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GOVERNANCE OF IMPACTS TO LAND AND WATER RESOURCES FROM OIL SANDS DEVELOPMENT IN ALBERTA

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About the Author

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Dr. Jordaan completed her Ph.D. in Environmental Design with a specialization in Energy and Environmental Systems at the University of Calgary in 2010. In her dissertation, she developed quantitative methods to systematically compare the land use of energy extraction in Alberta, with a more focused study on oil sands development. She has worked for Shell Canada both as a summer student in environmental performance management and in the development of their 2006 sustainability report. After graduating with a B.Sc. in Physics and Computer

Governance of impacts to land and water resources from oil sands development in Alberta

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Abstract

Transitions to unconventional fossil fuels may result in significant impacts to land and water. This review describes the governance challenges and successes related to land and water impacts of oil sands development in Alberta, resulting in four key conclusions. First, the province of Alberta appears to have developed robust systems for governance of impacts that are relatively easy to predict and measure over short timescales, such as water use. However, it has been less successful in developing governance mechanisms that deal with more complicated and subtle tasks such as those concerning cumulative effects, landscape fragmentation and water quality. Second, there are large variations in management on crown and aboriginal lands. Development on land surrounding Aboriginal territory may infringe upon constitutionally protected Aboriginal and Treaty rights and requires consultation with Aboriginal communities. Third, though impacts from oil sands development can be large, it is important to understand them in relative sense, particularly for water use. Looking across the whole province, agricultural water use has resulted in degraded watersheds in the southern portions of the province where water is scarce, leading to the emergence of water markets. By contrast, water withdrawn for oil sands development is from watersheds that do not have similar water constraints. Finally, there is large technological potential for mitigating water impacts. Whether emerging technologies are used will depend on if water policies can keep at the same pace as technological development. This review demonstrates that governance can be challenging where impacts are not easily quantified. One key recommendation is to ensure independent scientific research is undertaken to resolve disputes surrounding the magnitude of impacts, such as changes to water quality. Such research can support the development of governance systems. This review may be used more broadly to

develop policies and regulations in other regions that are experiencing similar environmental impacts from growing unconventional fossil fuel production.

1. Introduction

Unconventional fossil fuels are making a growing contribution to current energy systems, changing the ways in which energy technologies impact both land and water resources. As new technologies are developed that make the production of unconventional resources possible, it is important to understand how governance systems can mitigate these impacts. The development of oil sands in Alberta serves as an example that can contribute to the discussion surrounding how governance systems may address the nexus of unconventional energy, land and water. Bitumen production from Alberta's oil sands currently sits at about 1.5 million barrels per day and is forecasted to double within the next 10 years (ERCB 2010). It is extracted either by surface mining or *in situ* recovery methods. Surface mining techniques remove shallow depth oil sand deposits by truck and shovel and extract the bitumen by mixing the oil sand with water warmed using natural gas (ACR 2004). *In situ* technology is predominantly used for extracting deeper deposits[1]. Thermal *in situ* technologies use natural gas to produce steam that is subsequently injected to reduce the viscosity of the bitumen so that it can be pumped to the surface using production wells. These oil sands extraction technologies impact land and water resources in different ways. Surface mining results in the conversion of large tracts of land while *in situ* recovery results in landscape fragmentation. While *in situ* technologies would intuitively use more surface water, recycles rates and the use of brackish water have reduced surface water intensity far below that of surface mining. Surface mining is perceived to have significant water quality impacts, while *in situ* recovery is not. However, many factors that are necessary to assess how these technologies impact land and water in the long term are not fully understood. The goal of this paper is to provide a comprehensive review of information about key impacts,

[1] *In situ* technology can be divided into three key technologies, primary production, thermal recovery and experimental production which account for 32%, 68% and 0.1% of in situ production respectively (ERCB 2009). Primary production refers to the case where the bitumen can naturally flow to the well, though water-flooding and the use of polymers are also included in these numbers. Thermal technologies refer to Cyclic Steam Stimulation (CSS) and Steam Assisted Gravity Drainage (SAGD). Since 2000, SAGD has grown from a negligible percentage of in situ recovery to 30%.

policies and governance mechanisms related to both land and water impacts of oil sands development. This information can be used to inform policy development in other areas with rapidly expanding unconventional fossil fuel development. To meet this goal, three key areas are addressed. First, the land disturbance and related impacts of oil sands technologies are examined. Second, impacts on water resources are summarized and discussed, including consumption and quality. In each of these sections, current policies are reviewed and critiqued. Finally, the ways in which these issues relate to aboriginal lands are closely examined.

2. Land disturbance of oil sands development: impacts and governance

2.1.The impacts of oil sands development on landscapes

The oil sands are found within140,000 km^2 (54,000 square miles) of land in northern Alberta. The land footprint of surface mining is currently small compared to that of agriculture in the south, comprising less than 1% and roughly 30% of Alberta respectively. However, the cumulative footprint and fragmentation of developing the entire oil sands area may extend over approximately 20% of Alberta over the course of the development and even more if the footprint from natural gas production and transmission is included. Current development, however, is much less and depends on technology. Surface mining and *in situ* recovery affect landscapes in different ways (ACR 2004). Land use of surface mining is comprised largely of polygonal features (mine sites, overburden storage, tailing ponds and end pit lakes); whereas, *in situ* development is mostly defined by linear features that extend across the lease area (networks of seismic lines, access roads, pipelines and well sites) (CEMA-SEWG 2008). As of 2009, 600 km^2 were disturbed by oil sands mining, accounting for 0.3% of the area where oil sands resources are present, or less than 0.1% of the total land area of Alberta. No public data is available on the current land disturbance and reclamation associated with in situ recovery.

Though the majority of bitumen is currently produced with surface mining, the majority of reserves is currently expected to be developed using *in situ* technology. Approximately 1.7 trillion barrels of crude bitumen is estimated to exist within the oil sands areas while 170 billion barrels is recoverable using current technology (Government of Alberta 2010a). In 2009, 55% of bitumen was produced using surface mining while 45% was produced using *in situ* techniques

(ERCB 2010). By 2019, it has been forecasted by the ERCB (2010) that 53% and 47% of bitumen will be produced by *in situ* and surface mining technologies respectively. Approximately 80% of the resource is expected to be extracted using *in situ* technologies. This type of technology is also expected to affect a much larger land area than surface mining, amounting to approximately 137 000 square kilometres (98% of the oil sands area) under current technological and economic conditions (CAPP 2009).

