells remain suitable for disposal activities.[52] The OGC monitors testing compliance by having field inspectors examine on-site packer isolation test reports when they make site visits; the OGC also requires companies to submit a report on packer isolation test results when new disposal approvals are issued or existing well approvals are amended.[53] However, in a verbal conversation the Oil and Gas Commission engineer stated that the OGC is currently reviewing all 110 active disposal wells in BC to determine the last time each company did this test.[54] This does not necessarily mean companies have not been complying with the test: however, once the OGC has finished collecting this data, it will be interesting to carefully examine the data to determine whether all companies have conducted this test on a regular basis.

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[48] BC Oil and Gas Commission, *Water Source, Injection, and Disposal Service Wells,* online: BC Oil and Gas Commission <https://www.bcogc.ca/node/5997/download>.
[49] *Drilling and Production Regulation*, BC Reg 282/2010, s 16(3).
[50] *Drilling and Production Regulation*, BC Reg 282/2010, s 75.
[51] BC Oil and Gas Commission, *Water Source, Injection, and Disposal Service Wells,* online: BC Oil and Gas Commission <https://www.bcogc.ca/node/5997/download> at 9.
[52] Phone conversation with representative from OGC Reservoir Engineering, (24 February, 2014).
[53] Email conversation with representative from OGC Reservoir Engineering, (7 March, 2014).
[54] Phone conversation with representative from OGC Reservoir Engineering, (24 February, 2014).

As a final comment, please note it is possible to access disposal well permit applications online,[55] as well as disposal well approvals[56] and data on disposal volumes and wellhead pressures.[57]

To summarize, this section discussed how disposal wells are regulated in BC. It noted that disposal well permitting requires more information than on-going monitoring. Following disposal well permitting, the main parameters operators are required to monitor and disclose are disposal volumes, injection hours, and maximum wellhead pressure. This section also discussed the fact that important aspects of disposal wells are not regulated: operators are not required to record and report the characteristics of the fluid that is injected, or conduct baseline testing or on-going monitoring of water systems near the well.

The next section discusses the fact that the regulatory regime for disposal wells in BC has evolved over time; many wells are old, and date back to a time when there was poor regulation of disposal wells.

2.3 The history of disposal well regulation in BC

It is important to consider the history of disposal wells in BC, because information about current regulations does not tell us the whole story about these disposal wells. Many of the wells in BC are very old. A recent study of disposal wells in BC (see Appendix A) illustrates this fact.[58] Figure 1 of Appendix A shows the locations of disposal wells in BC. Figure 2 shows the number of wells used for disposal by drilling date, and Figure 3 shows how much waste has been injected for wells drilled in each decade. Figure 4 highlights the fact that the majority of wastewater (60%) has been injected into old wells (wells that are more than 43 years old).

The study highlights one well – well #2240 – that was used to dispose of wastewater as early as 1968 (see Figure 5). This means that today, this well is about 46 years old.[59] Approximately 16,693 OSP (Olympic swimming pools) – 41 billion litres -- of water have been injected into this one well over the last 46 years. This well is both the oldest well discussed in the study, and the well that has been injected with the most fluid – over six times as much as the next-largest well. The amount injected into well #2240 represents 39% of all the wastewater injected into disposal wells in BC. Because wastewater is not tracked after disposal, the fate of this massive quantity of wastewater is unknown. Yet the amount disposed of in this single well is equal in volume to 24 towers the size of the 9/11 World Trade Center Towers.[60]

Current disposal well regulation in BC is clearly inadequate; however, in the past there was even less regulation of disposal wells. For example, at the time well #2240 began operations, there were very few regulations regarding disposal wells. To provide a "snapshot" in time, in 1968 when well #2240 began operation, the regulatory framework for natural gas wells was as follows:

- The *Gas Utilities Act*[61] and the *Petroleum and Natural Gas Act*[62] were the main acts regulating the petroleum and natural gas industries at this time. To give you an idea of what these acts contain, a 1976 text produced by West Coast Environmental Law candidly remarks, "these statutes have no provisions relating directly to the environment."[63]
- The *Gas Utilities Act* dealt mainly with expropriation of land for gas utility companies. Therefore, of the two statutes, the only applicable legislation for natural gas wells was the *Petroleum and Natural Gas Act*.

[55] There is no digital database for this information: you must request it from the OGC Records Centre.
[56] BC Oil and Gas Commission, *Reservoir Engineering Approvals,* online: <http://bcogc.ca/industry-zone/engineering-approvals>.
[57] This data can be accessed by going to the OGC website, then Web Applications, then Data Downloads, then Drilling Data for all wells in BC, then water_disposal.csv (account set-up required).
[58] GW Solutions, 2014, [Data analysis regarding fracking wastewater disposal wells in BC], unpublished data files.
[59] GW Solutions, 2014, [Data analysis regarding fracking wastewater disposal wells in BC], unpublished data files.
[60] Email and phone communication with Dr. Gilles Wendling, President of GW Solutions (28 April, 2014)
[61] *Gas Utilities Act,* RSBC 1960, c 164.
[62] *Petroleum and Natural Gas Act*, *1965,* RSBC 1960, c 280.
[63] John Ince, *Environmental Law: A Study of Legislation Affecting the Environment of British Columbia*, (Vancouver, BC: University of British Columbia Centre for Continuing Education, 1976) at 76.

- The *Petroleum and Natural Gas Act* had few provisions dealing with natural gas wells and disposal of wastewater. The provisions that dealt with natural gas wells required that a person have a valid well authorization before beginning to drill or operate a well.[64] They also required that the application for the well authorization include the applicable fee, accurate identification of the location where the well was to be drilled, and include a proposed programme of drilling operations.[65] The *Act* also included a requirement for a "Well Register" that was to include information on the names of wells, changes made to them, their location, the well authorization number, the name of the person to whom the well authorization was issued, and the name of the drilling contractor.[66] Finally, the *Act* allowed the Chief of Branch to make an order requiring produced water to be disposed of in an underground formation.[67]
- Despite extensive powers to make regulations, including regulations regarding drilling operations, pollution prevention from wells into surrounding water systems, and minimum standards for well construction, there were no regulations made pursuant to this *Act* as of 1968.[68]

Therefore, it appears there were few requirements for natural gas wells at this time, and no requirements for disposal of produced water. The lack of previous regulation is concerning because many old wells are currently in operation today; indeed, as discussed above, the majority of wastewater has been injected into old wells. Age is a factor in well integrity because the tube of cement casing surrounding disposal wells can degrade over time, creating a potential risk of leaks into surrounding layers of rock or aquifers.[69] This is of special concern because of the potential for disposal wells and hydraulic fracturing wells to cause earthquakes – if the well already has a degraded seal, it seems logical that additional seismic activity would increase the risk of a leak.[70]

Currently the Oil and Gas Commission addresses well integrity by requiring wells be isolated by cement as a requirement of the permitting process, and requiring that operators conduct a "packer isolation test" every year.[71] The packer isolation test is a test to ensure hydraulic isolation of the well – basically, good integrity of the seal.[72] During an interview, an Oil and Gas Commission engineer stated that this is their main way of ensuring that wells remain suitable for disposal activities.[73]

However, if companies are not complying with the requirement to regularly test the seals, seals that were acceptable at the permitting stage could have continued to degrade with no one knowing about it. And we do not know the rate of compliance. The Oil and Gas Commission is currently conducting a monitoring and enforcement exercise by reviewing all 110 active disposal wells in BC to determine whether operators have been complying with this requirement.[74] Once the OGC has finished collecting this data, it will be interesting to carefully examine the data to determine whether all companies have conducted this test on a regular basis, especially the companies that are operating the oldest wells.

In summary, this part outlined fracking wastewater production, disposal practices, and concerns associated with disposal of wastewater in underground wells. It described BC's current regulatory framework for disposal wells: namely, there are many requirements at the permitting stage, and few reporting requirements after the permitting stage. Finally, it discussed concerns raised by the widespread current use of old wells built at a time when there was less stringent regulation.

