BRITISH COLUMBIA’S APPROACH TO DRILL CUTTINGS DISPOSAL: IS LEGISLATION FIT FOR THE PURPOSE?

by

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B.A., Kazakh State University, 1995
A thesis submitted in partial fulfillment of the requirements for the degree of

MASTER OF ARTS
in
ENVIRONMENT AND MANAGEMENT
We accept this thesis as conforming to the required standard

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Abstract

Planned acceleration in hydrocarbon development is a growing concern among British Columbians. My thesis explores BC’s regulatory regime governing non-aqueous drill cuttings disposal. The thesis particularly evaluates the regulatory regime through the lens of waste management hierarchy with the objective of assessing the extent to which they prevent potential adverse impacts on public health and the environment. As part of the qualitative research, I interviewed subject matter experts and conducted a cross-jurisdiction comparison to identify whether or not the provincial legislation can be improved. The research identified the need for a single waste management strategy to be supported by the BC Government, BC Oil and Gas Commission, and the petroleum industry. The lack of a cumulative approach to environmental assessment in the province, and the inability of the Commission to take the lead in forming such strategy are major weaknesses of the regulatory approach to drill cuttings management in BC.
Acknowledgements

This project would not have been possible without continuous support from my family; I am indebted to my husband, Alexandr, for taking on my share of the chores, raising a teenager, walking my dog, and being there for me when I needed it most. I will be forever grateful to my son, Slav, for being my inspiration on this road *per aspera ad astra*.

I owe special thanks to my dear friends and colleagues, Paul Mowatt and Paul Ericsson for their support with the technical reviews and critique of my work. Your encouragement and advice kept me going during the past two years and without you I would not have been able to pull it together and complete my thesis while jumping from one plane to another, changing countries in which I worked, and the drill teams I have been proud to be part of.

I am grateful to my thesis supervisor, Wally Braul, who undertook this huge task of coaching someone who he has never met in person. It has been an interesting journey and I learnt a lot from you, Wally. I hope I have never disappointed you or caused you to regret the decision to become my supervisor.

Finally, I dedicate my research to John Handley, my friend and a great driller from Texas who taught me to love drilling holes in the ground, to ride a horse on a ranch, and to hunt deer in East Texas. Although you are no longer with us, this is for you, John.
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List of Abbreviations

AER  Alberta Energy Regulator
BC   British Columbia
BC OGC B.C. Oil and Gas Commission
DPR  Drilling and Production Regulation
EAA  Environmental Assessment Act
EAO  Environmental Assessment Office
EHP  Department of Environmental and Heritage Protection
EMA  Environmental Management Act
ESRF Environmental Studies Research Funds
HWR  Hazardous Waste Regulation
LNG  liquefied natural gas
NADF Non-Aqueous Drilling Fluids
NEBC Northeast British Columbia
NORM Naturally Occurring Radioactive Materials
OGC  Oil and Gas Commission
OGP  Oil and Gas Producers
PAHs poly-aromatic hydrocarbons
RPR  Reviewable Project Regulation
RRC  Railroad Commission of Texas
SPE  Society of Petroleum Engineers
WBFs water-based fluids
WCEL West Coast Environmental Law
WDR  Waste Discharge Regulation
WMC  Waste Management Chapter
WRRA Waste Reduction and Recycling Act
Introduction

Purpose of the Study

Oil and gas development is occurring throughout Northeast British Columbia (NEBC). More than 10,000 oil or gas wells were drilled in NEBC over the past decade (Oil and Gas Commission [OGC], 2013). In February 2013, BC Premier Christy Clark announced plans to support the development of Liquefied Natural Gas plants in BC to pay down provincial debt. According to Horne, Bailie, Sauvé, and Cretney (2014), the shale gas production to satisfy “extensive liquefied natural gas (LNG) exports to Asia” promoted by the BC government “would require over 10,000 wells pumping shale gas to B.C.’s coast” (para. 1).

Drilling for the exploration and extraction of oil and natural gas requires the use of drilling fluids (muds) that are continuously pumped down to control formation pressure, maintain hole integrity prior to casing installation, and cool and lubricate the drill bit and string (Ball et al., 2011, p. 457; Environmental Studies Research Funds [ESRF], 2009, p. 12; OGP, 2003, p. 3). These fluids are returned carrying the rock phase (cuttings) that is extracted from the well (International Association for Oil and Gas Producers [OGP], 2003, p. 3; Onwukwe & Nwakaudu, 2012, p. 251). Drilled cuttings that are removed from the wellbore and spent drilling fluids are typically the largest volume of waste streams generated during oil and gas exploration and production drilling (Reise, 1992, p. 3). As Reis (1996, p.3) asserts, drilling waste accounts for 2% of the total waste volume in the United States. The subject of my thesis is drill cuttings; however, since the properties of the
cuttings are defined not only by the geological materials through which a well is drilled, but also by chemicals that had originally made up the drilling mud (ESRF, 2009, p. 13), the thesis also discusses different types of muds that may contaminate the cuttings.

According to Murray, Clark, Epps, and Lin (2009), the most common types of drilling fluids in NEBC are mineral and synthetic oil-based fluids (Non-Aqueous Drilling Fluids or NADF), and to a lesser degree, diesel-based fluids (p. 1). Although a substantial part of the spent NADF is typically recovered and reused due to its high cost (OGP, 2003, p. 7; Ministry of Environment Environmental Protection Division, 2007, p. 11), the industry is still left to deal with NADF-contaminated cuttings, which, as some researchers assert, have the potential to adversely affect the environment and public health if disposed of without due consideration of the cumulative environmental impacts (Krzyzanowski, 2012, p. 130).

Historically, drill cuttings in NEBC are disposed of at ‘dirt farms’ near Fort Nelson or at well site ‘sumps’; the latter accounting “for over half of the land disturbances caused by a company during a typical project (West Coast Environmental Law [WCEL], 2003, p. 19). Together with other industrial developments, such disposal practices contribute to landscape structure fragmentation, faunal species range reductions, and overall loss of ecological integrity of forest ecosystems within the NEBC region (Nitschke, 2008, p. 1737).

I reviewed key BC Acts and regulations (Environmental Assessment Act of 2002, Drilling and Production Regulation of 2010, Oil and Gas Waste Regulation of 2005, Hazardous Waste Regulations of 1988, Contaminated Sites Regulation of 1996), and guidance policies (Drilling Waste Management Chapter of 2009 BC Oil and Gas Handbook), and interviewed subject matter experts from the BC Oil and Gas Commission, BC Ministry
of Environment – Clean Technologies Section, Canadian Association of Petroleum Producers, and several independent (non-industry) organizations to see how these concerns are being addressed in BC. I also reviewed and analyzed comparable laws and policies adopted in Alberta, Canada and internationally (particularly those with long histories of active onshore oil and gas development) to identify alternative approaches for dealing with NADF-contaminated drilling waste. The following sections describe the results of the above-mentioned research, analysis, and evaluation. A more detailed description of the research purpose is provided on page 22.

**Literature Review**

Policy evaluation requires operationalization and clear definitions of the key terms (Scriven, 2005, p. 237), as well as explicit use of specific assessment criteria for evaluating "each individual setting" (Crabbe & Leroy, 2008, p. 2). The following sub-sections provide detailed descriptions of "drill cuttings," various evaluation criteria, and four selected management options based on the interviews with the subject matter experts (summarized in the Results section).

**Drill cuttings.**

The toxicity of cuttings is greatly affected by the chemicals that originally made up the drilling fluids (ESRF, 2009, p. 13), and hence, it is important to understand how different types of such fluids may change the drilled cuttings properties.

Exploration, appraisal, and production drilling for oil and natural gas requires the application of drilling fluids, also known as muds (Ball, Stewart, & Schliephake, 2011, p. 10).
457; OGP, 2003, p. 3). The drilling fluids are circulated down the well though the hollow drill string and return through the well annulus removing drilled bits of rock (drill cuttings) from the well (Ball et al., 2011, p. 457; OGP, 2003, p. 3; Reise, 1992, p. 3). In addition to removing the drill cuttings from the borehole, drill fluids cool and lubricate the drill, protect, support and stabilize the borehole walls, and maintain pressure down-hole (Ball et al., 2011, p. 457; ESRF, 2009, p. 12; OGP, 2003, p. 3). The latter is especially important as it prevents the potentially dangerous, uncontrolled flow of formation fluids into the well that could result in a blowout (OGP, 2003, p. 3).

Drilling fluids are of two primary types: water-based fluids (WBFs) and non-aqueous drilling fluids (NADFs) (OGP, 2003, p. 5). A typical WBF consists of water mixed with bentonite clay and barium sulphate (barite), to control mud density, as well as a number of other substances, such as salts (ESRF, 2009, p. 12; OGP, 2003, p. 5). NADFs are emulsions of primarily non-aqueous materials (diesel, mineral oils, low toxicity mineral-based fluids, synthetic oils, etc.) with additives similar to WBFs (OGP, 2003, p. 5).

Based on their aromatic hydrocarbon content, NADFs are split into three groups (OGP, 2003, p. 6). Historically, diesel and mineral oils were the base fluids (together referred to as Group I – high aromatic hydrocarbon content) used in NADFs (ESRF, 2009, p. 11). These were later replaced with low toxicity mineral-based fluids from Group II (medium aromatic content) to address the concerns over the toxicity of diesel-based fluids (ESRF, 2009, p. 11; OGP, 2003, p. 6). Group III consists of synthetic-based fluids with the lowest concentrations of aromatic hydrocarbons, such as synthetic hydrocarbons and highly processed mineral oils (ESRF, 2009, p. 11; OGP, 2003, p. 6).
Because of their properties, NADFs have an improved drilling performance compared to WBFs (OGP, 2003, p. 6). The former exhibit low reactivity with water-sensitive formations (primarily shales) and hence ensure better wellbore stability; better lubricity improves the drilling of highly deviated extended reach and horizontal wells (also known as ‘unconventional wells’) by reducing friction between the drill string and walls of the borehole; NADFs are more stable in high temperatures at greater depths, and prevent the formation of gas hydrates (OGP, 2003, p. 7). The above-mentioned characteristics significantly reduce drilling time and notwithstanding the high cost ($250 to $2,500 / m^3), NADF is a preferred option for deeper, unconventional wells (OGP, 2003, p. 7). According to Murray et al. (2009, p. 1), NADFs (mineral and synthetic oil-based fluids) are the most common types of drilling fluids used in NEBC, and though diesel is not used as a base, diesel oil is still used as a mud additive. Considering that proposed shale gas developments require the use of NADF and diesel oil, this will likely remain the case.

Ordinarily, operators recycle and re-use as much of the used NADFs as they can, because of regulatory requirements and the drilling fluid’s high cost (OGP, 2003, p. 10). Solids control systems apply various technologies to remove formation solids from the drilling fluid and to recover the fluids so that they can be reused. In the treatment process, the equipment not only removes formation solids, but also reduces spent mud volumes and valuable components like barite and bentonite (OGP, 2003, p. 10). Ultimately, the solid waste that remains after treatment consists of the drill cuttings (small pieces of stone, clay, shale, and sand) and drilling fluid that adheres to the cuttings (OGP, 2003, p. 10).
Drilled formation cuttings that are contaminated with NADF (especially from Group I) contain toxic compounds such as hydrocarbons, heavy metals (e.g., barium, chromium, cadmium, mercury, and lead), and inorganic salts (Onwukwe & Nwakaudu, 2012, p. 252; Reise, 1996, p. 3). Heavy metals may enter the fluid system from additives or “from naturally occurring minerals in the formations being drilled through”; however, the latter are typically not bioavailable (Reise, 1996, p. 3). According to Reise (1996, p. 5), the toxicity of drilling muds varies considerably depending on their composition; toxicities (LC$_{50}$s) of NADFs “can exceed one million, which means that fewer than 50% of a test species will have died during the test period.” A number of poly-aromatic hydrocarbons (PAHs) that may enter the soil through permitted disposal of hydrocarbon-containing cuttings are also considered highly carcinogenic or mutagenic (Krzyzanowski, 2012, p. 126). The toxicity of heavy metals found in NADF cuttings differs greatly and is related to their ability to interfere with the action of an enzyme that in turn “limits or stops biochemical processes in cells” (Reise, 1996, p. 5). In addition, as some studies show, drilling rig personnel may be overexposed to hydrocarbons, and the oil mist that is generated from agitated or heated drilling fluids with high aromatic hydrocarbon content and additives to drilling muds may negatively affect the health of workers (Murray et al., 2009, p. 6). Drilled formation cuttings may also contain Naturally Occurring Radioactive Materials (NORM) that can be harmful, but these are outside the scope of this thesis, and hence, are not discussed herein.