There are a variety of challenges arising from land disturbance from oil sands development in Alberta. The principal ecological concerns, each of which are addressed in turn, are a) habitat loss caused by large scale land transformation and fragmentation of the landscape, b) increased human access, and c) reclamation. Habitat loss arises from landscape conversion, particularly for surface mining of oil sands where large tracts of land are required. Landscape fragmentation occurs when a landscape is broken up into smaller intact units. There are a wide variety of impacts arising from landscape fragmentation. For example, when large tracts of land are converted or land is fragmented, species migration corridors can be lost, affecting species diversity and viability at larger scales. The conventional wisdom is that mining operations have a much larger landscape impact than *in situ* recovery, which has typically been viewed as more environmentally benign in terms of land use (ACR 2004, Sherrington 2005). However, this conclusion does not reflect landscape fragmentation caused by *in situ* projects and upstream natural gas production. The land impacts of *in situ* recovery can be comparable and even greater than that of surface mining when these are considered (Jordaan et al. 2009). Jordaan et al. (2009) examined fragmentation through a measure of edge effects, defined as the ecological impacts extending from the juxtaposition of two different landscape types.

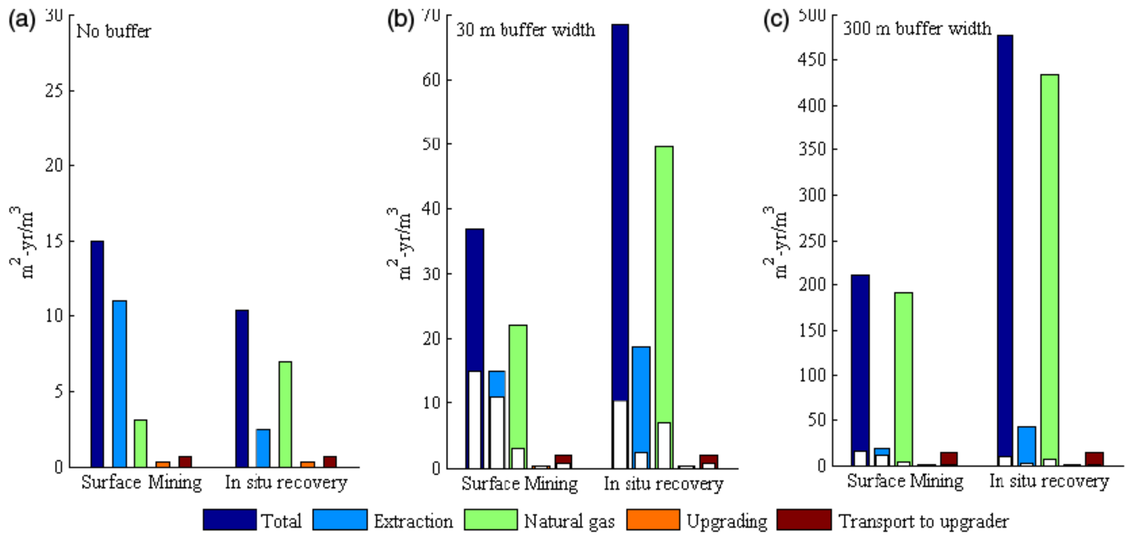

Figure 1. Land disturbance and fragmentation from oil sands surface mining and in situ recovery. Edge effects are included as a proxy for habitat fragmentation by applying a parametric buffer to linear features. (a) shows the land occupation without accounting for edge effects, (b) shows the land influenced when considering edge effects that extend 30 metres from the disturbance and (c) shows the land influenced when considering edge effects that extend 300 metres from the disturbance. Figure taken from Jordaan et al. (2009).

Human access to natural areas increases with the development of linear features such as roads and pipelines. Linear features can become access points for recreation, hunting, and fishing (Weber and Adamowicz 2002). When seismic lines are being cut and wells are being drilled, levels of human activity and noise (e.g. chainsaws) will be high and more likely to disrupt wildlife. Recreational use of linear features after their creation, such as hunting and off-road vehicle use, propagate their existence through time. Such impacts can be reduced through the use of access management plans. Features such as access roads may also be transferred to other land uses, such as forestry.

Alberta Environment reports that there has been significant reclamation of lands that have been disturbed by surface mining operations (14% of the 48,000 hectares); however, only 104 hectares have been certified as fully reclaimed (Alberta Environment 2006). Reclamation, of course, does not promptly return landscapes to their pre-disturbance ecosystems. This is of particular importance for oil sands mining, where large tracts of land are disturbed, and for high latitude areas where ecosystems are less productive and thus slower to regenerate. Significant time lags have been found to exist before a reclaimed landscape reaches the natural range of variability of the pre-disturbance landscape (Rowland et al. 2009). Using some practices, reclaimed mines fall within the natural range of variability of the pre-disturbance landscape only after 15-20 years. Varying some practices, such as by using lower levels of fertilization on areas reclaimed over tailings ponds, lead to outcomes that diverge considerably from the intended post-disturbance ecosystem (Rowland et al. 2009). As a result, special care must be taken in reclamation to ensure that the ecosystems develop as intended. Current reclamation techniques do not result in reconstruction of functional peatlands due to the complexity of their formation. Peatlands can require on the order of thousands to tens of thousands of years to form naturally (Koellner and Scholz 2008) and recovery to their original state is not viable with current technologies. Surface mines developed on peatlands are currently reclaimed to a mixture of uplands and wetlands. There is likely to be challenges for restoring hydrology and biogeochemistry after oil sands mining project are completed due to the large scale of the development and lack of planning (Johnson and Miyanishi 2008). Similar challenges exist for *in situ* projects in peatlands areas, where compaction can occur under roads and well pads and the land is reclaimed to upland. There is uncertainty surrounding the capability of industry to reclaim land impacted by oil sands developments. This is closely tied to the definition of reclamation, which will be discussed later in the review.