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[64] *Petroleum and Natural Gas Act*, *1965,* RSBC 1960, c 280, s 97.
[65] *Petroleum and Natural Gas Act*, *1965,* RSBC 1960, c 280, s 98.
[66] *Petroleum and Natural Gas Act*, *1965,* RSBC 1960, c 280, s 112.
[67] *Petroleum and Natural Gas Act*, *1965,* RSBC 1960, c 280, s 114.
[68] *Petroleum and Natural Gas Act*, *1965,* RSBC 1960, c 280, s 113; see also Province of BC Ministry of Justice Office of Legislative Counsel, *Index of Current BC Regulations 1958 to June 30, 2013 inclusive*, (Victoria, BC: Crown Publications Queen's Printer for British Columbia, 2013).
[69] Personal communication with Dr. Gilles Wendling, (15 January, 2014).
[70] Skype conversation with Gilles Wendling and Antonio Barroso, (11 February, 2014)
[71] BC Oil and Gas Commission, *Water Source, Injection, and Disposal Service Wells,* online: BC Oil and Gas Commission <https://www.bcogc.ca/node/5997/download>; *Drilling and Production Regulation*, BC Reg 282/2010, s 16(3).
[72] Alberta Energy and Utilities Board, *Interim Directive ID 2003-01*, online: <http://www.aer.ca/documents/ids/pdf/id2003-01.pdf> at 1.2.
[73] Phone conversation with representative from OGC Reservoir Engineering (24 February, 2014).
[74] Phone conversation with representative from OGC Reservoir Engineering (24 February, 2014).

The following part outlines examples of "best practices" wastewater disposal well regulations from other jurisdictions and authorities.

Part III: Selected case studies: best practice regulation of disposal wells in Canada and other jurisdictions

Fracking development is booming internationally as technological advances make it economically feasible to develop vast global natural gas resources. However, the spectre of major fracking development is raising serious public concern due to fears that insufficient regulation will lead to environmental and public health harms.

As a result, moratoria on fracking development have been put in place in some areas of Australia and certain European countries such as France and Bulgaria.[75] As shale gas development increases in the United States, hundreds of municipalities have begun to impose moratoria.[76]

Other countries that formerly had bans are beginning to open up to the possibility of fracking development, including South Africa and certain Australian states such as Western Australia.[77] In the European Union (EU), despite some member countries having moratoria on fracking, other countries such as the UK are actively pursuing fracking development. This has led the EU to work on strengthening and clarifying their regulatory framework for the exploration and development of unconventional natural gas.[78]

This part aims to describe emerging best practice examples of wastewater disposal well regulation. It is divided into four sections. The first section discusses the International Energy Agency's "Golden Rules for a Golden Age of Gas," a highly regarded report about best practices for hydraulic fracturing development.[79] The second section briefly discusses the Canadian Association of Petroleum Producers' voluntary guidelines for industry.[80] The third section discusses the United States' program for regulating fracking disposal wells, and the Natural Resources Defence Council's suggestions on how strengthen this program. The fourth and final section covers the recent European Commission Communication and Recommendation that outline minimum principles for shale gas development.[81]

3.1 The International Energy Agency's Golden Rules for a Golden Age of Gas

In 2012, the International Energy Agency (IEA) produced a report titled "Golden Rules for a Golden Age of Gas." This report outlines best practices for unconventional natural gas development. The International Energy Agency is a Paris-based autonomous organization that operates within the Organisation for Economic Co-operation and

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[75] ABC, "Fracking ban extended in Victoria until 2015" *ABC News* (13 November 2013), online: ABC News <http://www.abc.net.au/news/2013-11-21/fracking-ban-extended-in-victoria-until-2015/5107712>; EC, Commission, *Impact Assessment: Exploration and production of hydrocarbons (such as shale gas) using high volume hydraulic fracturing in the EU* (Brussels: EC, 2014) at 15, online: <http://ec.europa.eu/environment/integration/energy/unconventional_en.htm>.

[76] Geoffrey Lean, "Opposition to fracking is also rising in the United States, the shale oil and gas capital of the world" *The Telegraph* (23 October 2013), online: <http://blogs.telegraph.co.uk/news/geoffreylean/100242583/opposition-to-fracking-is-also-rising-in-the-united-states-the-shale-oil-and-gas-capital-of-the-world/>.

[77] BBC News Africa, "South Africa ends fracking freeze" BBC News (7 September 2012), online: <http://www.bbc.com/news/world-africa-19517046>; Andrew Burrell, "Gas fracking wars to open up on a new front" *The Australian* (30 December 2013), online: <http://www.theaustralian.com.au/business/mining-energy/gas-fracking-wars-to-open-up-on-a-new-front/story-e6frg9df-1226791683325#>.

[78] Tim Ross, "EU Plan for fracking law threatens UK's shale gas boom" *The Telegraph* (15 December 2013), online: <http://www.theguardian.com/environment/2014/jan/13/shale-gas-fracking-cameron-all-out>.

[79] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023>.

[80] Canadian Association of Petroleum Producers, *CAPP's Guiding Principles and Operating Practices for Hydraulic Fracturing,* online: <http://www.capp.ca/canadaIndustry/naturalGas/ShaleGas/Pages/default.aspx#operating>.

[81] EC, *Commission Recommendation 2014/70/EU of 22 January 2014 on minimum principles for the exploration and production of hydrocarbons (such as shale gas) using high-volume hydraulic fracturing,* [2014] OJ L39/72 at 1
EC, *Commission Communication (Draft) from the Commission to the Council and the European Parliament on the exploration and production of hydrocarbons (such as shale gas) using high volume hydraulic fracturing in the EU,* online: <http://ec.europa.eu/environment/integration/energy/unconventional_en.htm> at 8.

Development (OECD) framework, providing policy advice to the 28 member countries of the OECD.[82] Canada is a member country of the OECD.[83]

"Golden Rules for a Golden Age of Gas", or simply "Golden Rules", is a document that outlines best practices for unconventional natural gas development. The premise of the document is that we are poised to enter a "golden age" of natural gas. However, prosperous and effective development of natural gas will only be possible if government follows best practices that address public concerns about the environmental and social impacts of natural gas development.[84]

The IEA believe there is a "critical link" between a profitable shale gas industry and government and industry responsiveness to environmental and social concerns.[85] Governments must secure the "social license" to profitably pursue natural gas development and expand production in this field. IEA Executive Director Maria van der Hoeven states that we already have the capability to produce natural gas in an environmentally friendly way, but if we don't address social and environmental impacts "…there is a very real possibility that public opposition to drilling for shale gas and other types of unconventional gas will halt the unconventional gas revolution in its tracks. The industry must win public confidence by demonstrating exemplary performance; governments must ensure that appropriate policies and regulatory regimes are in place."[86]

The report sets out two case studies in order to demonstrate this argument – in the first case study, the "Golden Rules Case", the fictional government follows the Golden Rules (i.e. best practice standards set out by the IEA in this report), and there is a rapid and profitable expansion in the global natural gas supply. In the second case study, titled the "Low Unconventional Case", the government does not follow the "Golden Rules", and due to a lack of social license, natural gas development barely increases at all. In addition, carbon dioxide emissions are higher in this second scenario, although in both case studies emissions exceed the level needed to limit global temperature rise to 2 degrees Celsius.[87] The IEA estimates following the Golden Rules will lead to a 7% increase in overall financial cost for developing a typical shale gas well, but that this may be offset by reductions in operating costs.[88]

Before outlining the Golden Rules, it is worth noting that the IEA recognizes promoting or pursuing natural gas development may compromise the environment and the development of renewable energy. The Chief Economist of the IEA, Fatih Birol, has warned "A golden age for gas is not necessarily a golden age for the climate."[89] However, there is currently widespread interest in unconventional natural gas development across the globe, and it seems unlikely to abate in the near future. The value of the Golden Rules is that they outline best practices which A) factor in the environmental and social impacts of fracking and B) have already been favorably received by governmental bodies such as the EU. The EU incorporated the Golden Rules into their recent Commission Recommendation on best practices for development of unconventional natural gas resources.[90]

The Golden Rules are:[91]

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[82] International Energy Agency, *What we do*, online: International Energy Agency <http://www.iea.org/aboutus/whatwedo/>.
[83] OECD, *List of OECD Member countries - Ratification of the Convention on the OECD,* online: <http://www.oecd.org/about/membersandpartners/list-oecd-member-countries.htm>.
[84] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 9.
[85] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 9.
[86] International Energy Agency, Press Release, "IEA sets out the "Golden Rules" needed to usher in a Golden Age of Gas" (29 May 2012) online: <http://www.iea.org/newsroomandevents/pressreleases/2012/may/name,27266,en.html>.
[87] International Energy Agency, Press Release, "IEA sets out the "Golden Rules" needed to usher in a Golden Age of Gas" (29 May 2012) online: <http://www.iea.org/newsroomandevents/pressreleases/2012/may/name,27266,en.html> at 63.
[88] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 10.
[89] Fiona Harvey, "'Golden age of gas' threatens renewable energy, IEA warns", *The Guardian* (29 May 2012) online: <http://www.theguardian.com/environment/2012/may/29/gas-boom-renewables-agency-warns>.
[90] EC, *Commission Recommendation 2014/70/EU of 22 January 2014 on minimum principles for the exploration and production of hydrocarbons (such as shale gas) using high-volume hydraulic fracturing,* [2014] OJ L39/72 at 1.
[91] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 13-14.