According to Krzyzanowski (2012), the NEBC region “has experienced increased rates of cancers and other illnesses that have been linked to the contaminants and stressors
associated with [the upstream oil and gas industry]” (p. 125). Considering the potential impact of NADF cuttings on the ecosystems and human health in NEBC, my thesis is focused specifically on the issues related to the disposal of drill cuttings contaminated with non-aqueous drilling fluids.

**Evaluation criteria and available drilling waste management options.**

This thesis evaluates BC’s drill cutting regulatory regime, in particular, its efficacy with respect to preventing environmental impacts. Any evaluation study requires clear and explicit assessment criteria: “the precise nature of these criteria needs to be determined anew for each individual setting” (Crabbe & Leroy, 2008, p. 1). According to Muldoon, Lucas, Gibson, and Pickfield (2009), “environmental law is the body of legislated statutes and judge-made common law that can be used to protect and restore or improve the environment” (p. 9). This includes the regulation of pollution control, waste management, and other matters related to the prevention of damage through the reduction of potential impact; generally, environmental law in Canada aims at making things better and hence is “highly and openly value-laden” (Muldoon et al., 2009, p. 10).

As Reise (1992, p. 3; 1996, p. 1) asserts, one of the most efficient ways to reduce and mitigate environmental impact from exploration and production drilling activities is to develop and implement an effective waste strategy. To do so, operators need to identify the wastes generated by their proposed operations and apply suitable ways to manage, treat, and dispose of those wastes. The effective management of waste streams is a systematic process that sets out a preferred sequence of management steps (Onwukwe &
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Nwakaudu, 2012, p. 253; Reise, 1996, p. 7; Railroad Commission of Texas [RRC], 2001, p. 1-3). The first, and according to Reise (1992, p. 4), the most important step is to reduce the volume of toxic waste. Once this option is exhausted, the waste generator needs to move to the second step in the process, which is to reuse and recycle the waste (Reise, 1992, p. 4; Reise, 1996, p. 7; Onwukwe & Nwakaudu, 2012, p. 253). These two steps are the preferred options for waste minimization (Onwukwe & Nwakaudu, 2012, p. 253). Two further steps may be taken to deal with the wastes that remain after reduction, the reuse and recycle options: where the generator may treat and/or dispose of them (Reise, 1993, p. 4). These four options, identified by academic and professional sources as the waste management hierarchy (Onwukwe & Nwakaudu, 2012, p. 253; RRC, 2001, p. 1-3), should not be considered independently, but rather in a sequential and deliberate manner; one should not proceed to the next step or option until the previous one has been used up. The four options, and their sequential nature, are discussed below.

**Waste reduction.**

The first step in the waste management hierarchy is to reduce either the volume of generated drill cuttings or their toxicity, or both (Onwukwe & Nwakaudu, 2012, p. 253; Reise, 1996, p. 7; RRC, 2001, p. 1-3). According to RRC (2001), “source reduction is given the highest priority in the waste management hierarchy because avoiding waste generation altogether, or generating the least toxic waste possible, minimizes the problems associated with waste management” (p. 1-4).

The easiest source reduction approach is product substitution in drilling fluid systems, which should be done by drilling operators at the planning stage (Reise, 1996, p.
Many companies have found that replacing conventional Group I and II fluids (diesel and mineral oils) with low toxicity glycols, synthetic hydrocarbons, polymers, and esters from Group III is an effective drilling waste management strategy as it eliminates the generation of oil-contaminated cuttings (RRC, 2001, p. 5-4). According to some technical papers published by the Society of Petroleum Engineers (SPE), the industry is working on creating new fluid systems (including water-based muds) with suitable drilling properties but fewer toxic components or additives (Growcock, Curtis, Hoxha, Brooks, & Candler, 2002, p. 1; Using muds and additives with lower environmental impacts, para. 4, n.d.). As an example, an invert emulsion drilling fluid (Soil-Enhancing Synthetic Based Mud) has been developed with the same drilling characteristics as conventional invert muds, yet it can be used as a soil enhancer (Growcock et al., 2002, p. 1). Substitution of some of the key additives of drilling fluids, such as barite (the weighing agent), with less toxic products (e.g., hematite, calcium carbonate, and ilmenite) can reduce the loading of harmful substances to the environment (Using muds and additives with lower environmental impacts, para. 7, n.d.).

Another opportunity for waste reduction is in the use of an appropriate drilling practice to minimize the amount of drill cuttings generated. Typically, horizontal wells and directional drilling will generate less waste than several vertical wells, because the main well bore that produces the highest volume of cuttings (due to its diameter) is drilled only once (Drilling practices that minimize generation of drilling wastes, para. 6, n.d.; RRC, 2001, p. 5-5). Other process modifications are also available to reduce the volume of cuttings, e.g., slimhole drilling and coiled tubing drilling that involve drilling smaller diameter holes.
DRILL CUTTINGS DISPOSAL: ARE WE READY FOR MORE WELLS?

(Onwukwe & Nwakaudu, 2012, p. 254). Also, modification of solids control equipment and the addition of a secondary treatment step can ensure better recovery of NADF and cleaner cuttings (OGP, 2003, p. 10). The technologies and practices described above are not universally applicable; some of them are only appropriate for use in specific circumstances (Drilling practices that minimize generation of drilling wastes, para. 6, n.d.). Hence, for the purposes of this thesis, I will use product substitution as the key measure for waste reduction criteria.

**Waste reuse and recycling.**

When reduction at the source is not practical, the next preferred option is recycling. Recycling includes the reclamation of useful constituents of a waste material, removal of contaminants from the waste, or reuse of the waste for some other purpose (Onwukwe & Nwakaudu, 2012, p. 254; RRC, 2001, p. 1-4). As mentioned earlier, the NADF that is removed from the cuttings through primary solids control systems (shale shakers), when augmented with secondary equipment (vertical cuttings driers, centrifuges, etc.), can be successfully reused in drilling or plugging successive wells; such recovery of NADF generates lower volumes of muds that require disposal at the end of the drilling campaign and cuttings that retain a lower content of drilling fluid (OGP, 2003, p. 10). The resulting NADF cuttings may be re-used as fuel or in road construction, though for such uses, as much salt as possible would have to be removed prior to application (OGP, 2003, p. 20).

A combination of source reduction and recycling can form a waste minimization strategy (RRC, 2001, p. 5-4). The two remaining waste management options (waste treatment and disposal) are the least preferred.
Waste treatment.

Various methods are available for treating hydrocarbon-contaminated drill cuttings. Solids can be washed by a jet of high-velocity water with an added surfactant (Reise, 1996, p. 8). Bioremediation technologies are also available for treating the hydrocarbon-contaminated cuttings, including land-spreading, land-farming, and composting (Ball et al., 2011, p. 464; OGP, 2003. p. 20; Onwukwe & Nwakaudu, 2012, p. 255; RRC, 2001, p. 5-30). “Bioremediation can be defined as any process that uses organisms (bacteria, plants, fungi) or other enzymes to biologically degrade contaminated soil and waste into non-toxic residues” (Ball et al., 2011, p. 464). According to OGP (2003), “land spreading involves spreading untreated cuttings evenly over an area followed by mechanical tilling with addition of nutrients, water, air and or oxygen as necessary to stimulate biodegradation by naturally occurring [in soil] oil-degrading bacteria” (p. 20). Land-farming is similar to land-spreading except that material is applied several times at the same location. According to OGP (2003), both technologies “are more efficient in warm tropical climates, and may be inapplicable in areas where the ground is frozen part of the year” (p. 20). OGP (2003) suggests using composting as an alternative bioremediation method in cold climates. In composting, drilling cuttings are mixed with organic bulking agents, such as wood chips, straw, or other organic waste material to enhance aeration and microbial numbers (Ball et al., 2011, p. 464; OGP, 2003, p. 20). By combining the piling of material with the addition of bulking agents, high temperatures in the pile may occur, “which further increases rates of biodegradation and volatilization” and hence is more preferred in cold climates (OGP,
DRILL CUTTINGS DISPOSAL: ARE WE READY FOR MORE WELLS?

2003, p. 20). Like land-spreading and land-farming, composting may require tilling and the addition of water, nutrients, and oxygen (Ball et al., 2011, p. 464; OGP, 2003, p. 20).

Of the non-biological treatment options, thermal treatment is the most commonly used. The thermal technologies that have been used to treat wastes high in hydrocarbon content include thermal desorption and incineration (Ball, 2011, p. 463; OGP, 2003, p. 20; RRC, 2001, p. 5-30). With thermal desorption, cuttings are placed in a treatment unit and then heated (OGP, 2003, p. 20). The liquids are volatilized and re-condensed back into two phases: water and NADF (OGP, 2003, p. 20). The resulting waste streams are water (that will require treatment), hydrocarbons (that can be re-used), and solids (with essentially no residual hydrocarbons but still containing salt and heavy metals) (Ball, 2011, p. 463; OGP, 2003, p. 20). Incineration involves the combustion of cuttings that leads to oxidation of the hydrocarbons. “Stabilization of residual materials may be required prior to disposal to prevent constituents from leaching into the environment” (OGP, 2003, p. 20).

**Waste disposal.**

An operator may dispose of drilling waste off-site and on-site. On-site burial of NADF cuttings is limited to re-injection into a disposal well since burial of cuttings containing hydrocarbons, salts, metals, and other contaminants is not recommended (Ball, 2011, p. 460; OGP, 2003, p. 20). During re-injection, cuttings are ground up, mixed with produced water into a slurry, and injected into sub-surface formation (OGP, 2003, p. 14). The technology is limited to certain geological settings, as it requires the presence of a suitable formation with appropriate properties for the disposal and containment of the cuttings and associated NADFs (OGP, 2003, p. 14; Onwukwe & Nwakaudu, 2012, p. 255).
Among other disadvantages of this approach is the risk of groundwater contamination should the containment fail (OGP, 2003, p. 20; Onwukwe & Nwakaudu, 2012, p. 255). Cutting re-injection has been successfully used onshore on Sakhalin Island, Russia in challenging arctic conditions (Walker, 2012, para. 8).

According to Ball et al. (2011), sending formation cuttings, either treated or untreated, to landfills is another common method for disposing of drilling waste (p. 460). Based on several reports, historically, in NEBC drilling, wastes are disposed of at ‘dirt farms’ outside of Fort Nelson, or at a well site in a ‘sump,’ which “account for over half of the land disturbances caused by a company during a typical project” (WCEL, 2003, p. 19). Large landfills designed for disposal of drilling wastes from multiple wells are special facilities with built-in protective measures to prevent leaching or vaporizing of hazardous substances (Ball, 2011, p. 460; OGP, 2003, p. 20). Landfills must be carefully designed and continually maintained and monitored to sustain their effectiveness in containing waste (OGP, 2003, p. 20).

Treatment and disposal are the least favored options because, unlike source reduction, not only do they not “eliminate the creation of pollutants” (RRC, 2001, p. 5-30), but these options also generate hazardous by-products (e.g., emissions from incineration and waste water generation as a result of surfactant washing). Nevertheless, treatment can make the drill cuttings less hazardous and subsequently safer to transport, store, and dispose of; in some circumstances, wastes may be re-used following treatment (Onwukwe & Nwakaudu, 2012, p. 254; RRC, 2001, p. 1-4). These “end-of-pipe” approaches may have further long-term environmental and human health impacts related to the potential
contamination of soil and groundwater due to leaks and spills during transportation and on-site and off-site handling of the drilling wastes, and generation of air emissions, e.g., from running the treatment equipment and transport (OGP, 2003, p. 20). These options may be costly because of the rental of treatment equipment and disposal payments, installation of pollution abatement devices, and long-term use of large land areas for landfills and land application (RRC, 2001, p. 1-4). According to the OGP (2003, p. 21), land requirements are estimated to be approximately 0.04 acres per well for a landfill, depending on the assumptions. Such use of land increases the environmental load, because of landscape structure fragmentation, faunal species range reductions, and overall loss of ecological integrity of forest ecosystems within the NEBC region (Nitschke, 2008, p. 1737). If pollutants migrate to the groundwater or soil, larger scale, long-term impacts could be caused to the ecosystems and human health (OGP, 2003, p. 20).