2.2.Land Management decisions

Decisions about land use associated with oil sands development are made through a variety of different processes. After a lease or permit is granted through the tenure process, surface access is granted by Alberta Sustainable Resources Development (ASRD) as defined by the Public Lands Act. In the interim—between tenure and obtaining full surface access—there are a number of largely discretionary approvals that must be granted and regulations that must be followed (see Vlavianos 2007 for a comprehensive review of the legislative and regulatory framework for oil sands development). An Environmental Impact Assessment (EIA) must be submitted to obtain project approval by the Energy Resources Conservation Board (ERCB), though separate approvals from ASRD and Alberta Environment may also be required (Alberta Environment 2010b). Reclamation plans are submitted within EIAs and, once a project is completed and decommissioned, certification for reclamation may be obtained from Alberta Environment. The current framework does not include larger scale regional planning or cumulative effects, although there is widespread acknowledgment that both are necessary for proper assessment and management of valued ecosystem components such as wildlife and natural areas.

2.2.1. Tenure process

The use of land for oil sands development begins with the tenure process. In Alberta, the Crown owns the vast majority (81%) of the province's mineral rights. As a result, the decision to lease or permit land initially lies with the provincial government (Government of Alberta 2009a). Tenure processes for oil sands development are initiated when an oil sands company or individual submits a request to the Department of Energy for mineral rights linked to a parcel of land to be posted in a public offering. An internal review by is conducted by the Crown Mineral Disposition Committee (CDMC), where it is decided whether there are environmental constraints on the area. The CDMC is comprised of representatives from the Ministries of Sustainable Resource Development, Environment, and Community Development. The land is reviewed, potential surface-access restrictions are identified, and the Department is advised about the nature of the restriction. As this is an internal process, little information is publicly available regarding the criteria considered in the decision-making. In effect, some of the most important decisions about the impact of oil sands on landscapes are made through processes whose exact decision-making criteria are hard to fathom.

Once a tenure decision is made, land is subsequently leased or permitted by the Alberta Department of Energy. These leases and permits can be maintained provided the developer meets a minimum level of exploration or production as the government is seeking to provide tenure to those committed to developing the land and eventually generating revenues for the province. Once companies secure the rights to the oil sands resource underlying a parcel of land, they begin cutting access roads and seismic lines into the forest and clearing land to drill exploratory wells. Holroyd et al (2008) argue that this process is undertaken without consideration of social and environmental impacts and adequate planning. Exploration is also typically exempt from the EIA process; yet, the cumulative effects of such developments can result in significant land disturbance—notably through fragmentation (Creasey 1998).

2.2.2. Environmental Impact Assessments of oil sands operations

EIA is a process for identifying the impacts a project can have on the environment. This process includes the following steps: predicting environmental effects, identifying mitigation measures, evaluating significance, reporting and following-up to verify accuracy and effectiveness of the mitigation measures (CEAA 2009). It has been noted by several authors that investigating cumulative effects within EIA is insufficient due (in part) to the project-specific focus of EIAs (Baxter et al. 2001, Duinker and Greig 2006). The effects of hydrocarbon development on landscapes have often been underestimated when cumulative impacts and fragmentation effects are not considered (Walker et al. 1987, Schneider et al. 2003, Nitschke 2008, Jordaan et al. 2009). One concrete example of the ecological impacts of cumulative effects is related road density. Nielsen et al. (2007) showed that the occurrence of 6 of 14 species surveyed in Alberta's boreal forest was significantly related to road density. Occurrence of domestic dog (*Canis domesticus*), coyote (*Canis latrans*), deer (*Odocoileus* sp.) and snowshoe hare (*Lepus americanus*) increased with increasing road density, while the occurrence of lynx (*Lynx canadensis*), marten (*Martes americana*), wolf (*Canis lupis*), and fisher (*Martes pennanti*) all decreased.

Cumulative effects assessment is currently included within EIAs, but to a limited extent. The project proponent delineates a regional study area (larger than the immediately impacted region) within which cumulative effects is considered (Hegmann et al. 1999). However, the scale of regional planning in EIAs is not designed to match the full scale of the area that oil sands operations will affect and thus it is likely that there are larger-scale habitat effects from these projects that are simply unknown and not considered, such as impacts to connectivity between species populations. As a result, there is a need to reconsider regional-scale planning that is designed to address larger scale impacts to ecosystems. This outcome could stem from the new regional plans that are currently being developed, which will be discussed later.

2.2.3. Reclamation

Due to the uncertainty in some aspects of reclamation of oil sands projects, particularly for surface mining, it is an important component of policy in Alberta. Reclamation in Alberta has been defined as returning a disturbed land to a state of equivalent capability, where equivalent capability is 'the condition in which ecosystem processes are functioning in a manner that will support the production of ecosystem goods and services consistent in quality and quantity as present prior to disturbance' (ASRD 2007). In forested lands the standard is similar – oil sands producers must "return the land to equivalent capability to achieve a sustainable landscape with forest productivity equal or greater to that prior to development" (CAPP 2008). Restoration may be expected by some stakeholders, where the land is returned to a pre-disturbance state.

Companies are required to include Conservation and Reclamation Plans in the EIAs they submit before they develop in situ or surface mining projects. Within these plans, it is recognized that peatlands can not be restored and the new landscape is reclaimed with a significantly lower amount of wetlands. That precedent was established with projects such as Deer Creek Energy's Joslyn Mine—a surface mining operation. The same challenge exists for *in situ* development. If *in situ* production occurs on peatlands, the areas are generally reclaimed to uplands (e.g. Petro-Canada's Mackay River Expansion). Current research is ongoing to understand how in situ development can affect hydrology and ultimately the viability of peatlands adjacent to oil sands production infrastructure. In summary, there is a fundamental disconnect between reclamation and restoration. Land can be reclaimed and certified; however, some ecosystems may never be restored. One ambiguity is whether resources will be available at the end of a project. In recent years, this problem has been addressed by new rules that mandate oil sands mining companies to provide financial security for reclamation in the form of a bond posted to the Environmental Protection Security Fund.