1) Measure, disclose, and engage
2) Watch where you drill
3) Isolate wells and prevent leaks
4) Treat water responsibly
5) Eliminate venting, minimize flaring and other emissions
6) Be ready to think big
7) Ensure a consistently high level of environmental performance

Although the Golden Rules concern fracking in general, many of the rules and rule subcategories are relevant to fracking wastewater disposal well regulation. The rules are discussed in more detail below:[92]

1) Measure, disclose, and engage[93]

This rule includes four subcategories, of which all four are relevant to disposal wells:

- "Integrate engagement with local communities, residents and other stakeholders into each phase of a development starting prior to exploration; provide sufficient opportunity for comment on plans, operations and performance; listen to concerns and respond appropriately and promptly"
- "Establish baselines for key environmental indicators, such as groundwater quality prior to commencing activity, with continued monitoring during operations"
- "Measure and disclose operational data on water use, on the volumes and characteristics of waste water and on methane and other air emissions, alongside full, mandatory disclosure of fracturing fluid additives and volumes"
- "Minimise disruption during operations, taking a broad view of social and environmental responsibilities, and ensure that economic benefits are also felt by local communities"

2) Watch where you drill[94]

This rule includes three subcategories, of which one is relevant to disposal wells:

- "Properly survey the geology of the area to make smart decisions about where to drill and where to hydraulically fracture: assess the risk that deep faults or other geological features could generate earthquakes or permit fluids to pass between geological strata"

3) Isolate wells and prevent leaks[95]

This rule includes three subcategories, of which one is relevant to disposal wells:

- "Put in place robust rules on well design, construction, cementing and integrity testing as part of a general performance standard that gas bearing formations must be completely isolated from other strata penetrated by the well, in particular freshwater aquifers"

4) Treat water responsibly[96]

[92] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 42-48.
[93] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 13.
[94] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 13.
[95] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 13.
[96] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 14, 46.

This rule includes three subcategories, of which all three are relevant to disposal wells:

- "Reduce freshwater use by improving operational efficiency; reuse or recycle, wherever practicable, to reduce the burden on local water resources"
- "Store and dispose of produced and waste water safely"
- "Minimize use of chemical additives and promote the development and use of more environmentally benign alternatives" that will not impair groundwater quality if they accidentally migrate into groundwater or there is a spill; alternatively, use techniques that minimize use of chemical additives

5) Eliminate venting, minimize flaring and other emissions

This rule is not directly relevant to disposal wells

6) Be ready to think big[97]

This rule includes two subcategories, of which one is relevant to disposal wells:

- "Take into account the cumulative and regional effects of multiple drilling, production and delivery activities on the environment, notably on water use and disposal, land use, air quality, traffic and noise"

7) Ensure a consistently high level of environmental performance[98]

This rule includes five subcategories, of which two are relevant to disposal wells:

- "Ensure that anticipated levels of unconventional gas output are matched by commensurate resources and political backing for robust regulatory regimes at the appropriate levels, sufficient permitting and compliance staff, and reliable public information"
- "Ensure that emergency response plans are robust and match the scale of risk" This refers to the need for operators and local emergency services to have plans in place so that they can respond to accidents expeditiously and appropriately

Finally, in an introductory section on fracking and water contamination, the IEA discusses ways unconventional gas production can pollute water. These include: spills of wastewater or other fluids at the surface; fracking fluid, saline water, or hydrocarbons leaking through poor well seals into shallow aquifers; hydrocarbons or chemicals from the well leaking and travelling from the well through rock layers into shallow aquifers; and discharging insufficiently treated wastewater into groundwater or underground.[99] All but the first are relevant to disposal wells.

The IEA makes the following recommendations regarding these concerns:

- **Fracking fluid, saline water, or hydrocarbons leaking through poor well seals into shallow aquifers[100]**

  Controlling this risk requires best practice in well design and well construction. Special care must be taken during the cementing process to make sure there is a good quality seal. There must be systematic verification of the quality of the seal to ensure the seal does not break down over the well's lifetime. This is

[97] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 14.
[98] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 14.
[99] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 35.
[100] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 37.

particularly important for multi-stage hydraulic fracturing wells, because the repeated cycles of high pressure can weaken the casing. Therefore, these wells must have a casing of appropriate strength.

- **Hydrocarbons or chemicals from the well leaking and travelling from the well through rock layers into shallow aquifers[101]**

  The IEA states that this is not a likely scenario, although it could happen if there were deep faults acting as fluid pathways from the well to the surface, or if there were no impermeable layers between the well and the surface. The IEA recommends "appropriate prior studies of the local geology… before undertaking significant developments."

- **Discharging insufficiently treated wastewater into groundwater or underground[102]**

  The IEA recommends there be an "appropriate regulatory response." Regulation should require tracking and documentation of wastewater volumes, wastewater composition, and how wastewater is transported and disposed.

The Golden Rules and other recommendations are meant to act as general principles for governments and industry. The IEA recognizes that their applicability will vary based on each country's legal system, geology, social and political framework, land use practices, and water availability, amongst other factors.[103] However, in the IEA's view the Golden Rules provide a basic framework of the minimum best practices necessary for both industry and government to be able to pursue natural gas development with social license.[104]

As a final note, there is a short section on Canada in the "Golden Rules" document. This section references the Canadian Association of Petroleum Producers' voluntary guidelines for industry, stating "The Canadian Association of Petroleum Producers has recently issued new guidelines for its members, covering many of the issues in the Golden Rules."[105] These voluntary guidelines are discussed next.

3.2 The Canadian Association of Petroleum Producers' Guiding Principles and Operating Practices for Hydraulic Fracturing

In 2012, the Canadian Association of Petroleum Producers (CAPP) released their "Guiding Principles and Operating Practices for Hydraulic Fracturing." These guiding principles are voluntary guidelines for Canadian industry engaged in hydraulic fracturing.[106]

The CAPP voluntary guidelines are a small step in the right direction. They set out some of the principles discussed in the IEA's Golden Rules. However, they are not very detailed and they are not binding on industry. In addition, the guidance they currently provide for wastewater management and disposal is not as extensive as the other examples reviewed in this section.

The guidelines state that CAPP supports: disclosure of fracking fluid additives; development of fracking fluid

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[101] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 37.
[102] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 38.
[103] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 49.
[104] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 49.
[105] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 109.
[106] Carrie Tait, "Producers set voluntary guidelines for fracking" *The Globe and Mail* (30 January 2012), online: The Globe and Mail <http://www.theglobeandmail.com/report-on-business/industry-news/energy-and-resources/producers-set-voluntary-guidelines-for-fracking/article4171275/>; see also Canadian Association of Petroleum Producers, *CAPP's Guiding Principles and Operating Practices for Hydraulic Fracturing,* online: <http://www.capp.ca/canadaIndustry/naturalGas/ShaleGas/Pages/default.aspx#operating>.

additives with the least environmental risks; baseline testing of water and water monitoring; proper well design and construction; water recycling for reuse as much as is practical; safe disposal of wastewater at approved management facilities including disposal wells; and requirements for companies to assess and monitor the potential for induced seismicity.[107]

Although we do not cover the CAPP principles here in depth, it may be useful to check the CAPP guidelines periodically to see if they have developed further.

3.3 The United States Underground Injection Control Program and NRDC Recommendations

This section discusses how the United States (US) currently regulates wastewater disposal wells. It also summarizes Natural Resources Defence Council (NRDC) recommendations for strengthening the current regulatory framework for disposal wells. The NRDC is an American environmental advocacy group headquartered in New York.[108] Over the last decade, the NRDC has done extensive research and law reform work on fracking wastewater management in the US.

In the US, fracking is regulated at federal, state, and municipal levels.[109] Industry uses various methods to dispose of fracking wastewater. These include recycling it for further use; treating it at an industrial waste facility and then discharging it into local water sources such as rivers; injecting it deep underground, and spreading it on roads to control dust or ice.[110] This section focuses on US regulation of fracking disposal wells.