Table 1 summarizes the hierarchy of options described above. The summarized hierarchy serves as an analytical framework used to locate BC and other jurisdictions. That is, the table is intended to facilitate, in the sections below, an informed and systematic comparison of BC and other jurisdictions.

Table 1

<table>
<thead>
<tr>
<th>Source reduction</th>
<th>Re-use and recycling</th>
<th>Treatment</th>
<th>Disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product substitution – use of less toxic components and additives in drilling fluids.</td>
<td></td>
<td></td>
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<tr>
<td>Creation of new fluid</td>
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<tr>
<td>Use of better solids control equipment to recover NADF from cuttings (closed-loop systems, centrifuges, etc.).</td>
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<tr>
<td>Non-biological: thermal treatment (incineration, desorption), washing by a jet of high-velocity water with surfactant.</td>
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<tr>
<td>Disposal at off-site landfills.</td>
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<tr>
<td>Re-injection into a disposal well.</td>
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<tr>
<td>Disposal at a well site</td>
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</tbody>
</table>
Table 1: Options for NADF Cuttings Disposal

<table>
<thead>
<tr>
<th><strong>Source reduction</strong></th>
<th><strong>Re-use and recycling</strong></th>
<th><strong>Treatment</strong></th>
<th><strong>Disposal</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of drilling techniques minimizing drilling waste: horizontal drilling, directional drilling, slimhole drilling, and coiled tubing drilling.</td>
<td>Re-use of NADF cuttings as fuel.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Addition of a secondary treatment step to ensure better recovery of NADF and cleaner cuttings.</td>
<td>Re-use of treated NADF cuttings as filling material, or in road construction.</td>
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</tr>
</tbody>
</table>

Statement of Research Purpose

The "Purpose of the Study" indicated in the Introduction section summarizes the approach used in this thesis. The "Purpose" is elaborated in the following "Statement of Research Purpose".

The purpose of my thesis is to assess how the BC regulatory regime – comprising BC Acts, regulations and associated guidelines and policies – addresses drilling waste generated from onshore drilling with NADF, particularly from the perspective of potential adverse impacts to the environment and public health in Northeast British Columbia (NEBC). The BC regime is assessed with the framework described in Table 1. An underlying assumption of that framework is that the effective management of possible drilling waste impacts requires the development and implementation of a waste strategy (Reise, 1996) that uses a sequence of preferred waste management options (Onwukwe &
Nwakaudu, 2012, p. 253; Reise, 1996, p. 7; Railroad Commission of Texas [RRC], 2001, p. 1-3). The hierarchy approach shown in Table 1 is widely recognized in academic literature, in that waste reduction, reuse, and treatment and disposal should be considered and used to “manage drilling wastes in the most environmentally friendly manner possible” (Onwukwe & Nwakaudu, 2012, p. 253) with due consideration of operational and cost implications of each approach. The conceptual framework of Table 1, applied to the drilling waste context, helps to characterize the BC regulatory regime. Most notably, the following key factors formed the basis for the document review and interview questions:

- Requirement to broadly apply waste management hierarchy with waste reduction being the preferred option.
- Source reduction requirement to evaluate the use of lower toxicity mud to reduce environmental and health impacts.
- Drivers for selecting the waste management options by operator.

The same framework and key questions have been applied to other jurisdictions with longstanding oil and gas regimes, to allow for a further layer of assessment of the BC regime. This comparison also identifies certain lessons for possible reform from other jurisdictions that may have a longer history of active oil and gas development.

**Research Questions**

The study explored the following research questions:

1. To what extent does the BC regulatory regime prevent or mitigate potential adverse impacts from non-aqueous drilling waste disposal?
2. How does BC compare to other regulatory regimes and what lessons do the other regimes provide for reforming BC’s regime?
Significance of the Study

Several prominent environmental organizations, including West Coast Law and the Environmental Law Centre of the University of Victoria, have been actively involved in educating the public and provincial officials on the potential consequences of legislative apathy and in pushing for a law reform (Sandborn, 2012; WCEL, 2003). Currently, the BC government is undertaking an extensive review of the existing environmental laws to ensure they can meet the requirements of the growing resource-based industries and the needs of an increasing population in the province (C. Sandborn, personal communication, October 15, 2013). The research results are aimed at assisting policy makers, provincial government, and industry leaders involved in the law review in their legislative deliberations, since the thesis highlights both strengths and weaknesses of the existing legislation for managing NADF drill cuttings generated by the oil and gas industry.

This thesis may also be of interest to the general public in BC, where political debates are currently focused on the issue of shale gas fracking and pipeline projects in BC. In addition, wider audiences may not be aware of the potential issues associated with drill cuttings disposal, should the provincial government decide to proceed with plans for accelerated oil and gas developments in NEBC. My research will serve to make stakeholders aware of the issue and help them understand what management tools the BC government has in place to ensure that environmental legislation does its job to minimize health and environmental risks.

The conclusions and recommendations section describes recommendations for potential changes to BC laws and policies to reduce the potential environmental impacts.
from NADF drill cuttings disposal. The conclusions are based on the findings from the review of BC and other jurisdictions’ legislation in this area and from the interviews with the governmental officials and environmental NGOs.

**Methodology**

I used formative evaluation research methodology (Scriven, 1996, p. 158; Patton, 2000, p. 436; Walliman, 2006, p. 39) to study BC’s drilling waste regulatory regime. Evaluative research requires comparing the acquired data to standard, evaluative criteria (Hedrick, Bickman, & Rog, 1993, p. 73). Hence, the initial task was to operationalize and define key parameters and accepted approaches used for the evaluation. To avoid potential distortion of the research data ascribed to a normative study, I used the triangulation approach: I reviewed three sources of data (the BC regulatory regime, peer-reviewed scientific publications, and industry and third parties’ reports) and augmented these with interviews of government officials, industry representatives, and environmental NGOs. A detailed description and justification of the methodology are presented in the following five sections that cover justification of the methodological approach, validity and reliability, data collection and project participants, data analysis, and limitations and delimitations of the study.

**Justification of the Methodological Approach**

The purpose of this study is to assess BC’s regulatory regime, with respect to NADF drill cuttings disposal, particularly how it can effectively prevent or mitigate adverse impacts on health and environment. The formative evaluation methodology is especially
suitable for this assessment because it is designed “to move beyond ‘just getting the facts’ in order to make sense of the myriad human, political cultural and contextual elements involved” (Walliman, 2006, p. 38).

A common theme of the findings is the wide diversity of views for how the drilling waste regulatory regime should be reformed. The "evaluative approach" provides guidance for reviewing these diverse views, especially for achieving the study’s objective of providing practical lessons for BC. One leading proponent of the "evaluative approach," Scriven (1996, p. 158; 2007, p. 236), defines evaluation methodology as “the process of determining the merit, worth, or significance of things”. According to Clarke and Dawson (1999), evaluation is a type of policy research, a form of applied research, “the primary purpose of which is... to study the effectiveness with which existing knowledge is used to inform and guide practical action” (p. 2). Various other academics emphasize the practical use of evaluation research (Clarke & Dawson, 1999, p. 2; Patton, 2000, p. 436; Walliman, 2006, p. 39) when it has a particular emphasis on improving policy making, rather than just proving a theory (Clarke & Dawson, 1999, p. 2). These latter authors suggest that the orientation to policy making ("serving a decision maker") can be applied to social research (Clarke & Dawson, 1999, p. 174), while Scriven (2005, p. 236) sees the policy orientation as only one aspect of the task of evaluation.

Scriven is often credited with introducing two major elements in classifying the roles of evaluation: formative and summative (Clarke & Dawson, 1999; Scriven, 1996). The aim of the former is to improve a process or entity with the intention of remediating (Scriven, 1996, p. 153; Scriven, 2000, p. 273), while the latter is mostly concerned with
outcomes, such as the overall effectiveness or impact of a program or project, “with a view of recommending whether or not it should continue to run” (Clarke & Dawson, 1999, p. 8). Scriven himself, however, largely disagrees with such an artificial clear-cut dichotomy and argues that an evaluation can be both formative and summative, based on the context, and whether or not an evaluator decides on selecting either approach depends solely on the circumstances and context of the particular situation and on the role of the evaluator (Scriven, 1996, p. 154).

The evaluative approach, together with the notion that “the formative evaluation is aimed at improvement... and is more likely to benefit from an analytic approach” (Scriven, 1996, p. 157), have defined the methods selected for this research. One needs to bear in mind, however, that:

The results of any particular effort cannot be guaranteed. Each evaluation being a blend of unique ingredients, no standardized recipe can assure the outcome. We have only principles, premises, and utilization-focused processes to guide us, and we have much yet to learn. But, the potential benefits merit the efforts and risks involved. At stake is improving the effectiveness of programs that express and embody the highest ideals of humankind (Patton, 2000, p. 438).

**Validity and Reliability**

Evaluative research is fundamentally normative research based on value claims (Hedrick et al., 1993, p. 73). Value claims, while subjective, can be subjected to rigorous scrutiny. To apply such scrutiny, I followed Scriven (2005, p. 237), who suggests several
ways of justifying answers to value enquiries in a scientific and disciplined way. Notably, the validity of any inference “from factual premises to evaluative conclusions” can be made through operationalization and clear definition of key terms (Scriven, 2005, p. 237). As Scriven (2005) asserts, “because they are definitions, they do not count as values’ premises; that is, imported assumptions about the values” (p. 237). Scriven (2005) further suggests that evaluative conclusions should be validated “by legal research or systematic needs assessment,” which can be combined with “facts about a program’s performance to imply the merit (or lack of merit) of the program” (p. 237).

One of the dangers of the descriptive research approach, according to Walliman (2006), is a great chance of “distortion of the data” (p. 39). This risk is especially relevant in subject matter such as drilling waste disposal, which has attracted substantial and diverse public opinion. I addressed this risk with data triangulation methods, where the validity and reliability of qualitative data collected and my conclusions may be assured by collecting more information and empirical evidence in different ways and from multiple data sources (Thiétart & Wauchope, 2001, p. 199). Drucker-Goddard, Ehlinger, and Grenier (2001) similarly recommended using multiple sources of data in research, such as unstructured or structured interviews and various types of documentation to improve the “construct validity” (p. 200). This process is known as triangulation (Flick, 2007, p. 37; Newing, 2011, p. 115).

Of the several types of triangulation described by Flick (2007, p. 39) and Newing (2011, p. 115), the triangulation of data and cross-method triangulation are most useful for the design of this research. The former involves, for example, using different sources to
collect information on the same subject, and the construct validity can then be verified by comparing the results of documentary content analysis with the data collected by different methods (e.g., interviews with subject matter experts) (Thiéart & Wauchope, 2001, p. 207). The cross-method triangulation presumes the sequential use of multiple methods of data collection on the same subject (Newing, 2011, p. 57).

Finally, both Newing (2011, p. 75) and Thiéart and Wauchope (2001, p. 208) emphasize the significance of reaching saturation, the point at which the researcher can clearly see patterns in the collected data but further data gathering produces insignificant amounts of information, or no new information, which does not improve the researcher’s understanding of the issue under study. According to Thiéart and Wauchope (2001), “a sufficiently large amount of data helps to ensure the soundness of the data collection process” (p. 208).

Overall, as Patton (2000) notes, “the issue is not meeting some absolute research standards of technical quality but, rather, making sure that the methods and measures are appropriate to the validity and credibility needs of a particular evaluation purpose and specific intended users” (p. 433).

**Data Collection and Project Participants**

As Clarke and Dawson (1999) assert, “it is rare to find an evaluation study based on only one method of data collection” (p. 67). Using a range of data collection methods typically serves as a confidence-building safeguard; that is, relying on a range of data collection methods forms the “core of an overall research strategy, thus ensuring that the information acquired has the depth and detail necessary to enable the evaluator to produce
DRILL CUTTINGS DISPOSAL: ARE WE READY FOR MORE WELLS?

a report from which conclusions can be drawn with a certain degree of confidence” (Clarke & Dawson, 1999, p. 67).

The research methods used for this thesis are qualitative in nature. I conducted a review and analyzed factual information and documentation, and then conducted interviews with subject matter experts.