2.2.4. Regional landscape planning

The project-by-project manner of approving oil sands developments is generally viewed as insufficient in managing land use impacts resulting from the growth of resource extraction industries over time (Timoney and Lee 2001, Aumann et al. 2007). Two fundamental flaws in previous policies have been identified (Aumann et al. 2007). First, each policy has been predicated on the notion of multiple-use (all land uses can occur at all places at the same time). Second, policies have been lacking in enforceable goals to guide decision-making. The notion of multiple use is particularly important for in situ technologies, where forestry and other land uses occur on the same portions of land. Due to the case-by-case approval of oil sands approvals, the notion of enforceable goals is challenging, if not impossible, at the landscape scale. The failure of the current system to adequately address cumulative effects has sparked criticisms and debates surrounding the need for updated policies. This has resulted in a variety of planning initiatives, often involving the landscape scenario planning (e.g. Gardner 2007, CEMA-SEWG 2008). They have generally been unsuccessful due to lack of government commitment (Aumann et al. 2007).

Most recently, the Cumulative Environmental Management Association's Sustainable Ecosystem Working Group (CEMA-SEWG) developed a management framework meant for application to the Regional Municipality of Wood Buffalo (RMWB), a municipality that overlaps with a portion of the oil sands area. Several different scenarios were developed for different management regimes. The Terrestrial Ecosystem Management Framework was CEMA's deliverable and recommended approach to managing the cumulative effects of development and resource use on ecosystems and landscapes in the RMWB. The key recommended strategy was the application of a Triad land management approach. This approach involves the identification of three land use zones: Intensive, Extensive and Protected, where the following zones would be applied:

- An Intensive Zone characterized by bitumen extraction comprising 5% to 14% of the RMWB at any time;
- An Extensive Zone characterized by ecosystem forestry and other natural disturbance based activities comprising at least 46% of the RMWB at any time; and
- An expanded permanently Protected Zone where industrial activities are excluded comprising 20% to 40% of the RMWB.

Other actions were recommended such as management of off-highway vehicle access, further work on refining the size of each zone, and a periodic revision of the framework.

Additionally, CEMA-SEWG recommended a temporary moratorium on new oil sands leases in areas of high conservation value. This recommendation was supported by the majority of the members including some oil sands operators in the area. The Government of Alberta did not respond to this request, but supported further development of recommendations. The results and recommendations produced by a new Lower Athabasca regional plan will now take precedence over those generated from the near decade of work of CEMA-SEWG. In the meantime, development has occurred as usual without more stringent regulations and policies.

In 2009, the Government of Alberta released the Land Use Framework (LUF). This framework divides Alberta into seven regions for which regional plans will be developed, one of which is the new Lower Athabasca regional plan. In the LUF, the Government of Alberta has reported that stakeholders across the province have indicated that they would like stronger support from the government. In response, the Alberta Land Stewardship Act was passed and proclaimed in 2009, providing a means by which the Government of Alberta can give direction and provide leadership (Alberta Land Stewardship Act 2009). The implementation of the regional plans developed by the LUF will be implemented are outlined in the act. One significant step forward is that every decision-making body must review its regulatory instruments and make the necessary changes or initiatives to comply with the regional plan. The challenge is that the majority of policies are optional or discretionary based on the input from the Lieutenant Governor in Council (ie the Alberta government). Ultimately, the strength of the final regional plans and subsequent regulations will truly define whether or not the LUF will be successful.

At an operational level, there are several proposed policies in the LUF which could be of importance for public land decisions related to oil sands development, particularly tradable land use rights and conservation offsets. In a tradable land use rights system, publicly owned resources are capped and traded between resource users (Weber and Adamowicz 2002). The resource, in this case land, is then rationed through a pricing mechanism. If one company uses less land than their allocation, they can sell the right to another company requiring additional land. There are several ways a company can disturb less land than their allocation; for example, through better land use planning or using different technologies. Disturbance on an ecologically defined region can be limited by regulators to a certain percentage a year. Land conservation offsets are actions that compensate for the loss of biodiversity or natural areas. These can include replacing or restoring lands as well as financial compensation. This has previously been applied for the case of oil sands development. In 2006, Albian oil sands committed $4 million over 10 years to partially offset the terrestrial effects associated with their Muskeg River Mine expansion project through acquiring and restoring private land (Dyer et al. 2008). There are a variety of tools that oil sands companies use to reduce their land footprint. Companies involved with energy developments that are dominated by linear features can use best practices, such as smaller, curvilinear seismic lines, as means to reduce impacts. Integrated landscape management, which is already encouraged by the Alberta Government and used by industry, can be implemented by coordinating land disturbance of the energy sector with the forestry sector (ACR 2007).   This is typically undertaken using Area Operating Agreements (AOAs). AOAs are regulatory processes where multiple energy applications from a single company are reviewed. Companies are encouraged to plan at a landscape level for a year of exploration and drilling activities, where land use activities can be coordinated to reduce disturbance.

3. The impacts of oil sands development on water resources and related governance

3.1. Impacts of oil sands development on water resources

Currently, the key topics of concern to oil sands development in the water-energy nexus are water use, surface water quality, tailings ponds and groundwater quality (Woynillowicz et al. 2005, Griffiths et al. 2006, al 2009, Kelly et al. 2009). As with land, the amount of water consumed depends on the extraction technology. Surface mining has been reported to use from 2 to 4.5 barrels of water per barrel of bitumen produced (CAPP 2010b, NRCan 2010). A recent independent study provided a range of 2 to 4 barrels of water per barrel of bitumen produced (NRTEE 2010). In situ operators use brackish water where possible from underground aquifers. Where brackish water is used then only roughly 0.5 to 0.9 barrels of fresh water are used to produce one barrel of bitumen (CAPP 2010b, NRCan 2010). Over 90% and 80-95% of the water can be recycled for *in situ* recovery and surface mining respectively (CAPP 2010b), which is included within the numbers cited above.