In the US, fracking disposal wells are known as "underground injection wells" and are regulated by the federal government under the *Safe Water Drinking Act* (*SWDA*).[111] The Environmental Protection Agency (EPA) regulates the "Underground Injection Control" program or "UIC Program" for disposal wells established under the *SWDA*.[112] The EPA implements the program themselves unless a state is given authority, known as "primacy", to regulate the program.[113]

The UIC program prohibits underground injection unless authorized, and establishes standards for safe injection practices; the purpose of the program is to prevent injection that causes contamination of underground sources of drinking water.[114]

Under the UIC program, there are five different "classes" of wells, which are subject to different requirements and standards.[115] Fracking waste is currently disposed of in Class II wells, which are for the injection of "brines and

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[107] Canadian Association of Petroleum Producers, *CAPP's Guiding Principles and Operating Practices for Hydraulic Fracturing,* online: <http://www.capp.ca/canadaIndustry/naturalGas/ShaleGas/Pages/default.aspx#operating>.
[108] Natural Resources Defence Council, *About Us,* online: <http://www.nrdc.org/about/>.
[109] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 8.
[110] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 5; see also International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 33.
[111] *Safe Water Drinking Act,* 42 USC 300f-300j (1974).
[112] EPA, *Basic Information about Injection Wells,* online: United States Environmental Protection Agency <http://water.epa.gov/type/groundwater/uic/basicinformation.cfm#why_does>.
[113] EPA, *UIC Program Primacy,* online: United States Environmental Protection Agency <http://water.epa.gov/type/groundwater/uic/primacy.cfm#what>.
[114] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 9.
[115] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 77.

other fluids associated with oil and gas production."[116] In the 1980s the US government made a regulatory determination that fracking waste did not need to be regulated as a hazardous substance: therefore, the EPA does not require operators to dispose of fracking waste in the more stringently regulated Class I hazardous waste wells.[117] This is problematic because Class II wells have fewer safety requirements. Therefore, disposal in these wells poses a greater risk to public health and the environment, as well as increased potential for earthquakes.[118]

The NRDC has made extensive recommendations regarding fracking wastewater management in their report, "In Fracking's Wake".[119] First, they recommend that wastewater be minimized through use of techniques that require less water, and that any wastewater produced be reused and recycled for additional hydraulic fracturing.[120] They also recommend that operators be required to publicly disclose the method they use to manage wastewater, and the final destination of the wastewater.[121]

They also make two major recommendations about underground injection. The first recommendation is that fracking wastewater be treated as hazardous waste. As mentioned above, fracking wastewater and other oil and gas wastes have an exemption from being treated as "hazardous wastes" under the US *Resource Conservation and Recovery Act* (RCRA).[122] The NRDC argues that the EPA should eliminate the exemption for fracking wastewater, and classify fracking wastewater as hazardous waste in cases where it displays the qualities of hazardous waste.

The NRDC states that fracking wastewater contains many substances that are harmful to human health and the environment, which would meet *RCRA* standards for hazardous waste if not otherwise exempted.[123] Under the *RCRA*, a waste can be deemed a hazardous waste if it exhibits any of the following four characteristics: ignitability, corrosivity, reactivity, and toxicity.[124]

The NRDC states that produced water certainly meets the requirement for toxicity, and may meet requirements for other characteristics as well.[125] In the United States, research has found "contaminants of concern" in produced water such as arsenic, lead, hexavalent chromium, barium, chloride, sodium, sulfates, boron, and benzene, (many of which are known carcinogens) and normally occurring radioactive materials (NORM). One study done by the New

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[116] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 20.
[117] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 80.
[118] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 10.
[119] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf>.
[120] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 11, 18-19.
[121] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 78..
[122] *Resource Conservation and Recovery Act*, 42 USC §6901 (1976).
[123] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 87.
[124] Letter from the Natural Resource Defence Council to the United States Environmental Protection Agency (8 September 2010), *Re: Petition for Rulemaking Pursuant to Section 6974(a) of the Resource Conservation and Recovery Act Concerning the Regulation of Wastes Associated with the Exploration, Development, or Production of Crude Oil or Natural Gas or Geothermal Energy*, online: <http://docs.nrdc.org/energy/files/ene_10091301a.pdf> at 38.
[125] Letter from the Natural Resource Defence Council to the United States Environmental Protection Agency (8 September 2010), *Re: Petition for Rulemaking Pursuant to Section 6974(a) of the Resource Conservation and Recovery Act Concerning the Regulation of Wastes Associated with the Exploration, Development, or Production of Crude Oil or Natural Gas or Geothermal Energy*, online: <http://docs.nrdc.org/energy/files/ene_10091301a.pdf> at 40-41.

York State Department of Environmental Conservation tested produced water and found levels of radioactive material, specifically radium 226, at 267 times the safe limit for drinking water.[126]

Classifying some fracking wastewater as hazardous waste would require regular testing of shale gas wastewater to determine if it has the characteristics of hazardous waste. Regular testing is particularly important because the volume and chemical characteristics of fracking wastewater change throughout the life of the well.[127]

The second major recommendation the NRDC makes is that fracking wastewater be disposed of in Class I hazardous waste wells, which have more stringent standards than Class II wells.[128] Class I wells have more stringent regulations that better protect public health and the environment. Current injection into Class II wells risks wastewater migrating into drinking water, and may increase risks of earthquakes.[129] Several recent earthquakes in Ohio, Texas, Arkansas, and West Virginia have been linked to underground injection of fracking wastewater.[130]

Class I and II well requirements differ significantly. For Class II wells, the following requirements apply:[131]

- The EPA or a state with primacy must consider:
    - "The location of existing wells and other geographical features in the area
    - The well operator's proposed operating data, including daily rate, volume, and pressure of injection
    - The injection fluid's characteristics; the geological characteristics of the injection zone; the construction details of the proposed well
    - The operator's demonstration of mechanical integrity"[132]
- Class II wells must be sited so that the formation they inject into has a "fault and fracture free zone" between it and any underground sources of drinking water
- Class II wells must have proper casing and cementing to ensure there is no movement of fluids into or between underground sources of drinking water
- Class II wells must not inject past a precalculated maximum pressure to ensure the pressure does not create or enlarge fractures in the zone next to underground sources of drinking water, or cause movement of wastewater into underground sources of drinking water
- If the operator of a Class II well cannot maintain the mechanical integrity of the well they must stop operating it[133]

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[126] Letter from the Natural Resource Defence Council to the United States Environmental Protection Agency (8 September 2010), *Re: Petition for Rulemaking Pursuant to Section 6974(a) of the Resource Conservation and Recovery Act Concerning the Regulation of Wastes Associated with the Exploration, Development, or Production of Crude Oil or Natural Gas or Geothermal Energy*, online: <http://docs.nrdc.org/energy/files/ene_10091301a.pdf>.

[127] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 89.

[128] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 89.

[129] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 89.

[130] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 89.

[131] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 78.

[132] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 78.

[133] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 78.

In addition to these requirements, Class I hazardous waste wells require that:[134]

- Wells be drilled below the lowest underground source of drinking water to avoid water contamination (Class II wells can inject either above or below underground sources of drinking water)
- Before siting a Class I well, operators must submit additional information showing the location for the well is geologically suitable, and considering earthquake risk
- Operators of Class I wells must check for pathways from the well to underground sources of drinking water in a two mile radius around the well; Class II wells only require a quarter mile radius (note that Scott Anderson of the EDF mentioned to us that this is an important consideration for disposal wells, as a quarter mile radius is not likely large enough for a big project, and fluids do not spread underground as perfect circles)[135]
- There are more stringent procedures for well construction, operation, testing, and monitoring[136]

Finally, although the NRDC best practice recommendation is that injection occur in Class I wells, they recognize that this may not occur right away. They suggest that in the interim, states use their regulatory power to ensure Class II wells are more strictly regulated – at least as strictly as Class I hazardous waste wells.[137]

To summarize, the NRDC makes two main recommendations about underground injection of fracking wastewater. They recommend that fracking wastewater be reclassified as hazardous waste, and that operators be required to inject it into Class I hazardous waste wells. In the interim, they suggest states regulate Class II wells more strictly to match Class I well standards.