Ordinarily, data collection for applied research such as this thesis relies heavily on documentary evidence (Hedrick et al., 1993, p. 73). Hence, my first step involved the review and analysis of content of several types of documents, notably:

(a) relevant Acts, regulations and guidance policies (e.g., Environmental Assessment Act of 2002, Drilling and Production Regulation of 2010, Oil and Gas Waste Regulation of 2005, Hazardous Waste Regulations of 1988, and Drilling Waste Management Chapter of 2009 [BC Oil and Gas Handbook]),

(b) published and grey literature (reports done by industry and independent consultants), and

(c) official statistical and annual audit reports relating to drilling waste management.

This documentary review focused on "establish[ing] standards to help address normative questions: determining legislative intent, reviewing regulations and laws,... or identifying other sources of guidance” (Hedrick et al., 1993, p. 74). Of the many BC documents that deal with drill cuttings, I selected those that would likely assist in addressing the two fundamental "normative questions" described above. Similar documentary reviews were conducted with respect to analogous regulatory regimes in Alberta, Texas, US, and Queensland, Australia.
The next research stage involved interviewing experts. This research was similarly focused on the two fundamental questions stated in the "Research Purpose" above. Interviewing is another research method widely used by evaluators (Clarke & Dawson, 1999, p. 72; Kelly, 2008, p. 304). I used a combination of non-probability sampling strategies: targeted sampling (in-depth, more than 1-hour long interviews with subject matter experts from the provincial government, industry, and independent non-governmental organizations) and chain-referral. The interviews were qualitative and semi-structured (Newing, 2011, p. 53). I chose semi-structured interviews since, according to Clarke and Dawson (1999), open-ended questions are “designed to elicit more qualitative information and the interviewer can vary the order and phrasing of questions should this prove necessary within the context of an individual interview” (p. 72). Also, the interviewer is able to “probe for more information by encouraging respondents to digress and expand upon their answers” (Clarke & Dawson, 1999, p. 72), which is vital for research involving politicians who are used to giving vague and ambiguous answers.

For semi-structured interviews, I developed a written interview guide with five open-end questions and five supplementary questions. This approach is recommended by Pierce (2008, p. 126). The advantage of this approach is that semi-structured interviews with subject matter experts from various groups facilitates learning more about the subject of the research from different perspectives (Flick, 2007, p. 51; Newing, 2011, p. 115). These questions were primarily informed by the findings in the above-noted documentary research. The questions used for the interviews can be found in Appendix 1, and the consent form signed by the interviewees is provided in Appendix 2.
As noted above, my documentary research included consideration of three other regulatory regimes. This consideration was not intended to be comprehensive, but sufficient to inform a comparison of BC with the other jurisdictions. I selected the three other jurisdictions and portions of the regulatory regimes based on my professional experience within the industry. This professional judgment is in line with the adopted evaluation approaches that define the evaluator's role as a judge “when the emphasis is on determining a program's overall merit or worth” (Patton, 2000, p. 430).

**Interview Data Analysis**

I analyzed the qualitative interview data by identifying major themes in each separate interview. Initially, I divided the transcripts into segments corresponding to the five open-end questions and five supplementary questions from the written interview guide. I further analyzed each of the segments to see if ideas were emerging in the interview. The data were manually coded, that is, “a systematic form of annotation that involves marking sections of the text with standardized ‘codes’... that indicate the themes that they touch upon” (Newing, 2011, p. 245). I developed the codes from scratch in the process of reviewing the interview data. Once key themes were evident, I checked across all interviews to identify common ideas or concepts that later became the basis for the descriptive analysis, a narrative account describing and interpreting the key findings (Newing, 2011, p. 251).

The analysis stage was followed by interpretation with the objective “to create a storyline linking the different aspects together into a coherent account” (Newing, 2011, p. 251). As part of the interpretation task, I summarized information on particular topics
across a set of interviews in table format (Newing, 2011, p. 252). Based on the results of the data analysis, I identified what was important in the data, why it was important, and what the data was saying about the research subject.

Limitations and Delimitations

I view the following as the key limitations of this research:

- Time and resource constraints that require difficult trade-offs and lead to limited time for detailed analysis of collected data.
- Naturalistic fallacy ascribed by some in the field of evaluative research.
- Incorrect/biased interpretation of the legislation. The laws are typically written in a ‘special’ language that may be difficult to decipher.
- Limited objectivity of the information, by interviewing only people on one side of the debate – i.e., government officials (BC Oil and Gas Commission, the key regulator for oil and gas industry in the province).

I chose to delimit my research by applying the following:

- Adapting two triangulation approaches: cross-method and between-subject triangulation. I used factual data (regulations, official statistical reports from the BC OGC) and interviews with various stakeholders to ensure my understanding of the laws and how they are correctly applied. Also, I asked several people from NGOs and the industry about the same regulations and their value for mitigating adverse environmental impacts.
- Setting up “a position of strength at the start by being clear and transparent about the methods being used and the research process” (Kelly, 2008, p. 307), having clear quality standards to which I would adhere, and identifying and discussing in my thesis the different agendas of the stakeholders.
Avoiding the naturalistic fallacy, “a mistake of moving from a statement of fact (an ‘is’) to a moral judgment (an ‘ought’) without stating the value criteria for the judgment” (G. Brown, personal communication, October 3, 2012), by supplying the missing reasoning.

Results

These research results are broken down into several categories. The results section begins with a review of BC legislation and policies, and is followed by an examination of certain other jurisdictions and where they fall under the options, summarized in Table 1. Table 2 presents a high-level comparison of BC and the three other selected jurisdictions. The section ends with the results of the interviews with selected interviewees on relevant issues; summaries of the interviews are presented under the themes described in Table 2 at the end of the section.

BC Legislation and Policies Guiding NADF Drill Cuttings Disposal

A number of laws and regulations govern the operation of oil and gas exploration and production activities in BC. In terms of drill cuttings contaminated with hydrocarbons, the following regulations affect management and disposal approaches to various extents: Environmental Management Act, 2003 (EMA) and its Waste Discharge Regulation (2004), Hazardous Waste Regulation (1988), Contaminated Sites Regulation (1996), and Oil and Gas Waste Regulation (2005); Drilling and Production Regulation (2010); Environmental Assessment Act (2002); and policies (Drilling Waste Management Chapter of BC Oil and Gas Handbook [2009]).
The EMA prohibits the discharge of waste from prescribed industries, trades, businesses, operations, and activities to the environment unless the director of waste management designated by the Minister of Environment authorized the discharge (Environmental Management Act [EMA], S.B.C. 2003, c 53, s 6). According to the EMA, “a director may issue a permit authorizing the introduction of waste into the environment subject to requirements for the protection of the environment that the director considers advisable” (EMA, S.B.C. 2003, c 53, s 14). Other acceptable forms of authorization are comprised of approvals, operation certificates, and regulations issued in accordance with the EMA (EMA, S.B.C. 2003, c 53, s 6). The EMA explicitly bans the introduction of waste to the environment “in such a manner or quantity as to cause pollution” (EMA, S.B.C. 2003, c 53, s 6).

Waste Discharge Regulation, 2004 (WDR) defines prescribed industries, trades, businesses, operations, and activities under the EMA and establishes a three-tiered approach for discharges to the environment based on the risk to the environment and public health (Waste Discharge Regulation [WDR], B.C. Reg. 320/2004, O.C. 723/2004, s 2). The upstream oil and gas industry is a prescribed activity under the WDR (WDR, B.C. Reg. 320/2004, O.C. 723/2004, s 2). This means that, for the vast majority of oil and gas industry activities in BC, some form of authorization under the EMA is required for the discharge of wastes.

According to the Hazardous Waste Regulation, 1988 (HWR), hazardous waste from upstream oil and gas industry may include, among others, NADF cuttings if the oil content in them exceeds 3% (Hazardous Waste Regulation [HWR], B.C. Reg. 63/88, s 1). The HWR
provides a definition of hazardous waste and establishes minimum standards and requirements for handling, storing, transporting, and disposing of it. The HWR effectively bans the underground injection of hazardous wastes (HWR, B.C. Reg. 63/88, s 37), though the Oil and Gas Waste Regulation, 2005 (OGWR) provides an exemption for produced water (Oil and Gas Waste Regulation [OGWR], B.C Reg. 254/2005, s 7). According to the HWR, waste treatment is considered one of the recycling options, where recycle means to “wholly utilize hazardous waste or residue from a hazardous waste management facility” (HWR, B.C. Reg. 63/88, s 1). The regulation sets minimum sitting and operational standards for all hazardous waste facilities including waste treatment facilities and secure landfills. A substantial focus of the Regulation is on the hazardous waste transportation, manifesting, and reporting procedure.

Another regulation under the EMA is Contaminated Sites Regulation, 1996 (CSR). Essentially, the Regulation defines contaminated sites (Contaminated Sites Regulation [CSR], B.C. Reg. 375/96, s 1) and contains standards for contaminants in soil, sediment, and water (CSR, B.C. Reg. 375/96, Schedule 1). If the standards are exceeded, the resulting site will be classified as a contaminated site, so any land application or discharge of drilling waste must be managed in such a way that the resulting concentrations of substances in the soil do not exceed the established values (end points) (CSR, B.C. Reg. 375/96, s 5).

Also under the EMA is the Oil and Gas Waste Regulation, 2005 (OGWR), which authorizes the discharges of upstream oil and gas waste to the environment. The authorization reduces or completely eliminates the requirement for site-specific waste discharge approvals or permits for the facilities to which the OGWR applies.
covers most upstream oil and gas facilities (OGWR, B.C Reg. 254/2005, s 7). The regulation authorizes discharge to land of “waste drilling muds, and drill cuttings generated by drilling operations that use water-based drillings muds” provided it is done in accordance with the British Columbia Oil and Gas Book and requirements of the Agricultural Land Commission Act (OGWR, B.C. Reg. 254/2005, s 7). As for “drill cuttings generated by drilling operations that use non-aqueous drilling mud, such as oil-based or synthetic-based muds,” a discharge to the environment requires prior written notification provided to the Director of waste management, who sets the requirements for the discharge (OGWR, B.C Reg. 254/2005, s 7).

According to the OGWR, the Director may request additional information that in the opinion of the Director is “required to ascertain whether the discharges are causing or may cause adverse effects” (OGWR, B.C. Reg. 254/2005, s 8). A person who discharges or proposes to discharge waste into the environment must provide additional information that includes, but is not limited to, environmental impact assessments (OGWR, B.C. Reg. 254/2005, s 7).

Drilling and Production Regulation, 2010 (DPR) under the Oil and Gas Activities Act 2010, regulates drilling and production operations. It establishes minimum requirements for storage and disposal of drilling waste (Drilling and Production Regulation [DPR], B.C. Reg. 282/2010, s 51). The B.C. Oil and Gas Commission is designated as the provincial regulator for the oil and gas industry and is the owner of the BC Oil and Gas Handbook, mentioned earlier. Based on the powers under the Oil and Gas Activities Act, 2010, the B.C. Oil and Gas Commission administers regulations and grants approvals under designated provincial statutes, including the Environmental Management Act, 2005. According to
Section 111(1) of the Oil and Gas Activities Act (B.C. Reg. 282/2010), the BC OGC may also “make regulations respecting the carrying out of an oil and gas activity, including, without limiting, regulations as follows: ... respecting waste produced directly or indirectly by the carrying out of an oil and gas activity”.

Only two sections of the mentioned BC Oil and Gas Handbook, 1999 still exist: Emergency Response Plans and Drilling Waste Management. The latter of these was last updated in 2006. Essentially, it refers to Hazardous Waste Regulation, 1988 and Oil and Gas Waste Regulation, 2005 for disposal methods (Waste Management Chapter [WMC], 2006, p. 15). The Waste Management Chapter also states that “if, because of oil or any other constituent of the waste, the waste is designated as a hazardous waste, the waste must be handled pursuant to the requirements of the Hazardous Waste Regulation (HWR)” (WMC, 2006, p. 15). This statement assigns the responsibility to the Ministry of Environment, as the Hazardous Waste Regulation (1988) is under the auspices of the Ministry.

The last act in the list of legislations is the British Columbia Environmental Assessment Act, 2002 (EAA) that may be applicable to drilling waste management. The first EAA was passed in 1994 (Environmental Assessment Act [EAA], S.B.C. 1994, c 35), which established the Environmental Assessment Office, tasked with providing “an open, accountable and neutrally administered process for the assessment” of a broad range of “reviewable projects” (EAA, S.B.C. 1994, c 35, s 2). The purpose of the BC EAA, 1994 was “to promote sustainability by protecting the environment and fostering a sound economy and social well-being” and “to prevent and mitigate adverse impacts of reviewable
projects” through “timely and integrated assessment of the environmental, economic, cultural, heritage and health effects of reviewable projects” (EAA, S.B.C. 1994, c 35, s 1).