Currently, on a provincial scale, water use from oil sands developments is not overly significant when compared to that from agriculture (Figure 2). The northern river basins of Alberta, where oil sands deposits are situated, have a relative abundance of water. However, as oil sands production rises, so will water consumption. While water allocations are increasing the fastest in the Athabasca River Basin (by 88% since 2000, 9 times faster than the provincial average), the government no longer accepts water allocation applications in the South Saskatchewan River (Alberta Environment 2010c). Agriculture dominates in the south where water is already scarce. This is not to say water use from oil sands development is without impacts. Impacts are more likely during the winter when flows are naturally lower (Woynillowicz and Severson-Baker 2006). Withdrawals during this time may affect a larger portion of fish habitat and decrease the amount of dissolved oxygen available to fish in the winter. Decaying vegetation can consume oxygen in ice-capped rivers and the quantity of oxygen available depends, in part, on the water flow. Lower levels of dissolved oxygen may delay hatching, change the mass of post-hatched fish and change spawning periods for certain species of fish (Chambers et al. 2000). It has been demonstrated that some rivers in Northern Alberta, including the Athabasca, already have low dissolved oxygen due to effluents from industries other than oil sands development (Chambers et al. 2000). The combined effects of oil sands and other industries should be better examined as my review of the literature found no studies on the significance of these additive impacts on smaller scale ecological processes.

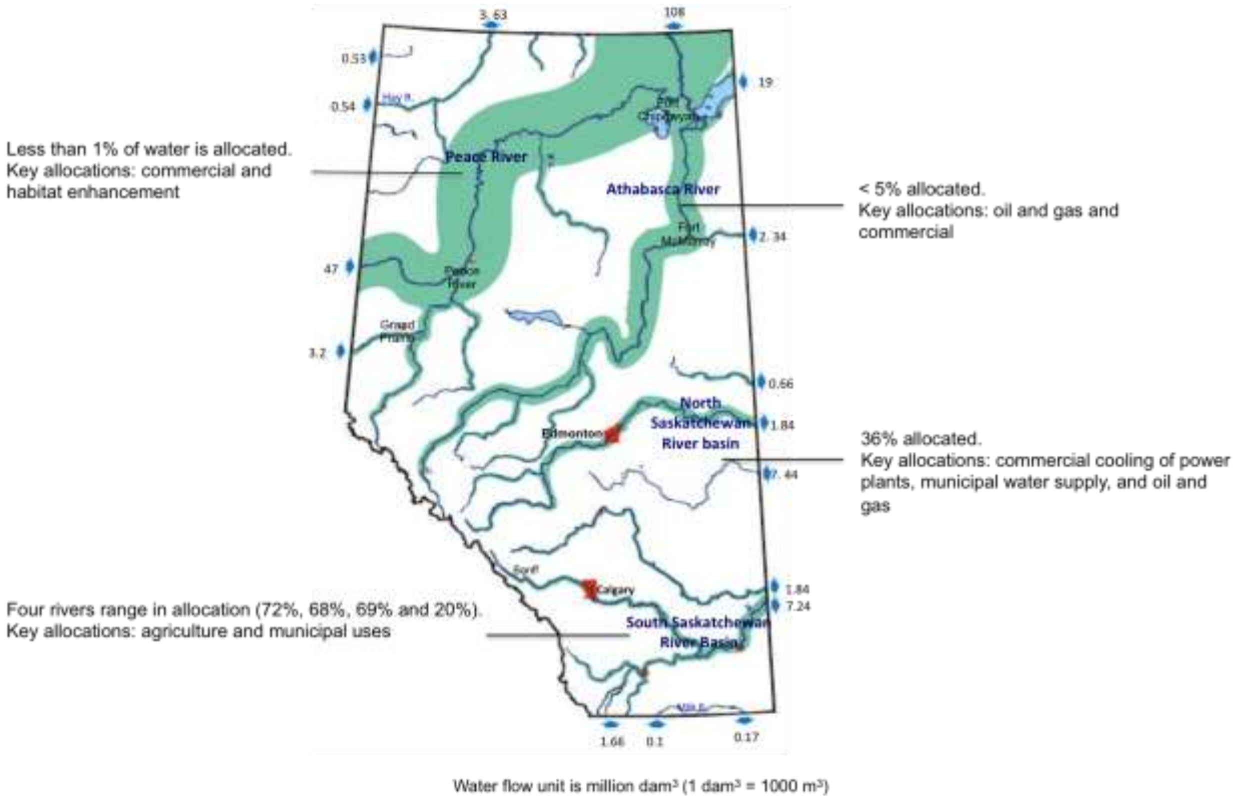

Figure 2: Annual flow and water allocation of major water basins in Alberta (Alberta Environment 2010c).

The significance of surface water quality impacts of oil sands development is disputed. The Government of Alberta has monitored water quality in the oil sands region for over 30 years and their data indicates no increased contaminants of surface water (Government of Alberta 2010c). In another study, elevated levels of polycyclic aromatic compounds (PACs) have been found downstream of oil sands development, contradicting results reported by the Alberta Government (Kelly et al. 2009). Actually measuring PAC levels is difficult because the Athabasca River (as befits an area rich in oil sands) is exposed to natural seepages of bitumen. To account for this, Kelly et al. (2009) measured PACs upstream and downstream of oil sands development in areas that were exposed to natural seepages. Several other reference sites were selected in areas unaffected by the oil sands industry. Though the PACs were not found to reach nearby communities in this study, they were found to be at levels high enough that are likely toxic to fish embryos. A second study indicated that the levels of seven pollutants (cadmium, copper, lead, mercury, nickel, silver and zinc) were found to have exceeded Canada or Alberta's guidelines for the protection of aquatic life in melted snow and/or water collected near or downstream of oil sands development (Kelly et al. 2010). Kelly et al (2009, 2010) argue that the government's monitoring system is inadequately designed and in need of improvement. Though the study was carefully designed, there is some debate surrounding the source of the pollutants, whether naturally occurring or from oil sands development. That pollutants were found in snow cover is a strong indication the source is from oil sands development.