3.4 The European Commission Recommendation on minimum principles for the exploration and production of hydrocarbons (such as shale gas) using high-volume hydraulic fracturing

Interest in hydraulic fracturing has been rising in Europe; while some member countries like France and Bulgaria have enacted moratoriums, other countries like the UK are aggressively pursuing hydraulic fracturing development. In response to increasing public concern about the environmental and public health risks posed by hydraulic fracturing development, the EU conducted a series of studies and released a Recommendation on this topic on January 22nd, 2014.[138]

The EU acknowledges in a Communication accompanying the Recommendation that EU environmental legislation was developed at a time when modern hydraulic fracturing practices were not being used in Europe, and therefore there are some important gaps left unaddressed in the body of EU legislation.[139] Though general and specific EU legislation relating to hydraulic fracturing already exists, member countries are uncertain how this legislation applies, interpret existing legislation in differing ways, and have begun to develop individual regulation including bans and moratoriums.[140] Therefore, the stated goal of the Recommendation is to provide basic minimum principles for hydraulic fracturing exploration and production of unconventional natural gas in Europe. The EU states this will

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[134] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 78, 89-90.
[135] Email communication with Scott Anderson, Senior Policy Advisor, US Climate and Energy Program, EDF (31 March, 2014).
[136] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 90.
[137] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 10, 90.
[138] EC, *Commission Recommendation 2014/70/EU of 22 January 2014 on minimum principles for the exploration and production of hydrocarbons (such as shale gas) using high-volume hydraulic fracturing,* [2014] OJ L39/72 at 1.
[139] EC, *Commission Communication (Draft) from the Commission to the Council and the European Parliament on the exploration and production of hydrocarbons (such as shale gas) using high volume hydraulic fracturing in the EU,* online: <http://ec.europa.eu/environment/integration/energy/unconventional_en.htm> at 8.
[140] EC, *Commission Communication (Draft) from the Commission to the Council and the European Parliament on the exploration and production of hydrocarbons (such as shale gas) using high volume hydraulic fracturing in the EU,* online: <http://ec.europa.eu/environment/integration/energy/unconventional_en.htm> at 7.

assist Member States in adapting their own legislation to ensure "safe and secure" development of unconventional natural gas resources, and "foster a level playing field for this industry" across Europe.[141]

A recent article in the *Guardian* stated that although the EU wanted to implement a legally binding directive, the UK – which is "going all out" for shale – defeated this goal through intense lobbying. The result was a non-binding Recommendation. However, each EU member country is expected to produce a public "scorecard" in the following six months where they detail which recommendations have been implemented. Based on the results, the Commission can make a new legislative proposal if it believes it is necessary.[142]

However, regardless of its implementation in Member States, the Recommendation provides a valuable set of best practice principles for regulation of disposal wells. The EU Recommendation covers all fracking activity; however several recommendations are relevant to disposal wells. The EU recommends that:

- "A strategic environmental assessment is carried out prior to granting licenses for hydrocarbon exploration and/or production which are expected to lead to operations involving high-volume hydraulic fracturing, in order to analyse and plan how to prevent, manage and mitigate cumulative impacts and possible conflicts with other uses of natural resources or the underground;"[143]

- "A site specific risk characterization and assessment is carried out, related to both the underground and the surface, to determine whether an area is suitable for safe and secure exploration or production of hydrocarbons involving high volume hydraulic fracturing…"[144] It would "make it possible to assess the risk of leakage or migration of drilling fluids, hydraulic fracturing fluids, naturally occurring material, hydrocarbons and gases from the well or target formation as well as of induced seismicity."[145]

- "Baseline reporting… takes place, in order to provide a reference for subsequent monitoring or in case of an incident;"[146] to include baselines for "(a) quality and flow characteristics of surface and ground water, (b) water quality at drinking water abstraction points, (c) air quality, (d) soil condition, (e) presence of methane and other volatile organic compounds in water, (f) seismicity, (g) land use, (h) biodiversity, (i) status of infrastructure and buildings, (j) existing wells and abandoned structures."[147]

- Member States should ensure that operators: "develop project-specific water-management plans to ensure that water is used efficiently during the entire project. Operators should ensure the traceability of water flows. The water management plan should take into account seasonal variations in water availability and avoid using water sources under stress."[148]

- "The public is informed of the composition of the fluid used for hydraulic fracturing on a well by well basis as well as on waste water composition, baseline data and monitoring results. This is needed to ensure that

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[141] EC, *Commission Communication (Draft) from the Commission to the Council and the European Parliament on the exploration and production of hydrocarbons (such as shale gas) using high volume hydraulic fracturing in the EU,* online: <http://ec.europa.eu/environment/integration/energy/unconventional_en.htm> at 4.
[142] Damian Carrington, "UK defeats European bid for fracking regulations", *The Guardian* (14 January 2014) online: <http://www.theguardian.com/environment/2014/jan/14/uk-defeats-european-bid-fracking-regulations>.
[143] EC, *Commission Communication (Draft) from the Commission to the Council and the European Parliament on the exploration and production of hydrocarbons (such as shale gas) using high volume hydraulic fracturing in the EU,* online: <http://ec.europa.eu/environment/integration/energy/unconventional_en.htm> at 9.
[144] EC, *Commission Communication (Draft) from the Commission to the Council and the European Parliament on the exploration and production of hydrocarbons (such as shale gas) using high volume hydraulic fracturing in the EU,* online: <http://ec.europa.eu/environment/integration/energy/unconventional_en.htm> at 9.
[145] EC, *Commission Recommendation 2014/70/EU of 22 January 2014 on minimum principles for the exploration and production of hydrocarbons (such as shale gas) using high-volume hydraulic fracturing,* [2014] OJ L39/72 at 5.2.
[146] EC, *Commission Communication (Draft) from the Commission to the Council and the European Parliament on the exploration and production of hydrocarbons (such as shale gas) using high volume hydraulic fracturing in the EU,* online: <http://ec.europa.eu/environment/integration/energy/unconventional_en.htm> at 9.
[147] EC, *Commission Recommendation 2014/70/EU of 22 January 2014 on minimum principles for the exploration and production of hydrocarbons (such as shale gas) using high-volume hydraulic fracturing,* [2014] OJ L39/72 at 6.2.
[148] EC, *Commission Recommendation 2014/70/EU of 22 January 2014 on minimum principles for the exploration and production of hydrocarbons (such as shale gas) using high-volume hydraulic fracturing,* [2014] OJ L39/72 at 9.2.(a).

the authorities and the general public have factual information on potential risks and their sources. Improved transparency should also facilitate public acceptance"[149]

- "The well is properly insulated from the surrounding geological formations, in particular to avoid contamination of groundwater" and operators "ensure well integrity through well design, construction and integrity tests. The results of integrity tests should be reviewed by an independent and qualified third party to ensure the well's operational performance, and its environmental and health safety at all stages of project development and after well closure."[150]

- In terms of monitoring requirements, the Member State should ensure the operator has a program of regular monitoring that employs the baseline study as a reference. The operator should consistently measure the composition of fracking fluid used in each well; the volume of water used in each well; the pressure applied during fracking; the fluids that emerge following fracking (return rate, volume, characteristics, and quantities reused or treated); and air quality. Member States should measure and report these results to the applicable authorities.[151]

The EU also recommends that Member States ensure companies use "best available techniques" (BAT), strive for maximum transparency, strive to innovate with technology and improve operating practices; ensure permitting authorities have adequate resources and information; consult with citizens and stakeholders early in the process; and exchange good regulatory practices and other information with each other.[152]

All the recommendations listed above are relevant to the regulation of disposal wells. They also share significant similarities with the "Golden Rules." Although it is unclear whether the EU Recommendation was modeled on the Golden Rules, the Recommendation does cite the Golden Rules on its first page.[153]

In summary, this part considered four examples of key principles for best practice disposal well regulation: the International Energy Agency's recommendations included in their report, "Golden Rules for a Golden Age of Gas"; the Canadian Association of Petroleum Producers' Guiding Principles and Operating Practices for Hydraulic Fracturing; the United States' approach to regulating fracking disposal wells, and NRDC recommendations on how to improve this approach; and the European Union's recent Recommendation regarding minimum principles for shale gas development. The next section synthesizes these best practice examples into key principles that could strengthen BC's regulatory framework for disposal wells.

Part IV: Recommendations to strengthen BC's regulatory framework for disposal wells

This part synthesizes the best practices identified in Part III, and aims to identify key principles that could strengthen BC's regulatory framework for disposal wells. It sets out one overarching recommendation, as well as six key principles that should be incorporated into regulatory requirements. A summary of specific "best practices" regulatory rules is included under each key principle.

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[149] EC, *Commission Communication (Draft) from the Commission to the Council and the European Parliament on the exploration and production of hydrocarbons (such as shale gas) using high volume hydraulic fracturing in the EU,* online: <http://ec.europa.eu/environment/integration/energy/unconventional_en.htm> at 9.
[150] EC, *Commission Recommendation 2014/70/EU of 22 January 2014 on minimum principles for the exploration and production of hydrocarbons (such as shale gas) using high-volume hydraulic fracturing,* [2014] OJ L39/72 at 9.2.(e).
[151] EC, *Commission Recommendation 2014/70/EU of 22 January 2014 on minimum principles for the exploration and production of hydrocarbons (such as shale gas) using high-volume hydraulic fracturing,* [2014] OJ L39/72 at 11.
[152] EC, *Commission Communication (Draft) from the Commission to the Council and the European Parliament on the exploration and production of hydrocarbons (such as shale gas) using high volume hydraulic fracturing in the EU,* online: <http://ec.europa.eu/environment/integration/energy/unconventional_en.htm> at 9, 10.
[153] EC, *Commission Recommendation 2014/70/EU of 22 January 2014 on minimum principles for the exploration and production of hydrocarbons (such as shale gas) using high-volume hydraulic fracturing,* [2014] OJ L39/72 at 6.