In 2002, the provincial government repealed and replaced the 1994 EA Act “as part of a broader deregulation initiative across provincial environmental laws” (Haddock, 2010, p. 223). Although both EAA (1994) and EAA (2002) came up with respective Reviewable Project Regulations for determining which projects should undergo assessment using a project-threshold approach, the Reviewable Project Regulation (RPR) (B.C. Reg. 370/2002) exempted some of the projects from the review by increasing thresholds (e.g., hazardous waste treatment facilities if their treatment capacity was below 100,000 kg per day) (Reviewable Project Regulation [RPR], B.C. Reg. 370/2002, s 10). It also repealed the requirement for an environmental assessment report to include “consideration and evaluation of alternative sites and methods to the proposed project” (Haddock, 2010, p. 224). The new EAA states that the Minister of Environment has the authority to designate a project as reviewable if the Minister “is satisfied that the project may have significant adverse environmental, economic, social, heritage or health effects, and that the designation is in the public interest” (Environmental Assessment Act [EAA], S.B.C. 2002, c 43, s 6). Nevertheless, this power has not been exercised (Haddock, 2010, p. 229), and the Minister has not yet designated for assessment such highly intrusive undertakings as exploration for oil and gas (Environmental Assessment Office [EAO], n.d.).

Generally, neither of the Acts designate exploration and production drilling for oil and gas as reviewable projects. Although a federal environmental assessment must be conducted for drilling oil and gas wells on federal land (Northern Canada and on Indian
Reserves), “in BC federal environmental assessments are limited to well drilling projects that might harm fish habitat and require an authorization under the Fisheries Act” (WCEL, 2003, p. 24). According to WCEL (2003, p. 24) the federal public registry contains very few examples of upstream oil and gas project assessments since 1995.

Overall, the analysis of current regulations in BC indicate that the focus in the province is on disposal of the drilling waste, which effectively puts BC into the furthest right column in Table 1. I found no evidence of a waste hierarchy, in general, or waste reduction, specifically, being explicitly spelled out in the major regulations described in this section.

**Summary of Drilling Waste Disposal Adopted by Other Jurisdictions**

To analyze the drilling waste disposal options adopted by other jurisdictions, I selected Queensland, Australia; Texas, US; and Alberta, Canada. All three places have active onshore drilling projects and a long history of oil and gas development. In addition, due to historic and economic ties, BC regulators try to harmonize legislation with their neighboring province, and hence, the comparison of the two Canadian provinces would be of interest. Although the selected jurisdictions may differ substantially from BC in terms of climatic conditions, making the comparison of disposal options difficult and unjustified, the evaluation criteria used in the research provides for an objective assessment of drill cuttings disposal options available through regulatory tools. This section summarizes the result of the review of documentary evidence pertaining to the drilling waste management regulations and practices adopted in other jurisdictions.
Queensland, Australia.

In Queensland, Australia, the Department of Environmental and Heritage Protection (EHP) is the environmental regulator of petroleum operations (Department of Environmental and Heritage Protection [EHP], 2013, p. 1). EHP is guided primarily by two acts: the Environmental Protection Act, 1994 (Qld) (EPA) (1994) and the Waste Reduction and Recycling Act, 2011 (Qld) (WRRA) and relevant regulations. The object of the Queensland EP Act is to promote ecologically sustainable development (Environmental Protection Act [EPA] 1994 (Qld), s 3); the WWRA is complimentary to this in that it promotes waste management principles such as avoidance, reduction, and resource recovery and efficiency actions (Waste Reduction and Recycling Act [WRRA] 2011 (Qld), s 3). The WRRA formally introduces a waste and resource management hierarchy where waste disposal is the least preferred option, used only when no viable alternative is available (WRRA 2011 (Qld), s 9). The WRRA establishes a polluter pays principle, where all costs associated with the management of waste, including rectifying environmental harm caused by waste, are borne by the waste generator (WRRA 2011 (Qld), ss 10, 11).

Operators need to apply to EHP for an environmental authority (EA) for oil and gas developments that are considered an environmentally relevant activity under the Environmental Protection Act (EPA 1994 (Qld), s 37[b]). Applications for EAs for projects that include drilling of wells must include characterization and assessment of waste drill fluids and cuttings (EHP, 2013, p.3). Waste characterization is required to establish if the waste is regulated and trackable (EHP, 2013, p.2). Certain additives, such as ethers, mineral oils, emulsions, etc. will most likely trigger the regulated and trackable waste
classification. Trackable wastes have special record-keeping requirements and handling responsibilities. In addition to waste characterization, operators are required to assess environmental risks for each additive, including environmental fate and transport, ecotoxicology, biodegradation, potential for bioaccumulation, etc. (EHP, 2013, p. 4). An application for EA must also include a proposed drill waste management strategy. According to EHP (2013, p. 4), “this will assist EHP to assess the proposal and develop site-specific conditions in the EA for managing environmental impacts associated with the handling, storage, treatment, transport, and disposal of the drilling fluids and/or cuttings”. Accordingly, drilling fluids “should be used in such a way that enables drilling activities to be carried out effectively, but also in a way that minimizes waste generation and protects the environment” (EHP, 2013, p. 4).

If drill cuttings are not regulated waste, the operator or another company can use them, for example, in road construction, brick/concrete/block manufacturing, fill and composting/soil conditioning (EHP, 2013, p. 4). The WRRA requires beneficial use approval (BUA) for the beneficial use of drilling wastes (WRRA, 2011 (Qld), s 156).

In summary, Queensland Department of Environmental and Heritage Protection can be firmly placed between the first two columns of Table 1 (“Reduction” and “Re-use and Recycling”) with the overall focus on drilling waste reduction.

Texas, US.

Hazardous and non-hazardous wastes are managed in accordance with the federal waste regulations under the Resource Conservation and Recovery Act (RCRA), originally
enacted in 1976 (RRC, 2004, p. 1-1). In 1980, however, recognizing the unique characteristics of oil and gas waste, US Congress specifically exempted waste associated with exploration, development, and production of crude oil or natural gas from the RCRA Subtitle C as hazardous wastes (RRC, 2004, p. 1-3). “Exempt oil and gas wastes are generated by a large number of individual oil and gas operations – around 250,000 wells and 12,500 operators in Texas” (RRC, 2001, p. 3-2). This exemption is known as the “E&P Exemption” and it covers, among others, drilling fluids and drill cuttings generated onshore, as well as those from offshore operations if disposed of onshore (RRC, 2004, p. 1-5). Although these wastes are exempt from hazardous waste regulation, other regulations will apply, such as the Railroad Commission Statewide Rule 8, which governs the transportation, storage, and disposal (other than by underground injection) of exempt and nonexempt nonhazardous oil and gas wastes (RRC, 2004, p. 5-24).

The Texas Railroad Commission (RRC) is an equivalent of the BCOGC. In addition to regulating oil and gas operations for the purpose of conserving natural resources, the RRC also has jurisdiction over oil and gas wastes, including all wastes from drilling operations. Based on the Texas Natural Resources Code, the Commission is legally obliged to encourage oil and gas waste reduction and minimization by implementing a Waste Minimization Program (RRC, 2001, p. viii). The program offers assistance to oil and gas operators and, according to RRC (2004, p. 1-6), operators who participated in the program were able to efficiently reduce the volume of waste that needed to be treated or disposed of. As part of the program, the Commission provides operators with training and technical assistance on waste reduction and minimization, technology transfer, and waste minimization planning
software, as well as on-site assistance with assessments of operations and the development of individualized waste minimization plans. The RRC developed a manual with the assistance of the industry that offers source reduction and recycling concepts, practical examples from other operators, and guidance on developing an individualized waste minimization plan (RRC, 2004, p. 1-7).

Generally, in terms of waste management strategies, Texas belongs in the first two columns of Table 1, similarly to Queensland, Australia. The active stance of the RRC on drilling waste reduction and their role in the overall process is worth a special note.

**Alberta, Canada.**

Pursuant to the Oil and Gas Conservation Act and its regulations, the Alberta Energy Regulator (AER, formerly ERCB) is responsible for developing and maintaining requirements for the management of oilfield wastes in the province, including drilling waste, and for ensuring that these wastes are stored, treated, and disposed of in accordance with the AER requirements (Alberta Energy Regulator [AER], 2012, p. 6). The key regulatory document used by the AER to manage oilfield waste is Directive 50 that was initially adopted in 1996 and updated as recently as May 2012.

The Directive was designed to provide oilfield operators with drilling waste management practices and methods “that are protective of the environment and harmonized with other waste management practices” (AER, 2012, p. 5). The regulation sets out waste management techniques to ensure that “drilling waste is restored to equivalent land capabilities” (AER, 2012, p. 5) and monitoring and reporting requirements.
Notably, by ‘absorbing’ several earlier and interim regulatory publications, the Directive became a single manual for the operators containing all the necessary information pertaining to drilling waste, from soil endpoint requirements, to waste management options, storage, and handling requirements.

The Directive does not split drilling wastes into hazardous and non-hazardous; rather, it requires an operator to do an assessment of waste toxicity and select an appropriate management method based on the analytical results. For land applications, such as landspray, landspray while drilling, and disposal onto forested public lands, the operators have an option of developing a generic mud system, analyzing it, and using the result to determine the applicability of each disposal method to alleviate any uncertainties about resulting waste toxicity (AER, 2012, p. 23). If drilling practices change, and a different component is added to the mud system, the toxicity levels are required to be re-assessed.

Land application methods are only applicable if the endpoints for salts, metals, and hydrocarbons are not going to be exceeded. The operators may make this decision based on calculations that predict hydrocarbon concentrations in soil/waste mixes using the formulas provided in the Directive’s Appendix 6. An analysis of drilling waste samples for parameters specified by the regulation is a mandatory requirement. Certain waste management methods, such as landspray while drilling, pump-off, mix-bury-cover, land spreading, and disposal onto forested public lands are not allowed for hydrocarbon-based cuttings (unless these have undergone biodegradation).
 Basically, the three methods approved by the AER for hydrocarbon-based drilling waste management are biodegradation (land treatment and biodegradation in contained systems), subsurface disposal, and shipment to approved waste management facilities. The Directive stipulates the requirements for biodegradation treatment and any deviation from them must be approved by the AER (AER, 2012, p. 66). Once treated, cuttings may be disposed to the land (mix-bury-cover, spreading, etc.), landfilled, or used as an ingredient to manufacture a product or by-product, provided the AER has approved such use. Subsurface disposal “is a planned process that involves disposing drilling waste down the wellbore of a well that is in the process of being drilled and has had surface casing set and cemented to a depth that will cover the known base of groundwater protection” (AER, 2012, p. 77). Lastly, approved waste management facilities are regulated by a separate regulation, Directive 058, which establishes the requirements for dangerous and non-dangerous oilfield waste facilities and accepted waste parameters, and regulates the use of mobile thermal treatment units for the management of drilling waste.

Overall, Directive 50 is harmonized with BC regulations that manage hydrocarbon-based cuttings, though it provides more waste management options than the BC Waste Management Chapter. The major difference is that the Alberta regulator, AER, is solely responsible for all drilling waste, whether NADF or water-based. At the same time, Directive 50 does not have any incentives for waste reduction or re-use and is mostly focused on disposal, though some operators are voluntarily moving toward reduction. For example, Encana Corporation uses recycled drilling cuttings and clays in constructing well pad foundations and for road surfacing, and invested $15 million over a three-year period
into improved biodegradation at 38 sites, 21 of which were completed by 2006 (Encana, 2005). Another example is the Breton Soil Treatment Facility, which operates in the Pembina area; the facility treats and re-uses contaminated soil and cuttings contaminated with invert muds on a commercial basis using bioremediation, soil washing, thermal desorption, bioventing, and other techniques (Breton Soil Treatment Facility, para. 1, 2005-2006).