Tailing ponds are a controversial subject that has received a wide variety of criticisms due to their toxicity to birds and wildlife, perceived risk of seepage, as well as the uncertain timescales associated with their existence. Most recently, Syncrude Canada has been found guilty of environmental charges stemming from the deaths of over 1600 birds in their tailings ponds as their bird deterrents were not deployed quickly or early enough to deter the birds from landing on the ponds (Wingrove 2010). The Alberta government and environmental groups have divergent perceptions surrounding the significance of seepage from tailings ponds. The Alberta government states that all of the leakage from tailings ponds is detected and captured by groundwater monitoring systems or ditches and that there are no impacts to surface water outside these sites (Alberta Environment 2010a). A recent Environmental Defense report included an estimate of 11 million litres a day for the amount of tailings seeping from the ponds that is not captured in monitoring systems (Environmental Defense 2008). Another publication reviewed a variety of sources (including the Environmental Defense report) and suggested that tailing ponds are seeping (Timoney and Lee 2009). Some tailing ponds are located on the edge of the Athabasca river, which has caused concern among environmental organizations regarding the potential for dyke breaches (Holroyd and Simieritsch 2009, Timoney and Lee 2009). Finally, there is concern surrounding the timescales at which tailings ponds will exist on landscapes. Oil sands producers and the Government of Alberta are making efforts to improve water use efficiency and reclamation management to "minimize and eventually eliminate long-term storage of fluid tailings in the reclamation landscape" (Allen 2008, ERCB 2009b). One reclamation plan for fine tailings waste is the "wet landscape" approach in which the MFT would be transferred to an abandoned mine pit and then capped with water to form a "lake" (Fedorak et al. 2003, Allen 2008). Alternatively, "dry landscape" reclamation experiments such as composite tailings (CT) by adding calcium sulfate to MFT to quickly release most of water within hours allow re-vegetation on top of the dried landscape. Resolution of the challenges arising from tailing ponds remains a work in progress.

Both surface mining and in situ operations may affect groundwater quality and quantity. In addition to tailings ponds there are also risks from cross-contamination of aquifers caused by drilling wells for in situ extraction. To address the growing concerns around the possible impact of oil sands development on groundwater, Alberta Environment - through the Oil Sands Environmental Management Division - is developing the Groundwater Management Frameworks for both the Athabasca Oil Sands and the Industrial Heartland region (Government of Alberta 2010f). The nature and extent to which groundwater is contaminated or depleted is unclear and is in need of transparent, scientifically verifiable investigation and reporting.

3.2. Governance of impacts to water resources

The degree to which water impacts are addressed in policy is highly variable in Alberta. Water use by oil sands appears to be well-managed while water quality remains a contentious subject. Under Canadian law, provincial governments manage water within their borders. In Alberta, the Water Act sets out the regulations related to the allocation of all surface water and groundwater. Individuals and municipalities submit applications for licences to divert or use water to Alberta Environment. The federal government is seldom involved, though there are a few activities in Alberta that may trigger federal laws (for example, the Fisheries Act). The Government of Alberta has addressed the issue of low flows in the winter in rivers affected by oil sands operations by developing a Water Management Framework for the Lower Athabasca River (Government of Alberta 2009b). This framework places a weekly cap on water use by oil sands companies that is based on the natural and seasonal changes in river flow. During periods of low flow, water consumption is limited to the equivalent of 1.3 per cent of annual flow. In practice, such seasonal restrictions can lead industrial users to be restricted to less than half of their normal requirement. Beyond these seasonal flow issues most experts do not see significant problems related to water quantity in the oil sands area.

As previously discussed, water use in oil sands development is not a significant issue when compared to the southern watersheds that have been severely impacted by agricultural water use. Potential impacts also appear to be well managed under the current system. Due to water constraints in the south created by uses unrelated to oil sands, water markets have begun to emerge in Alberta. The Water Act, developed in 1999, made it possible to buy and sell water licences in Alberta (AWRI 2009). Some proposals for buying rights to water via inter-basin transfers have been made for areas that have scarce water supplies. Between 1999 and 2004, there were 23 applications for permanent water right transfers (Nicol et al. 2007). Six of these applications can be described as market transactions, involving transfers for money. The majority of applications for water rights transfers were not market-based, but instead involved changing the points of diversion and/or adding to the points of diversion or changing the transfer system. Four of the six cases the water right transfer involved buyers and sellers in close proximity, but in two cases water rights were moving over long distances (over 100 kilometers). The average trading price of water rights was $448 per dam^3 (Nicol et al. 2007). Prices paid were highly variable, ranging from $140 per dam^3 to $740 per dam^3 (Canadian dollars – year not specified). There has been resistance against water markets from ENGOs, particularly regarding factors that are not well-represented in costs, such as ecological and basic human water needs. Several reports indicate that water markets could be acceptable provided there was some regulation from government to ensure that ecosystems and human needs are considered within such a system (Nicol et al. 2007). Heading into the future with oil sands development projected to increase significantly, there is currently opportunity to improve both technologies and policies to manage water use. If necessary, once markets in Southern Alberta have become more mature, they may be used as a model for watersheds impacted by oil sands development.

Governance of both surface and groundwater quality is much less developed, particularly for PACs, tailings, and aquifer cross-contamination from drilling wells. Unlike water use, water quality issues are controversial due to conflicting reports from different parties. A key example of this is the PACs in surface water, which are in need of transparent monitoring and reporting. The Regional Aquatics Monitoring Program (RAMP) is the current government program within which the water quality in the oil sands region in northeastern Alberta is monitored. It was initiated in 1997 by the Government of Alberta to monitor and assess the health of rivers and lakes in this region. The program is designed to identify and address water-related impacts of oil sands development. The polycyclic aromatic compounds (PACs) offer an example of an area where RAMP should develop stronger monitoring systems and transparent research. Only through independent research (notably Kelly et al (2009)) was it demonstrated that RAMP's monitoring may be insufficient and pollutant levels have exceeded existing guidelines to protect aquatic life.