A) Overarching Recommendation

BC should adopt the NRDC recommendations for fracking wastewater disposal wells. BC disposal wells should be required to meet the US EPA guidelines for Class I hazardous waste wells.

Currently, BC disposal wells do not have to meet all the specifications for US Class II wells; BC disposal wells do not have to meet *any* of the specifications for US Class I hazardous waste wells. BC should ensure disposal wells meet the following requirements:

- Wells are sited so that the formation they inject into has a fault and fracture free zone between it and any source of underground drinking water (Class II requirement)[154]
- All wells must be drilled below the lowest underground source of drinking water to avoid water contamination (Class I requirement)[155]
- Before siting a well, operators must submit additional information showing the location for the well is geologically suitable, and considering earthquake risk (Class I requirement)[156]
- Operators of disposal wells must consider a two mile radius around the well to see if there are pathways from the well to underground sources of drinking water (Class I requirement)[157]

The US regulatory framework combined with the NRDC recommendations provides a strong model for BC regulations. Adopting the above requirements will help address the risk that disposal wells may contaminate groundwater, or cause earthquakes.

However, combining this model with the best practice recommendations set out in the following six key principles would ensure an even stronger regulatory framework that reflects international best practices and protects public and environmental health. The next section discusses the six key principles in detail.

B) Recommendation: The following six key principles should be incorporated into regulatory requirements.

Principle 1: Minimize water used and wastewater produced

The government should require operators to employ best practices in water use and wastewater recycling. The less wastewater that needs to be disposed of, the better. This is not currently required by BC legislation, though the BC MOE Procedure has a section on "Deepwell Disposal Philosophy" where it states "waste minimization shall be implemented prior to using the deepwell disposal option; resource conservation, including surface water and the waste streams themselves, shall be pursued whenever possible…the waste generator has the primary responsibility to ensure the aforementioned waste minimization and resource conservation principles are followed."[158] The OGC

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[154] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 78

[155] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 89.

[156] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 89.

[157] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 89; Note that some take a wider perspective on the type of water that should be protected – as Dr. Gilles Wendling states, the key underlying risk associated with drilling, fracking, and disposal of liquid waste is that we may modify the long term interconnection between groundwater and surface water. Therefore, a more precautionary perspective would not limit our assessment only to sources of drinking water; it would also encompass how ***ecosystems*** may be altered by oil and gas related activities (for example, the way lakes, rivers and wetlands might be affected as the influx of water they receive is modified in quality and quantity); email communication with Dr. Gilles Wendling, President of GW Solutions, (17 April, 2014).

[158] BC Ministry of Environment, *Procedure for Authorizing Deepwell Disposal of Wastes*, online: British Columbia: Environment <http://www2.gov.bc.ca/gov/topic.page?id=CC13CEECAEAF48F0BF4DA4314F5690A3&title=Oil%20and%20Gas>

states on their website that currently 40% of produced water is reused in hydraulic fracturing regulations.[159] This suggests some operators are voluntarily recycling produced water.

As discussed in Part IV, all four best practice case studies mention this key principle. The NRDC recommends operators minimize wastewater by using techniques that require less water, and reusing and recycling wastewater for additional hydraulic fracturing.[160] The IEA recommends that operators reduce, reuse and recycle freshwater. They also recommend operators minimize use of chemical additives and develop and use more environmentally benign alternatives.[161] The CAPP recommends operators recycle water for reuse as much as is practical.[162] The EU suggests operators be required to develop "project-specific water-management plans" to ensure water is being used efficiently, consider seasonal changes in availability of water, and refrain from using water sources that are already experiencing stress.[163]

Summary of Best Practices Rules: BC should require operators to reduce, reuse, and recycle wastewater; minimize their use of chemical additives; create "project-specific water-management plans"; and refrain from using water sources that are already experiencing stress.

Principle 2: Carry out a strategic environmental assessment for fracking and wastewater disposal wells

With the predicted imminent increase in fracking in north-eastern BC, a strategic environmental assessment of fracking wells and wastewater disposal wells is desperately needed.

The EU states that best practice is to conduct a strategic environmental assessment before development begins.[164] The IEA recommends that governments consider the cumulative and regional effects of multiple drilling, production and delivery activities on the environment, notably on water use and disposal, land use, air quality, traffic and noise.[165]

Summary of Best Practices Rules: BC should conduct a strategic environmental assessment to assess the cumulative impacts of fracking and disposal well activities in north-eastern BC. BC must consider the cumulative impacts of fracking and injection activity to ensure improperly sited wells do not cause earthquakes, and to reduce the chances of a changing underground environment opening up new pathways for wastewater to make its way to the surface. See the Environmental Law Centre's report on the need for a Strategic Environmental Assessment of the proposed new LNG industry at www.elc.uvic.ca.

Principle 3: Carry out detailed geographic surveys and hydrogeologic investigations of the area before drilling a well and starting operations

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[159] Oil and Gas Commission, *What happens to produced water?*, online: <https://www.bcogc.ca/what-happens-produced-water>.
[160] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 11, 18-19.
[161] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 14, 46.
[162] Canadian Association of Petroleum Producers, *CAPP Hydraulic Fracturing Operating Practice: Water Sourcing, Measurement and Reuse,* online: <http://www.capp.ca/getdoc.aspx?DocId=218142&DT=NTV >.
[163] EC, *Commission Recommendation 2014/70/EU of 22 January 2014 on minimum principles for the exploration and production of hydrocarbons (such as shale gas) using high-volume hydraulic fracturing,* [2014] OJ L39/72 at 9.2.(a).
[164] EC, *Commission Communication (Draft) from the Commission to the Council and the European Parliament on the exploration and production of hydrocarbons (such as shale gas) using high volume hydraulic fracturing in the EU,* online: <http://ec.europa.eu/environment/integration/energy/unconventional_en.htm> at 9.
[165] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 14.

BC should require that operators carry out a detailed geographic survey and hydrogeologic investigation of the proposed disposal well area before commencing operations, to ensure there is no chance wastewater will migrate to drinking water aquifers or surface water systems.

The EU states best practice is to conduct a site-specific risk assessment that examines underground and surface. This goal of this assessment is to determine the risk of fluids leaking or migrating to the surface, and the risk of wells inducing seismicity (resulting in weakened well integrity and a modified fracture network).[166] The IEA echoes a very similar recommendation.[167] In addition, in a communication with Scott Anderson, an expert on disposal wells from the US EDF, Mr. Anderson highlighted the importance of considering the surrounding area for disposal wells, taking into account both active and inactive wells. He stated that if wells are being sited in an area that poses a high risk of inducing seismicity, special precautions should be taken.[168]

The NRDC also recommends operators of disposal wells consider a two mile radius around the well to see if there are pathways from the well to underground sources of drinking water, as discussed above in the overarching recommendation.[169] Finally, another key factor to consider in mapping these potential pathways is time. The approach must consider that wells will be there forever, once drilled. Therefore the movement of fluids (gas, liquids) from the well should be modeled using very long timeframes (100, 200 years).[170]

Summary of Best Practices Rules: BC should require operators to carry out a site-specific risk assessment that examines underground and surface in a sufficient radius around the well, taking into account an appropriate timeframe. Operators should be required to submit this information as part of the permitting application. If there is a chance the well will allow fluids to migrate to the surface or induce seismicity, permitting authorities should be required to refuse the permit.

Principle 4: Ensure wells are constructed to best practice standards; monitor wells throughout their lifetime to ensure they retain integrity

To prevent contamination of the surrounding environment, it is vital that wells be constructed to best practice standards and monitored throughout their lifetime to ensure they have adequate integrity.[171] BC's current permitting standards for disposal wells require that testing be done to ensure old wells have an adequate seal, and that new wells have hydraulic isolation from surrounding water sources.[172] BC also requires that operators conduct an annual packer isolation test to check hydraulic isolation of the well.[173] However, it is unclear whether all operators have been regularly conducting this test, as discussed above.