In summary, the Alberta regulations are similar to those adopted by BC, though a trend can be seen for the AER to take more control over the fate of drilling waste. Although the AER provides more regulatory options for waste management, in terms of regulatory regime, the province is largely stuck between the last two columns of Table 1, namely, “Treatment” and “Disposal,” without explicitly stated objectives to move towards waste reduction.
Table 2

Summary Jurisdiction Comparison

<table>
<thead>
<tr>
<th>Waste reduction</th>
<th>Re-use and recycling</th>
<th>Treatment</th>
<th>Disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Queensland: the legislation promotes waste generation avoidance and reduction by making the generator cover all costs related to waste management. Environmental authorities (permits) issued by the local regulator to operators is the key mechanism in waste reduction. As part of the permitting process, the regulator requires operators to do drilling waste categorization and risk assessment, and to propose management strategies with the view of liability and financial implications. The local regulator typically prohibits use of oil and synthetic-based fluids via conditions on the permits.</td>
<td>Queensland: cuttings can be directed for beneficial use (construction, composting/soil conditioning). Beneficial Use Approval is required for re-use of regulated cuttings.</td>
<td>BC: the current legislation provides for bioremediation and thermal treatment of NADF cuttings; however, the decision is with the operator. The regulatory regime provides no incentive for going this route.</td>
<td>BC: if the oil content in NADF cuttings exceeds 3%, they are deemed hazardous waste and should be disposed of at specialized hazardous waste facilities. If the oil content is less than 3%, cuttings may be discharged to the environment provided the Director of waste management approves.</td>
</tr>
<tr>
<td>Texas: local regulator promotes recycling and reuse of drilling waste as a substitute for a commercial product, or as feedstock in an industrial process.</td>
<td>Alberta: the regulations allow for re-use of treated drill cuttings as an ingredient to manufacture a product or by-product provided the local regulator has given approval.</td>
<td>Alberta: regulatory regime provides for treatment of drill cuttings (land treatments, biodegradation) provided certain conditions are met and the local regulator approves. Use of thermal treatment units for drill cuttings treatment is another approved method for cuttings management.</td>
<td>Alberta: the regulations are focused on injection of drill cuttings into subsurface as an on-site and off-site disposal method, discharge of treated drill cuttings to the land, and disposing of the waste at secured landfills.</td>
</tr>
<tr>
<td>BC: the current legislation provides for bioremediation and thermal treatment of NADF cuttings; however, the decision is with the operator.</td>
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</table>
Summarized Results of Semi-Structured Interviews

This section presents an overview of the major themes that emerged during the analysis; more detailed information on specific views by the interviewees is described in Table 3. The full transcripts of the interviews are provided in Appendix 3.

Environmental assessment process and its role in selection of alternatives.

As discussed earlier, exploration and production of oil and gas is generally not subject to the Environmental Assessment Act. Without environmental assessment being part of the Act, the interviews were designed to identify what review was being used to regulate drilling waste. The interviewees generally confirmed that each well application goes through a review process with the Oil and Gas Commission. The OGC process, according to the interviewees, has several defining features. In particular, certain interviewees described the OGC process as more of a high-level land use review (setbacks, proximity to streams, etc.) that does not necessarily deal with the characteristics of the chemical mud or the volume of hazardous waste that might be generated from drill cuttings.

A feature of the OGC review, noted by one of the interviewees, requires proponent and OGC consultation with potentially affected First Nations. This process, according to the interviewee, could be used to identify environmental issues. Also, as one of the interviewees suggested, the OGC can add specific environmental conditions (such as product substitution for more environmentally benign components in muds) to the well permits they issue.
EA can apply to drilling waste in certain limited circumstances. Most notably, landfills used to treat NADF cuttings are subject to provincial EA. Aside from EA, construction of secure landfill facilities for hazardous wastes require Ministry of Environment (MoE) authorizations that mandate precautionary measures being in place, such as setting up a liner system, placing facilities in areas with predominantly clay material, establishing groundwater monitoring systems, etc.

A criticism of BC’s EA legislation, expressed by some interviewees, was that it focuses on project-by-project assessment, so that even where environmental impacts are assessed, the process fails to consider cumulative impacts from multiple projects. Hence, according to some interviewees, switching to region-based environmental assessment and aligning the activities between several operators, e.g., by using common infrastructure and adopting common waste management strategies, impacts could be reduced by avoiding landscape fragmentation, which will also help to preserve biodiversity in the region. As one of the respondents put it, since waste management from oil and gas operations has been fairly static for a long time, it would be beneficial to reassess how it could be done with a more strategic approach or at a bigger regional context, rather than at a project-specific or well-specific basis.

**Drivers for selection of waste management options.**

My review of BC’s regulatory regime found that NADF cuttings designated as hazardous waste cannot be discharged to the environment without the relevant authorizations. Further, any disposal or new treatment technology for NADF cuttings
requires approval of the Director under the Environmental Management Act, and operators are encouraged to contact the Ministry of Environment as early as possible when planning the drilling program. Some interviewees noted that authorizations for drilling waste, both aqueous and non-aqueous, are made “after the fact,” when waste has already been generated in the production process, without requiring any reduction or change in the wellsite production process or technology.

The interviewees also noted that current practice in BC is to send NADF cuttings to approved commercial treatment and disposal facilities (landfills). Earlier attempts had been made to treat the cuttings onsite via a bioremediation process, which did not prove to be efficient, though it had been authorized under the Waste Management Chapter. It may still be cheaper to use landfills, and hence, operators have no incentive to pursue other options.

Generally, all of the participants cited economic considerations as the key factors defining waste disposal methods. Due to the high cost of the non-aqueous mud systems, the operators try to recover and reuse as much as they can, but only as far as it is cost effective. In the words of some participants, until it is a regulatory requirement, or until the cost of new treatment technology goes down, operators will not use other waste management options. Both regulatory and financial incentives are needed for the industry to make smarter choices. Economic incentives, such as additional tax on drilling waste or reduction in royalties, were also mentioned by the interviewees as a way to push the industry towards NADF drill cuttings reduction.
Another issue that was frequently mentioned by the interviewees was the long-term liability for operators. One respondent suggested that disposal of NADF cuttings at a landfill may not necessarily mean that the generator is no longer liable for any future damage; for example, due to leachate from the facility. An interviewee suggested that it would be better financially for even small operators not to haul their waste to the landfill, considering the long-term liability and the risks and costs of dealing with hazardous materials.

Enhanced collaboration with other jurisdictions, and between the industry and regulators in drilling waste reduction.

All the interviewees mentioned the need for better coordination and collaboration between BC and the other western provinces, as well as between the Ministry of Environment, the Oil and Gas Commission, and the industry in efforts to reduce drilling waste.

The interviewees noted that the Ministry of Environment has limited opportunities to contribute to what is happening onsite due to their lack of industry experience and technical expertise in the drilling process. The OGC has relevant knowledge but considers itself “a policy taker, not a policy maker,” relying on the MoE and Ministry of Energy and Mines to make any changes in the regulatory regime. Both regulators appear to presume that the industry will take the lead on cuttings reduction by introducing it as “the best industry practice”. The industry, in turn, has good information flow and collaboration with the regulator (OGC) but would like to have better interactions with policy makers, e.g., with the Ministry of Environment.
Some of the interviewees expressed concerns about potential consequences of pushing for waste reduction in isolation from the other jurisdictions and the need to harmonize BC legislation with other western provinces. Specifically, if the changes in regulations are not synchronized with Alberta, operators may start hauling their waste to the neighbouring province, as was the case decades ago when BC did not have approved waste treatment and disposal facilities.

**Factors affecting BC’s regulatory capacity in the oil and gas sector.**

According to all of the participants, the oil and gas industry in the province is still new and growing too quickly, with active development beginning in just the past 10-15 years. The provincial government is still learning how to deal with industry issues; amending existing regulations takes a long time and can be delayed because of conflicting priorities among the ministries.

The BC government’s creation of the OGC in 1998, as a single window for the oil and gas industry, was viewed by the experts as a big step since it resolved the issue of having to apply to multiple regulators for the required permits. Nevertheless, the interviewees generally perceived that the OGC is not a policy-making organization, but just a regulator, and the policy-making function still lies with the various provincial ministries.

One of the interviewees mentioned the isolation of bureaucracy from the industry in BC. Typically, opportunities for learning exist when people with industry experience work for the government, and vice versa. In BC, an insufficient movement takes place between policy makers and industry, which can affect the communications between regulators and
industry, and inhibit the decisions made by both sides that are based on a broader understanding of the issues.

**Split responsibility for drilling waste between the OGC and the Ministry of Environment.**

At present, the OGC cannot act as a single window with regards to all drilling waste; in line with BC regulations and policies, the authority for NADF cuttings lies with the MoE under the Environmental Management Act and its Hazardous Waste Regulation. Nevertheless, if the amount of oil in cuttings is brought below 3%, the Oil and Gas Waste Regulation leaves it open for the OGC to authorize the disposal. Therefore, with the right technology, the OGC will be able to manage that waste stream. At the moment, however, the split responsibilities could affect the effort to reduce the volume of NADF cuttings that are generated. Currently, the MoE is not involved with onsite activities to the same extent as the OGC, and therefore, cannot influence the process. The OGC, though a single window for operators, is not authorized to manage NADF cuttings and may not take as many steps towards reducing the impact of that waste stream.

**Table 3**

*Major Themes Identified in the Interviews*

<table>
<thead>
<tr>
<th>Themes</th>
<th>BC Ministry of Environment</th>
<th>BC Oil and Gas Commission</th>
<th>Canadian Association of Petroleum Producers</th>
<th>Environmental Non-governmental Organization #1</th>
<th>Environmental Non-governmental Organization #2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Environmental Assessment (EA) process and its role in selection of alternatives</strong></td>
<td>Clean Technologies Section comes into the picture too late, when the drilling waste has already been generated. We</td>
<td>Oil and gas activities on site have not been subject to the EA. It’s down to drilling and production engineers to decide which mud</td>
<td>The EA process is not absent; it is just different. OGC has a suite of experts who can identify environmental issues.</td>
<td>BC EA law is weak and inadequate, especially with regards to the alternatives. We are stuck in a project-by-</td>
<td>We need to move from project-based to region-based EAs, to a strategic approach focused on aligning the activities between</td>
</tr>
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</table>
DRILL CUTTINGS DISPOSAL: ARE WE READY FOR MORE WELLS?

<table>
<thead>
<tr>
<th>Drivers for selection of NADF drill cuttings management options</th>
<th>In 1990s, attempts were made to treat invert cuttings biologically. Those attempts failed due to high residual levels of other co-contaminants, e.g., salt. Current practice is to send invert cuttings to secure landfills. They are spreading out and more are being proposed. There is a movement within the industry to use newer, better technologies, without actually being regulated. The trend is due to economics and liability issues.</th>
<th>It's cheaper to landfill than to remediate. The government needs to focus on what technologies are available and what incremental cost would be incurred before making it a mandatory requirement. Operators are already reducing and reusing as much as they can if it's cost-effective and because of liability issues. But environmental protection should not be driven just by positive economics.</th>
<th>There's an economic driver in this. It may be cheaper to take the drilling waste to landfills, but there should be both regulatory and financial incentives to make smarter choices.</th>
<th>The ability of companies to maintain their social license for their operations will become the driver. Economic incentives, such as additional tax or reduction in royalty, should be introduced. A need exists to identify who has the long-term liability for the waste: the Crown or the taxpayers?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhanced collaboration with other jurisdictions, and between the industry and regulators in drilling waste reduction</td>
<td>BC and Alberta must have synchronized efforts, as drilling waste from BC should not go to landfills in Alberta. We need to coordinate our efforts in waste reduction with OGC as we don't have enough expertise to tell operators which mud to use. We don't have much influence on what is going on on-site.</td>
<td>MoE is reorganizing to be more industry-focused, so we anticipate better traction and closer ties with the new oil and gas group. OGC only regulates. We don’t make the policy. MoE can change their legislation. CAPP needs to be involved so that regulators don't do something on their own. Alberta and Saskatchewan should also be involved, for consistency.</td>
<td>The level of cooperation between the industry and the OGC is good; we meet quarterly to discuss the issues. But OGC is a policy taker, not a policy maker. This is what a regulator should be. The MoE needs to step in. The ministries and regulators have different databases and they need to bring their systems together.</td>
<td>The existing split in drilling waste regulation between two different regulators requires better coordination if we want to figure out how to best regulate those aspects.</td>
</tr>
<tr>
<td>Factors affecting BC's regulatory capacity in the oil and gas sector</td>
<td>The oil and gas industry in BC is still new and has been actively developing for the last 10 years or so. We are still trying to learn from other jurisdictions, but amending regulations</td>
<td>BC OGC is a policy taker, not a policy maker. The policies that are set up by government are used either through the Ministry of Energy and Mines or the Ministry of Cross-pollination is not taking place between industry and the policy makers in BC, and hence, the regulators are lacking people with true industry experience. The historical focus</td>
<td>The regulatory capacity is an issue. In BC, oil and gas developments are recent (last 5-10 years) and have happened too quickly. Time is not available to deal with the Oil and gas development is new for BC and people may not realize how much impact accelerated drilling can have if we start implementing the provincial</td>
<td></td>
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Discussion

This study was based on the following research questions:

1. To what extent does the BC regulatory regime prevent or mitigate potential adverse impacts from non-aqueous drilling waste disposal?