Little data is available from the government on the other key topics of concern, more specifically, tailings leakage and groundwater monitoring. Ponds are monitored and where seepage is detected, government requires a recapture system to return the tailings to the pond (Government of Alberta 2010b). Tailings ponds are constructed with groundwater monitoring and seepage capture facilities (Government of Alberta 2010d). Any seepage detected is reported to the ERCB, yet no data found in this review to verify whether or not the interception of seepage is successful. The National Pollutants Release Inventory (NPRI) included the tailings substances produced by oil sands development (NPRI 2010). These data do not examine if these are released through seepage, but rather reports the quantities of the individual substances that were disposed of in an on-site or off-site tailings area over the course of the given year. The Canadian Association of Petroleum Producers (CAPP) reports that none is released (CAPP 2010a). In response to growing concerns about the impacts of tailings ponds, the Energy Resources Conservation Board (ERCB) has recently developed a directive to reduce the inventory of tailings that are stored in ponds by capturing tailings and storing them in disposal areas (ERCB 2009a). A report released by environmental groups has claimed this directive has not been enforced and plans developed by companies have not been in compliance (Simieritsch et al. 2009). Several issues related to tailings ponds are in need of better governance, if only by improving reporting to demonstrate whether seepage is occurring or not.

The issue of groundwater contamination has yet to be addressed. The Alberta government is currently developing Groundwater Management Frameworks for the Athabasca and Cold Lake portions of the oil sands region (Government of Alberta 2010f). The objectives of these frameworks are to identify groundwater contamination, maintain groundwater quality, prevent dewatering of aquifers, and develop a monitoring strategy for oil sands development. According to CAPP (2009), Alberta Environment is developing a new policy (Assessment and Management of Non-saline Groundwater in Direct Contact with Bitumen for In situ Oil Sands Operations) that will require additional assessment, monitoring and mitigation for in situ projects in geologic settings where non-saline water is naturally in contact with the oil sands. It is clear that there are significant challenges related to the governance of water quality, pointing to an need for the government to address the perceived risks of the public. One way to manage this dilemma is to ensure adequate reporting is released to the public by an independent scientific body.

4. Governance of oil sands development on and surrounding Aboriginal land

Oil sands development affects land and traditions of Aboriginal communities while providing economic opportunity. The effects of oil sands development on Aboriginal communities are of special concern as their rights are protected by the Canadian constitution[2], and thus land and water impacts are governed with different mechanisms from those addressed above. These mechanisms have a larger role for government oversight and also different rights for the communities living on the land.

Aboriginal people are a significant portion of the local population surrounding oil sands developments. Eighteen First Nations with approximately 16,000 people living on-reserve and six Métis Settlements with approximately 6,000 residents live in areas where oil sands are found[3]. Thousands more Aboriginal people live off-reserve and off-Settlement in the oil sands regions. In total, these communities represent approximately 10% of the region's population (Government of Alberta 2010e). As previously mentioned, the Crown owns 81% of the

[2] These rights, as defined by the *Constitution Act of 1982*, apply to not only First Nations but also to Métis. Aboriginal people "include the Indian, Inuit and Métis peoples of Canada" as defined by the *Constitution Act of 1982*. Aboriginal rights are recognized alongside treaty rights in section 35 (1): "the existing aboriginal and treaty rights of the aboriginal peoples of Canada are hereby recognized and affirmed."

[3] People of mixed First Nation and European ancestry identify themselves as Métis, as distinct from First Nations people, Inuit or non-Aboriginal people. The Métis have a unique culture that draws on their diverse ancestral origins, such as Scottish, French, Ojibway and Cree (Indian and Northern Affairs Canada 2008a).

province's mineral rights. The remaining 19% are freehold mineral rights owned by the federal government on behalf of First Nations or in National Parks (11%), and by individuals and companies (8%). The standard for Government management of tenure on Aboriginal land is "for the benefit of the First Nation". Moreover, even where Aboriginal communities are not the ultimate beneficiaries of oil sands rights, oil sands projects often overlap areas that may be used for traditional reasons, such as hunting, fishing or trapping. Indeed, developing oil sands on land in close proximity to reserves or in ways that affect aboriginal water resources may infringe upon Treaty or Aboriginal rights as defined and protected by the Canadian constitution. The challenge in understanding the implications of these rights is that their definition is neither fixed nor clear. These rights are considered at the discretion of the Supreme Court on a case-by-case basis, depending on judicial decisions and the evolution of common law rather than legislative action.

Treaty rights depend upon the treaty under which they are defined. Treaties were developed to legally acknowledge the existence of reserve lands, benefits (e.g. farm equipment and animals, annual payments, ammunition, clothing) and rights (e.g. to hunt and fish) for the First Nations who occupied large areas of land that were given up to the Crown (Indian and Northern Affairs Canada 2003). The oil sands areas lie within Treaty 8, an area covering a large portion of western Canada. This treaty was made in 1899 when "the First Nations who lived in the area surrendered to the Crown 840,000 square kilometres of what is now northern Alberta, northeastern British Columbia, northwestern Saskatchewan and the southern portion of the Northwest Territories" (*Mikisew v. The Queen*). Oil sands underlie 17% of this region. First Nations in this area were promised reserves of land and other benefits in exchange for the ultimate ownership of the land, most important to them were "the rights to hunt, trap and fish throughout the land [that has been] surrendered to the Crown" (*Mikisew v. The Queen*). The exception is that "such tracts as may be required or taken up from time to time for settlement, mining, lumbering, trading or other purposes".

The Supreme Court ruled that the Crown has a legal duty to consult and possibly accommodate[4] Aboriginal communities when the Crown has "real or constructive[5] knowledge" of an established or potential Aboriginal Right and is contemplating action that may adversely affect it (Indian and Northern Affairs Canada 2008). By definition, constitutional law delimits the powers of government and "overrides all other statutes inconsistent with their principles" (Statistics Canada 2008). These Aboriginal rights are even more difficult to define than treaty rights. Indian and Northern Affairs Canada (2003) use the definition "rights that some Aboriginal peoples of Canada hold as a result of their ancestors' longstanding use and occupancy of the land." The difficulty in defining these rights lies in that they "vary from group to group depending on the customs, practices and traditions that have formed part of their distinctive cultures" (Indian and Northern Affairs Canada 2003). Aboriginal rights are determined through common law and are shared by all members of an Aboriginal group rather than being specific to an individual person. The test to prove Aboriginal rights has evolved with each court case. The current definition (modified last in *Van der Peet*) is that the proponent must show (1) the activity was historically practiced by Aboriginal people, (2) the right was never extinguished and (3) "the activity must be an element of a practice, custom or tradition integral to the distinctive culture of the Aboriginal group claiming the right." Proving an Aboriginal right is no simple task, especially for a culture that passes on knowledge orally.