The EU states that best practice requires good well design and construction;[174] The CAPP also makes this recommendation.[175] It is also important to note that best practice well design and construction must take into account

[166] EC, *Commission Recommendation 2014/70/EU of 22 January 2014 on minimum principles for the exploration and production of hydrocarbons (such as shale gas) using high-volume hydraulic fracturing,* [2014] OJ L39/72 at 5.2.
[167] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 13.
[168] Email communication with Scott Anderson, Senior Policy Advisor, US Climate and Energy Program, EDF (31 March, 2014).
[169] Rebecca Hammer & Jeanne VanBriesen, *In Fracking's Wake: New Rules are Needed to Protect our Health and Environment from Contaminated Wastewater,* online: Natural Resources Defence Council <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf> at 89.
[170] Email communication with Dr. Gilles Wendling, President of GW Solutions, (17 April, 2014).
[171] Note that in practical terms, the "lifetime" of the well is indefinite. Once a hole is drilled in the ground, it is there forever. Although the hole can be backfilled with grout, guaranteeing the seal operates properly – forever – is currently a technical challenge; email communication with Dr. Gilles Wendling, President of GW Solutions, (17 April, 2014).
[172] BC Oil and Gas Commission, *Deep Well Disposal of Produced Water / Non-Hazardous Waste Application Guideline*, online: BC Oil and Gas Commission <https://www.bcogc.ca/deep-well-disposal-produced-water-non-hazardous-waste-application-guideline>.
[173] *Drilling and Production Regulation*, BC Reg 282/2010, s 16(3).
[174] EC, *Commission Recommendation 2014/70/EU of 22 January 2014 on minimum principles for the exploration and production of hydrocarbons (such as shale gas) using high-volume hydraulic fracturing,* [2014] OJ L39/72 at 9.2.(e).

the fact that once drilled, wells remain forever – therefore, adequacy of well design and construction must be assessed using a very long timeframe (100 to 200 years.)[176]

The EU also states that operators must conduct integrity testing, and suggests integrity tests be evaluated by an independent, qualified third party to ensure the well is operating properly, and the environment and public health are kept safe.[177] They state this should take place throughout the life of the well and after well abandonment. The IEA recommends stringent well construction standards to ensure that "gas bearing formations… [are] completely isolated from other strata penetrated by the well, in particular freshwater aquifers." They also recommend systematic verification of the quality of the seal, to ensure the seal does not degrade over the well's lifetime. This is particularly important for multi-stage hydraulic fracturing wells, because the repeated cycles of high pressure can weaken the casing. Therefore, these wells must have a casing of appropriate strength.[178]

Summary of Best Practices Rules: BC should require operators to ensure best practice in well design and construction, systematically verify the integrity of the well and quality of the seal, and have this integrity testing evaluated by an independent, qualified third party.

Principle 5: Carry out baseline reporting

In BC, baseline testing of the groundwater and soil around the disposal well is not required prior to operation. However, this means there are no baseline values to compare to in the event of a leak or spill.

As per the EU Recommendation, best practice is to carry out baseline reporting before development takes place and wells become operational, so there is a reference point for future monitoring or in the case of a spill or accident. The EU recommends baseline reporting include baselines for, at minimum: quality and flow characteristics of surface and ground water, water quality at drinking water abstraction points, soil condition, and seismicity.[179] The IEA echoes this recommendation, and states that continued monitoring should take place during operations.[180] The CAPP also recommends baseline testing and monitoring.[181]

Summary of Best Practices Rules: BC should require comprehensive baseline testing of surface and groundwater, soil, and seismic activity near the well prior to operation; this monitoring should continue to take place throughout the life of the well.

Principle 6: Ensure robust regulatory regimes and adequate emergency response plans are in place

A strong legislative framework is nothing without a robust monitoring and compliance regime, and adequate emergency response plans in the event of a spill.

The IEA recommends anticipated levels of unconventional gas output be matched by commensurate resources and political backing for robust regulatory regimes at the appropriate levels; sufficient permitting and compliance staff;

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[175] Canadian Association of Petroleum Producers, *CAPP Hydraulic Fracturing Operating Practice: Wellbore Construction and Quality Assurance,* online: <http://www.capp.ca/getdoc.aspx?DocId=218137&DT=NTV>.
[176] Email communication with Dr. Gilles Wendling, President of GW Solutions, (17 April, 2014).
[177] EC, *Commission Recommendation 2014/70/EU of 22 January 2014 on minimum principles for the exploration and production of hydrocarbons (such as shale gas) using high-volume hydraulic fracturing,* [2014] OJ L39/72 at 9.2.(e).
[178] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 13, 37.
[179] EC, *Commission Recommendation 2014/70/EU of 22 January 2014 on minimum principles for the exploration and production of hydrocarbons (such as shale gas) using high-volume hydraulic fracturing,* [2014] OJ L39/72 at 6.2, 9.
[180] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 13.
[181] Canadian Association of Petroleum Producers, *CAPP Hydraulic Fracturing Operating Practice: Baseline Groundwater Testing,* online: <http://www.capp.ca/getdoc.aspx?DocId=218135&DT=NTV>.

and reliable public information. They add that government should ensure emergency response plans are robust and match the scale of risk, and operators and local emergency services must have plans in place so that they can respond to accidents expeditiously and appropriately.[182]

Yet serious questions have been raised about British Columbia's retreat from vigorous environmental regulation efforts over the last decade. For example, since 1998 staff for the Ministry of Environment have been reduced by 25%; the number of mine inspections dropped by 50% between 2001-2008; and a 2009 review of the Ministry of Environment found the lowest level of environmental convictions in the previous twenty years.[183]

Summary of Best Practices Rules: BC should ensure a robust monitoring and compliance regime exists, along with adequate emergency response plans. An appropriate way for BC to ensure robust monitoring and compliance efforts for disposal wells would be to give affected First Nations and other affected communities adequate resources to hire staff to conduct baseline testing; provide monitoring and compliance services throughout the lifetime of the well to ensure wastewater does not adversely impact the environment or public health; and develop, in conjunction with industry, adequate emergency response plans and procedures that give First Nations and other affected communities adequate notice of spills and leaks.

Conclusion

In conclusion, although BC currently regulates some aspects of wastewater disposal wells, the regulatory framework is insufficient. Current legislation must be strengthened to provide adequate assurances that disposal wells will not contaminate drinking water and surface water systems. Building wells to Class I standards is a good start. Combining this overarching recommendation with the six key principles and supporting Best Practices contained in Part IV will ensure a strong regulatory framework that reflects international best practices and protects public and environmental health.

[182] International Energy Agency Office of the Chief Economist, *Golden Rules for a Golden Age of Gas,* online: International Energy Agency <http://www.worldenergyoutlook.org/goldenrules/#d.en.27023> at 14.

[183] See Calvin Sandborn, *Maintaining Natural BC for Our Children*, pp. 34-35. For more details about the dramatic cuts in provincial staff managing natural resources, see *Trends in renewable resource management in BC by Don Sidney Eastman, Ralph Archibald, Rick Ellis, Brian Nyberg*
http://jem.forrex.org/index.php/jem/article/view/556.