2. How does BC compare with other regulatory regimes and what lessons do they provide for reforming BC’s regime?

This section is organized to respond to the questions with express consideration of the framework proposed in Table 1.

**Question 1: To what extent does the BC regulatory regime prevent or mitigate potential adverse impacts from non-aqueous drilling waste disposal?**

As noted above, an efficient way to reduce and mitigate environmental impact from exploration and production drilling activities is to develop and implement an effective waste disposal approach (Reise, 1992, p. 3) comprised of a sequence of preferred waste...
management options, such as source reduction and recycling, which would form a waste minimization strategy (RRC, 2001, p. 5-4). To recall from the above discussion, the remaining two waste management options are waste treatment and disposal, which are the least favored because, unlike source reduction, they do not “eliminate the creation of pollutants” (RRC, 2001, p. 5-30). They are “end-of-pipe” approaches and could have further long-term environmental and human health impacts related to the potential contamination of soil and groundwater, due to leaks and spills during transportation, on-site and off-site handling of drilling wastes, and the generation of air emissions (OGP, 2003, p. 20). All four options form the evaluation matrix (Table 1), which was used as a framework for the current study.

My research, especially the results of interviews with subject matter experts, demonstrates that disposal is the most common way of dealing with NADF cuttings in BC, which places the province in the last column of Table 1. This common industry practice is consistent with the predominant theme in the regulatory regime on disposal. The regulations I reviewed in the course of this study were predominantly focused on criteria for drill cuttings discharge to the environment, mechanisms for regulating the discharges, and minimizing the impacts from such disposal methods.

The interviews support the other research findings that the BC approach is focused on disposal. Although the Hazardous Waste Regulation (1988) provides for a thermal treatment option, the interviewees indicated that this is rarely used due to economic considerations. Based on the Waste Management Chapter (2006), other treatment options may be used if authorized by the Ministry of Environment, and the interviews suggest that
several attempts have been made in the NEBC to use bioremediation to treat NADF cuttings, which were authorized by the Ministry. These attempts eventually failed due to the inability to meet the limits, as prescribed by the Contaminated Sites Regulation (1996), e.g., for salt content, and because the operators had to haul their NADF cuttings first to Alberta and then to secure disposal facilities in BC once they were set up. Overall, no reference was made to the minimization strategies discussed in Table 1 in any of the reviewed regulations.

This research attempted to identify reasons for the focus on the disposal option. One of the factors appears to be the split jurisdiction over drill cuttings between the Ministry of Environment and the BC Oil and Gas Commission, which share the authority for drilling waste handling. Jurisdiction over a particular drilling waste is established from the oil content; according to the Hazardous Waste Regulation, if the oil content in cuttings is $>3\%$, they become hazardous waste and are regulated by the MoE under the powers given to it by the Environmental Management Act (2005). In all other cases, drill cuttings are managed by the OGC.

The split responsibilities require very close and efficient coordination of the efforts between the two regulators, especially if the objective is to reduce and re-use the cuttings. As indicated by the interviewees, this can lead to a gap; while the HWR is ‘owned’ by the MoE, which is the policy-maker for anything related to hazardous waste, the Ministry has limited industrial expertise and capacity, and is little involved with onsite operations. By the same token, because OGC, which has closer ties with the operators and regulates their onsite activities through various permits, is not responsible for hazardous waste, it relies
on the Ministry for any changes in regulations and policies related to potential reduction of the waste stream. In this research, all of the interviewed experts agreed that the collaboration between the regulators needs to be improved to improve the management of NADF cuttings. In summary, the OGC is a 'policy-taker' while the Ministry of Environment is the maker of drilling waste disposal policy. The latter agency, however, does not have day-to-day experience with the cuttings issues.

The interviewees also suggested that an industry perspective on evolving technologies could assist in developing new options that have less reliance on disposal. Although waste minimization strategies are not the focus of the current legislation in the province, as noted during the interviews, operators in NEBC are trying to recover and reuse as much NADF as possible due to the high cost of the mud. Industry initiatives in waste reduction and for new technologies that reduce the hydrocarbon content of the drill cuttings could inform the development of regulations that discourage reliance on the disposal option.

Not all technologies and practices for drill cuttings minimization may be universally applicable: some are only appropriate for use in specific circumstances, whereas others can function in many settings but may not be cost-effective. Consequently, operators need to carefully consider new technologies and practices. The total cost of drilling a well is usually hundreds of thousands to millions of dollars (RRC, 2001, p. 5-45). These technologies are not chosen simply for their ability to reduce drill cuttings volumes, and waste management costs are only one small component of the total well cost (RRC, 2001, p. 5-45). The technologies must provide increased performance and save money for the operators.
Nevertheless, as they are used, they can contribute to a waste management benefit. In BC industry, the decisions for using certain waste reduction practices and technologies are not subject to financial incentives or disincentives from the regulatory regime; that is, the decisions in the industry are mostly based only on internal financial criteria. This is in contrast to the use of certain financial incentives in the regulatory regimes in Queensland, Australia. In that jurisdiction, polluters must pay, so that the industry bears not only the costs associated with containing, treating, and disposing of waste, but also the costs of rectifying environmental harm caused by the waste (the ‘externalities’). In the drill cutting context, the actual cost of cuttings disposal would be much higher, if the potential future liability and damage to public health and the environment are taken into account.

A further weakness of the BC legislation is the lack of focus on strategic environmental impact assessments for new and existing developments and projects. An ecosystem approach requires a holistic and large-scale understanding of development impacts. Such understanding means going beyond individual projects and taking a higher-level strategic assessment approach. In the Environmental Assessment Act (2000), the Province attempted to introduce strategic assessments in Section 49, which allowed the Minister of Environment to direct the Environmental Assessment Office to “undertake an assessment of any policy, enactment, plan, practice or procedure of the government” (EAA, 2002, S. 49), but according to Haddock (2010, p. 229), “this provision has not been used in more than a decade”. Such strategic assessment of environmental impacts from accelerated drilling programs proposed by the provincial government could highlight issues with the current lack of drilling waste management strategy in BC. More wells
drilled will inevitably result in disposal of greater volumes of NADF cuttings, to increase demands on the infrastructure, such as the requirement to have additional secure landfills. Without careful planning and a drastic change to the strategic approach to drilling waste management, large-scale impacts from the government-supported plan will further fragment ecosystems, with habitat degradation and loss of ecosystem resilience.

Another gap in the 2002 Act is the lack of requirements for assessing the cumulative effects of several projects in the same geographical region. The academic literature suggests that “assessing cumulative effects is good practice, makes good sense, should assist in making good decisions about sustainable development and it is a requirement in many countries” (Connelly, 2011). According to West Coast Environmental Law (WCEL, 2013), “B.C. currently lacks a legal framework to proactively and comprehensively manage the cumulative impacts of multiple resource developments within the same region, including the effects of climate change” (para. 3). Without looking at drill cuttings management in a bigger regional context, it will be impossible to make it more efficient; e.g., by coordinating the activities of different operators so that they can reduce their waste, or use resources they have more efficiently.

The above-noted weaknesses will likely become more prominent as Northeast BC oil and gas production increases. In a study performed by the Pembina Institute on the environmental impact of the proposed LNG developments in the province, the authors indicated that “by 2020, the carbon pollution from LNG development could be 3/4 the amount produced from the oilsands — more than doubling B.C.’s current levels” (Horne et al., 2014, para. 1). Based on the Pembina Institute’s calculations, at least 10,000 shale gas
wells will need to be drilled to meet the goals set by the provincial government (Horne et al., 2014, para. 2), which is more wells than have been drilled in BC in the past decade. With the current regulatory regime, more secure landfills will be needed in the province, and when taken together with well pads, roads, and seismic lines, may result in an even greater industrial footprint, more wildlife habitat fragmentation, and the overall loss of ecological integrity of forest ecosystems within the NEBC, where “65 percent of the Peace region [alone] has already been impacted by oil and gas development, logging, mines, large dams and other industrial infrastructure, leaving few intact natural areas” (WCEL, 2013, p. 3). Such lack of strategic thinking and region-based assessment, as opposed to project-based considerations, undermines the Province’s ability to understand large-scale impacts of governmental actions.

**Question 2: How does BC compare with other regulatory regimes and what lessons do they provide for reforming BC’s regime?**

As part of this research, I analyzed drilling waste management strategies adopted by other jurisdictions, namely: Queensland, Australia; Texas, US; and Alberta, Canada. All three jurisdictions have active onshore drilling projects and decades of history of oil and gas development, which has affected the way they regulate industry activities. Although some of the selected jurisdictions may differ substantially from BC, in terms of climatic conditions, which would make wholesale comparisons of the disposal options difficult and unjustified, the evaluation criteria used in the research can provide an objective assessment of drill cuttings disposal options available through regulatory tools.
Of the selected jurisdictions, Queensland and Texas appear to have the most environmentally-sensitive regulatory regimes for addressing the NADF drill cuttings issues, particularly when viewed against the hierarchy in Table 1. Both jurisdictions have implemented a variety of waste minimization requirements. In Queensland, for example, the waste management hierarchy is introduced and mandated by the Waste Reduction and Recycling Act (2011). The Act specifies achieving waste avoidance as the primary objective, and further calls for long-term strategies for the continuous improvement in waste management via investments in innovation and resource recovery practices and technologies. Although Texas technically exempts drill fluids and cuttings from the hazardous waste designation, its Railroad Commission Statewide Rule 8 requires that oil and gas operators apply minimization practices. Regulations from both Queensland and Texas emphasize drill cutting reduction as follows:

- To encourage product substitution when selecting drilling fluid, both require that an operator should consider waste generation minimization and environmental protection in addition to the efficiency of the drilling process.

- They also promote re-use of drill cuttings that are not designated as regulated or hazardous waste, though some additional permitting may be required for such beneficial use for safety and environmental considerations.

- Both Queensland and Texas have considerable discretion for deciding whether or not an environmental assessment is required for a particular oil and gas project based on risk and environmental impacts, including impacts from drilling wastes to be generated.

Overall, based on the regulations, these two jurisdictions tend to use or require the options found in the first two columns in Table 1; that is, they reflect a primary objective of
waste reduction and to prevent or mitigate environmental and health impacts from oil and gas activities.

Alberta’s place in the hierarchy in Table 1 is slightly different: it is located between the two jurisdictions mentioned above, and BC. The primary focus of Directive 50 is safe disposal of the NADF drilling waste at waste management facilities and via subsurface injection; several treatment options are also approved, including biodegradation. Once treated, drill cuttings may be used as an ingredient to manufacture a product or by-product provided that the regulator approves such uses. Therefore, though Directive 50 tends to be oriented to disposal with no explicit incentives for waste reduction, it contemplates “Re-use” and “Treatment” options in the columns of Table 1.

Common to the three other jurisdictions, but distinct from BC, is the active role played by regulators in drilling waste management. Regulators in the three other jurisdictions are active policy-makers when it comes to waste management strategies, unlike the policy-taker role of the OGC. For example, the Texas Railroads Commission is required to encourage oil and gas waste reduction. To meet this requirement, the Commission implemented a Waste Minimization Program that provides training workshops and technical assistance for operators to achieve drilling waste reduction. In Queensland, the Department of Environmental and Heritage Protection permitting function requires that applications for the Environmental Authorities include a proposed drill waste management strategy, a characterization of waste to be generated, and risk assessment for each drilling fluid additive. The Alberta Energy Regulator keeps its regulations and policies up to date with new technologies available in the waste management area and has
authority over drilling waste as a whole, whether or not it is regulated. It is a true ‘single window’ that is authorized to approve not only disposal of drilling wastes, but also their re-use and treatment.