Appendix A: Recent study of disposal wells in BC

Figure 1: Locations of disposal wells in BC

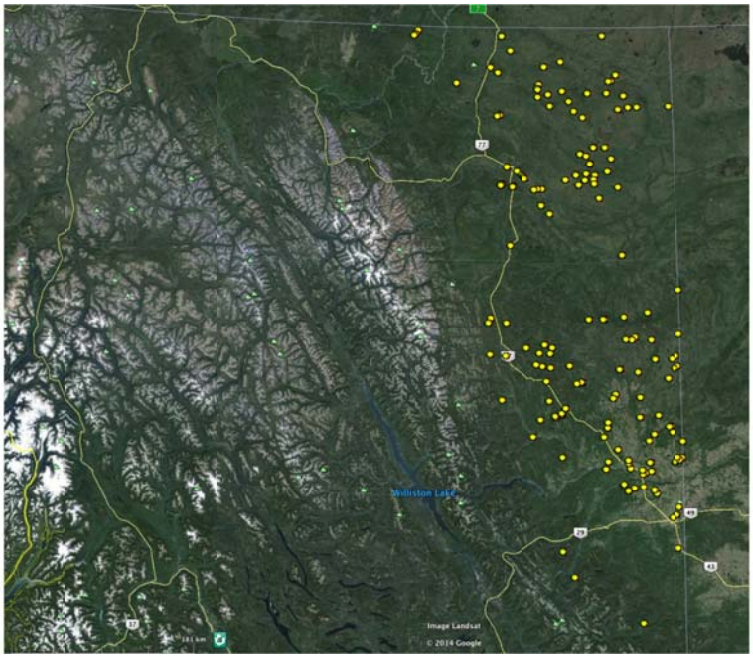


Figure 2: Number of wells used for disposal, by drilling date

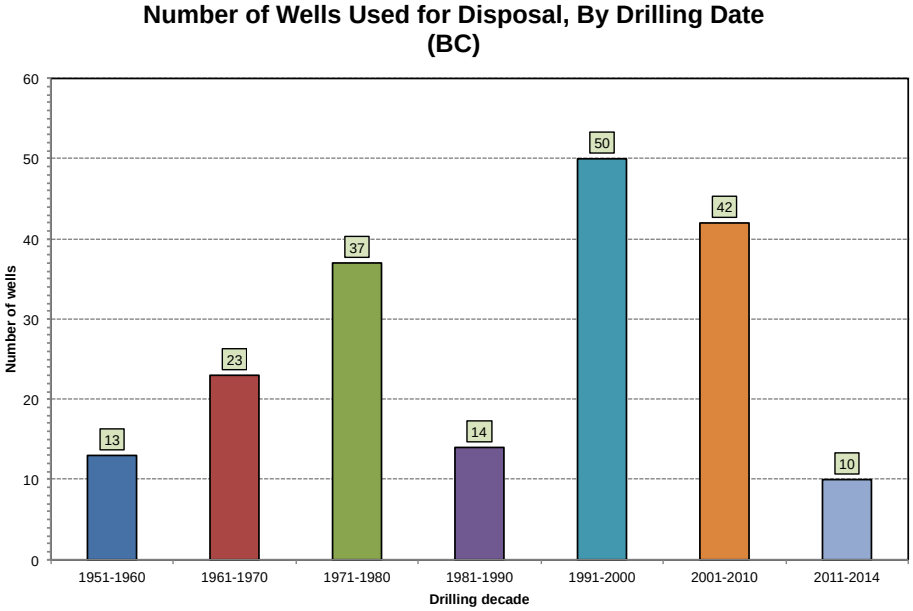


Figure 3: For wells drilled in each decade, how much waste has been injected?

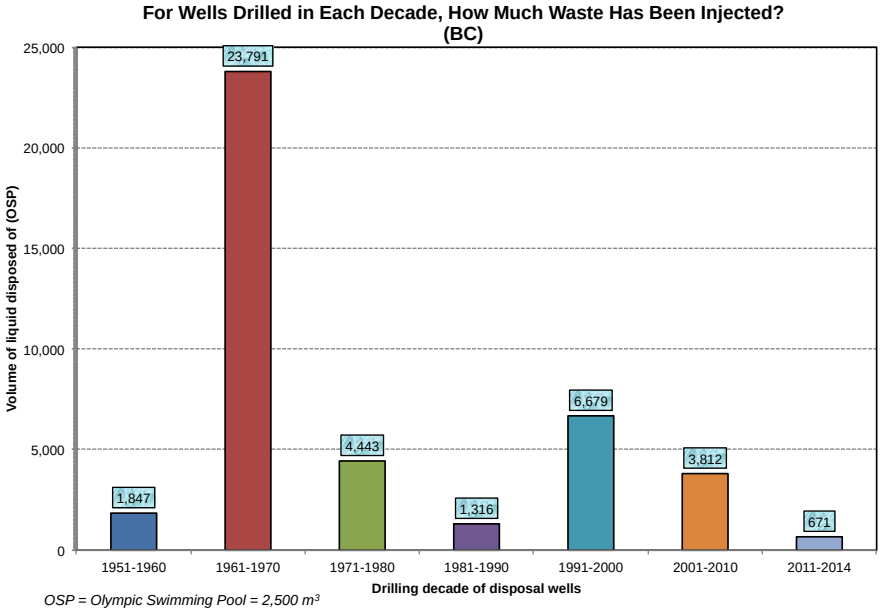


Figure 4: Percentage of liquid waste injected into old wells (more than 43 years old) in BC

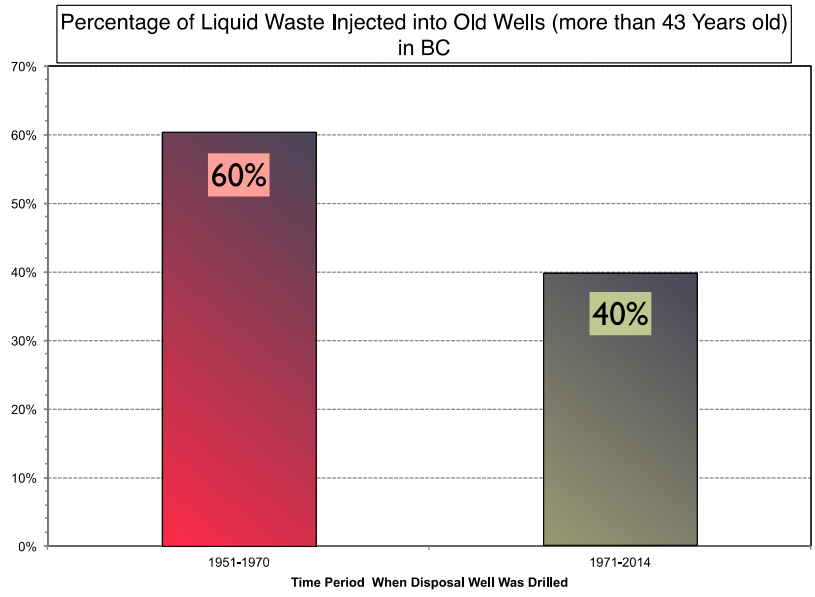
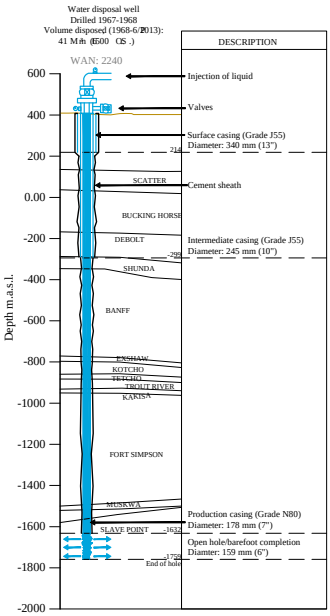


Figure 5: An extraordinary example: well #2240

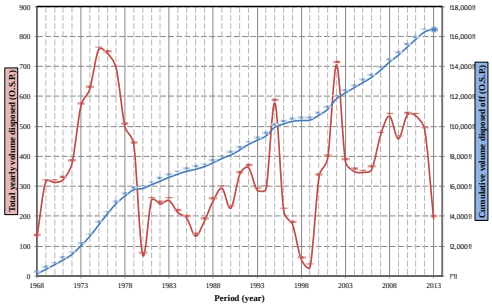


An Extraordinary Example: Well 2240
Drilled/completion 1967-1968

Volume disposed from 1968 to 06/2013: 16,494 OSP of "waste water"

16,494 OSP = 41 Billion litres, 39% of all liquid waste disposed of in BC

Volume disposed over time WAN: 2240



Tests completed on well 2240

- Acoustilog - 1967. Interval depth 214 to -299 masl (190 to 703 m depth)
- Acoustilog - 1968. Interval depth -299 to -1757 masl (703 to 2161 m depth)
- Dipmeter log - 1968. Interval depth -1391 to -1757 masl (1795 to 2161 m depth)
- Induction log - 1968. Interval depth -299 to -1759 masl (703 to 2163 m depth)
- Casing Collar Log - 2003. Interval depth -1486 to -1604 masl (1890 to 2008 m depth)

Appendix B: Scott Anderson's list of disposal well issues meriting close attention

This list is from an email communication with Scott Anderson, the EDF's Senior Policy Advisor, US Climate and Energy Program (March 31st, 2014). Mr. Anderson mentions in his email that these are five disposal well issues that merit close attention.

1. Are there sufficient safeguards against surface spills and leaks at disposal wells? E.g. truck accidents; lack of proper liners under tanks; lack of proper leak detection with regard to tanks.

2. Is the Area of Review (AOR) large enough/calculated with enough sophistication? (1/4 mile is not likely large enough for a big project, and fluids do not spread underground as perfect circles).

3. Are injection pressure limits conservative enough from the perspective of assuring continued integrity of confining caprock? (This is a safety factor issue - in the US, states tend to limit injection to anywhere from 70 to 90 percent of calculated frac pressure; in theory 99.99 per cent might be ok, but in practice 70 percent might be safer – this depends on how well the geology is known and how closely the well is watched).

4. Does the AOR review and evaluate not just inactive wells but also active wells? It should, at least if there is any chance that the active wells have not been constructed in a way to keep them from becoming conduits.

5. Induced seismicity. Are the wells being sited in an area that may be too risky? If so, prohibit them. Is it an area where a "traffic light" system may be in order? If so, develop one – which is much easier said than done.