In contrast, the BC approach – reflected in the regulatory documents and confirmed by several of the interviewees – is to mandate the OGC essentially as a policy-taker. The OGC’s relatively passive stance is illustrated in part by the fact that the Waste Management Chapter was initially issued as part of the Oil and Gas Handbook in 1999, last updated in 2006. Currently, no plans exist to re-work this fundamental source of policy guidance to the industry.

This is not to suggest that the OGC is prevented from being more active as a policy-maker. Interestingly, while the OGC does not ‘own’ the Hazardous Waste Regulation and hence must rely on the Ministry of Environment for any changes, nothing precludes the Commission from making its own regulations or Waste Management Chapter. On the contrary, according to Section 111(1) of the Oil and Gas Activities Act (2010), BC OGC “may make regulations respecting the carrying out of an oil and gas activity, including, without limiting, regulations as follows: ... respecting waste produced directly or indirectly by the carrying out of an oil and gas activity”. Hence, BC OGC could potentially take the lead in introducing changes in existing regulations and policy to ensure any environmental and health impacts from the proposed accelerated petroleum developments in the region are mitigated.
Conclusions and Recommendations

According to Crabbe and Leroy (2008), “policy evaluation is generally not an end in itself. Its purpose is, rather, to improve policy in one way or another, even when the impact of evaluation studies on actual policies is an issue in itself” (p. 2). By assessing the performance of environmental law and policies, evaluative research can inform legislative deliberations and can therefore become an integral part of an adaptive management approach to environmental and natural resources policy. The approach requires for the policy-makers to revisit regulatory standards periodically to ensure they still meet the legislative goals of environmental protection in the province. In this particular case, a review of current regulations and policies was necessitated by the proposed increase in petroleum activities to support the development of Liquefied Natural Gas plants in BC promoted by the provincial government.

The objective of the present research was to use the framework described in Table 1 to explore BC laws, guidelines, and policies regulating the disposal of drill cuttings generated as a result of onshore drilling using non-aqueous muds, to understand how these regulatory tools mitigate potential adverse impacts of drilling waste on the environment and public health in NEBC. I also reviewed laws, guidelines, and policies adopted elsewhere to see what BC can learn from the legislative experience in other jurisdictions that have a longer history of active oil and gas development. Although the selected jurisdictions may differ substantially from BC, in terms of climatic conditions, and make comparisons of the disposal options difficult and unjustified, the evaluation criteria used in
this research provide for an objective assessment of drill cuttings disposal options available through regulatory tools.

Several key conclusions emerged during the research. First, the research demonstrates that, in BC, existing regulations and policies for managing drilling waste from upstream oil and gas activities, specifically NADF cuttings, have an explicit emphasis on disposal. Some opportunities – but absent incentives – are indicated for treatment, which are subject to further authorizations from the BC Ministry of Environment. I found no clear strategy in the provincial policies and regulations for promoting waste reduction, re-use, or recycling, which are the cornerstones of a waste management hierarchy, as they are aimed at minimizing and mitigating environmental and health impacts from the drilling operations. Considering the imminent intensification of upstream oil and gas operations, instigated and supported by the provincial government, the lack of any long-term strategy could result in more landfills spreading out in NEBC, with more landscape structure fragmentation, faunal species range reductions, and overall loss of ecological integrity of forest ecosystems in the region.

Second, the interviews with the subject matter experts showed that while operators are making efforts to use new technologies that result in reduced volumes of NADF drill cuttings being generated, they are only successfully applied if they can reduce the operational costs. In the words of one of the experts; however, environmental protection should not be driven just by positive economics. BC needs to ensure that it has an overall waste management strategy that includes both regulatory and financial incentives for promoting such behavior among the operators, which should be the ultimate objective of
any policy-making and its implementation. Regulatory policies are adopted and then implemented and enforced to create incentives for individuals and companies to change their behavior in ways that will solve the initial problem. If a policy works properly, the behavioral change it induces will, in turn, result in the desired changes in environmental conditions, public health, or other outcomes.

Third, this research demonstrated that the regulatory experiences in other jurisdictions have relevant lessons for BC if the province decides to rely less on the disposal end of the spectrum in Table 1. Examples from Texas and Queensland are used and the jurisdictional comparisons suggest that a push to cleaner options can be facilitated with more active policy-making. The BC Oil and Gas Activities Act authorizes the OGC to enact regulations that would be consistent with the Act, and introduce rules and incentives to reduce the current reliance on disposal. In addition, the OGC could enhance education, such as by using workshops that are being arranged by the RRC in Texas. The OGC could also become more active in terms of compliance and enforcement. It could also select the kind of enforcement or other strategies like adding mandatory conditions to permits issued by the Commission that would require drilling waste minimization through product substitution, like the approach used by the EHP in Queensland to ensure compliance with policies. Overall, BC OGC needs to become a true single window for BC operators, which is the case for its counterparts in other jurisdictions.

Lastly, the existing split in authority for drilling waste requires a much improved cooperation and coordination among the Ministry of Environment that ‘owns’ the Hazardous Waste Regulation, the BC Oil and Gas Commission as a single window for the
industry in the province, and the industry itself. The collaboration between the key stakeholders will ensure the end-of-pipe approach, when regulators have to deal with drill waste that has been already generated, will be replaced with the one where proactive involvement of all the parties in careful planning of the drilling programs and risk assessment will ultimately lead to the mitigation of environmental impact due to waste. The province needs to have a true single waste management strategy for mitigating the environmental and health impacts in the NEBC, through the reduction of NADF cuttings being generated. Other jurisdictions have been able to adopt successful strategies; it is time for BC to make the change.
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Appendix 1. Semi-Structured Interview Questions

The following questions were used for the semi-structured interviews:

- The 2002 Environmental Assessment Act “reviewable projects” list does not include oil and gas exploration. Typically, EA process helps an Operator to select an alternative that will have lower environmental and social impact through screening of several potential options and scenarios. The results of such screening are then used to justify the selection to the public and regulators. In your experience, based on what parameters the BC operators make decisions about preferred NADF generated cuttings disposal options if environmental risk and impact assessments are not required?

- Some oil and gas majors will probably have to go through the risk assessment process because of their corporate standards, but even then it is not guaranteed that they will adopt a more expensive alternative if this is not a regulatory requirement. But what about smaller operators that do not have to think in terms of reputational damage and that typically have limited funding?

- Alberta Energy Regulator developed a separate Directive #50: Drilling Waste Management, initially enacted in 1996 and significantly updated as recently as in 2012. Among the changes are additional mud system requirements, toxicity, field screening, and storage and re-use requirements. Directive #50 provides industry with several alternatives for drilling waste disposal, including bioremediation, and subsurface disposal. Also, it merged several regulations pertaining to the drilling waste handling and disposal into one directive. How do you think this compares to BC Waste Management Chapter from the BC Oil and Gas Handbook issued by Oil and Gas Commission?

- The Waste Management Chapter broadly discusses two disposal methods: land treatments (if specific end-point values are met) or disposal at a hazardous waste management facility (if deemed hazardous based on Hazardous Waste Regulation).
According to the Chapter, “If an alternate disposal method not endorsed in this Chapter is being considered, the Operator requires written authorization from the Manager prior to conducting any waste disposal. Why do you think the Waste Management Chapter only permits two disposal mechanisms and sets a requirement for additional approval that is likely to require extra time and hence will be costing more money to the operators?

- Drilled cuttings removed from the wellbore and spent drilling fluids are typically the largest volume waste streams generated during oil and gas exploration and production drilling. Typically, any waste management strategy should be “avoid, reduce, reuse, recycle, landfill. The landflling should be used only as the last resort, when all other options are exhausted. According to literature review, the drilling wastes are taken to “dirt farms” outside of Fort Nelson. Why do you think the other options are not employed in the NEBC?

- What do you think of such specific disposal options as product substitution in drilling mud (avoid/reduce), cuttings bioremediation and thermal desorption (treatment), re-use of treated NADF cuttings as filling material, or in road construction (recycle)?

- BC Oil and Gas Commission publishes Annual Reports and Technical Reports on their website, including compliance and enforcement reports. Some of the documents mention issues identified with waste management practices, but provide no specifics on the nature of excursions. How are these related to drilling waste disposal?

- In February 2013 BC Premier Christy Clark announced plans to support Liquefied Natural Gas plants development in BC to pay down the provincial debt, which means more wells will be drilled. Do you believe that the current policies and regulations in British Columbia are sufficient to deal with increased environmental and health risks related to higher volumes of drilling waste to be generated as a result of accelerated drilling activities?
• Right now the NADF cuttings are taken to ‘dirt farms’ outside of Fort Nelson. Do these facilities have the capacity to deal with the increased volume? What might be the cumulative impact of more drilling?
Appendix 2. Consent Form

Informed Consent Form


Researcher: Valentina Yetskalo  
Graduate Student, Environment and Management,  
School of Environment and Sustainability, Royal Roads University

Purpose of the Research: The purpose of the thesis is to explore BC laws, guidelines and policies regulating disposal of drilling waste generated as a result of onshore drilling using non-aqueous drilling fluid. The study will look into how these laws, regulations, and policies mitigate potential adverse impacts of drilling waste on the environment and public health in Northeast British Columbia (NEBC).

What You Will Be Asked to Do in the Research: You will need to answer several open-ended questions during a one-hour interview. The questions will mainly focus on the existing key policies, laws, regulations and procedures related to the research subject and their implementation. Depending on your availability, the researcher may contact you with a follow-up questions or provide you with a summary of the interview for your review and validation.

Risks and Discomforts: We do not foresee any risks or discomfort from your participation in the research. If you don’t feel comfortable with electronic recording, you have the right to decline it. In this case the researcher may seek the participant’s agreement for a different, anonymous data collection method (e.g. handwritten notes).

Benefits of the Research and Benefits to You: The research results will be of interest to policy makers, provincial government, industry leaders, and general public in BC; currently, political debates are focused around the issue of shale gas fracking and pipeline projects in BC and wider audience may not be aware of potential issues associated with drilling waste disposal should the provincial government decide to proceed with the plans for accelerated oil and gas developments in the NEBC. The proposed research will serve to make stakeholders aware of the issue and help them understand what management tools BC government has in place to ensure health and environmental risks are mitigated.

Voluntary Participation: Your participation in the study is completely voluntary and you may choose to stop participating at any time.

Withdrawal from the Study: You can stop participating in the study at any time, for any reason, if you so decide. In the event you withdraw from the study, all associated data collected will be immediately destroyed.

Confidentiality: All information you supply during the research will be held in confidence and unless you specifically indicate your consent, your name will not appear in any report or publication of the research. The use of code numbers or pseudonyms to identify the results obtained from individual participants will protect anonymity. Only the researcher will have access to raw data or identifying information. The interview may be recorded with a digital device; alternatively, the researcher will be taking handwritten notes. Digitally recorded information will be stored on researcher’s password protected personal computer, and any paper documentation, including signed consent forms and original research data, will be stored in a lockable filing cabinet. The researcher will keep the raw data for five years and then it will be destroyed. Confidentiality will be provided to the fullest extent possible by law.
Questions About the Research? If you have questions about the research in general or about your role in the study, please feel free to contact the researcher either by telephone at ___ __, or by e-mail (___ __). You may also contact the Graduate Program - Dr. Chris Ling, Head of MEM Program, School of Environment and Sustainability, Office Phone number or by e-mail: ____. This research has been reviewed and approved by the Royal Roads Academic Council, RRU Ethics Review Board and conforms to the standards of the Canadian Tri-Council Research Ethics guidelines.

Legal Rights and Signatures:

I ____________________________________________ consent to participate in MA research on BC Approach to Drilling Waste Disposal conducted by Valentina Yetskalo, Graduate Student with the Royal Roads University. I have understood the nature of this project and wish to participate. I am not waiving any of my legal rights by signing this form. My signature below indicates my consent.

Signature _____________________________ Date _________________
Participant

Signature _____________________________ Date _________________
Principal researcher
Appendix 3. Participant Consent Forms

Questions About the Research? If you have questions about the research in general or about your role in the study, please feel free to contact the researcher either by telephone at , or by e-mail ( ). You may also contact the Graduate Program - Dr. Chris Ling, Head of MEM Program, School of Environment and Sustainability, Office Phone number or by e-mail: . This research has been reviewed and approved by the Royal Roads Academic Council, RRU Ethics Review Board and conforms to the standards of the Canadian Tri-Council Research Ethics guidelines.

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Principal researcher
Appendix 4. Interview Transcripts