The duty consult arises from a Supreme Court decision and is based on the notion of protecting Aboriginal rights. However, some argue that since there is disagreement regarding the definition of these rights, consultation may not be adequate and there is a subsequent risk that rights may be infringed upon (Passelac-Ross and Potes 2007). Alberta currently manages the Crown's duties to consult and possibly accommodate as laid out in the Government of Alberta's *First Nations Consultation Policy on Land Management and Resource Development* (Government of Alberta 2006b). This document was developed specifically for First Nations, not Aboriginals as defined by the constitution. "Rights and Traditional Uses" are defined by the Government of Alberta as

[4] The Government of Alberta interprets accommodation as "the creation of a reasonable balance between the potential impact of a particular decision on a First Nation with the competing societal concerns. In determining adequate accommodation, compromise is inherent to the reconciliation process." (Government of Alberta 2006).
[5] Implied by law.

"uses of public lands such as burial grounds, gathering sites, and historic or ceremonial locations, and existing constitutionally protected rights to hunt, trap and fish and does not refer to proprietary interests in the land." This definition has been a point of contention for First Nations. According to Passelac-Ross and Potes (2007: 25), "fundamental differences of opinion are arising between government and First Nations about the nature and scope of treaty rights and the government's constitutional obligations." To some, defining these rights has overstepped the provincial government's role – this matter is the responsibility of the Supreme Court. A unanimous resolution by the Assembly of Treaty Chiefs rejected the government's *First Nations Consultation Policy on Land Management and Resource Development* including the Framework and Consultation Guidelines (Government of Alberta 2006a). Many of the current disputes and compensations over land in relation to oil sands development are currently centered on the notion of aboriginal and treaty rights.

There appears to be a mix of benefits and risks for Aboriginal communities. The Government of Alberta reports on a variety of economic benefits received by Aboriginal communities as a result of oil sands development. These include the value of contracts between Alberta oil sands companies and Aboriginal companies being at $575 million in 2008. Furthermore, there is some interest in developing oil sands on reserves (Government of Alberta 2006c). A joint venture between Bigstone Cree and Bronco Energy has resulted in the biggest oil sands project ever undertaken on First Nation reserve lands in Canada. There are few regulations that existed for the development of resources on reserves until recent years. As a result, the First Nations Commercial and Industrial Development Act was developed to facilitate development on First Nations lands at the request of several First Nations across Canada. One of these First Nations was Fort Mackay who has shown interest in developing oil sands on their lands. A set of regulations were developed to overcome regulatory barriers to developing oil sands on their reserve (CanLII 2007). Though there may be economic benefits and interest in developing oil sands on reserves, the environmental and social trade-offs may be significant. These trade-offs are ultimately best understood by the Aboriginal communities themselves and cannot be interpreted without direct consultation.

Though there are clear benefits, there are potential trade-offs for many of those involved. If a right is infringed upon, a development may be impeded or delayed. Conversely, proving Aboriginal rights to the Supreme Court is challenging. If the case is not made, the right is not considered to be in existence. Furthermore, without adequate policies to regulate cumulative effects and water quality, some rights may be extinguished inadvertently. Passelac-Ross and Potes (2007) argue that the Province of Alberta could subsequently be held accountable. The duty consult arises from a Supreme Court decision and is based on the notion of protecting Aboriginal rights. As there is disagreement regarding the definition of these rights, it is not inconceivable that these rights may be infringed upon (Passelac-Ross and Potes 2007). As a result, these authors argue that the current consultation guidelines may not be adequate.

5. Conclusions

The results of this review point to the fact that, while policies adequately address some impacts to land and water, there are other areas where governance should be improved. In the case of land, the key impacts are related primarily to the transformation of large tracts of land, landscape fragmentation, access management and reclamation. There are several smaller scale policies, such as using Area Operating Agreements to implement Integrated Landscape Management, that have set impressive rules for reducing the land footprint of oil sands development. However, history has shown that larger regional planning is lacking. Broad scale land policy and planning is required to ensure large-scale biological conservation in Alberta. There is currently opportunity to develop regional plans under the umbrella of the LUF. Whether or not the current challenges will be addressed is uncertain as it rests in the strength of the final regional plans. The governance of land and water impacts related to oil sands development must account for Aboriginal and Treaty rights. Due to the trade-offs faced by Aboriginal communities and the judicial, case-by-case basis of the governance, it is challenging, if not impossible, to assess the overarching quality of governance from an external perspective.

On the subject of water use, policies appear to be adequate and even forward thinking. The impacts of water use on the Athabasca River are relatively minor in comparison with the impacts caused by the agricultural sector in the south. As oil sands development grows, there is opportunity to use the southern markets as a model to assist in the regulation of water use. The most significant points of contention have grown from water quality where there is little public data. While government and industry report there are no PACs in surface water or tailings seepages, there are still public concerns surrounding these subjects. To tease out real and perceived environmental risks and respond to public concerns, there is a need to perform independent scientific studies that are reported in a transparent manner. One way this could be accomplished is to develop an independent scientific board that collects and disseminates information about the environmental impacts of oil sands development and provides recommendations on how to better manage these impacts.

While the land and water impacts of oil sands development are significant, it is important to keep them in perspective. At the broadest level, the land disturbance is minimal when compared to first generation corn ethanol. Based on the heating values of the fuels, it would take all 66 million ha of Alberta approximately 210 years to produce the same amount of energy contained in the oil sands from corn ethanol in the U.S. (Jordaan 2007). This land area is roughly 5 times greater than the area that could be affected by the oil sands development (140,000 km^2). Local impacts can, however, be significant. Furthermore, cellulosic ethanol and biodiesel from yellow grease both have negligible land disturbance in comparison to oil sands. Technology can also improve the land disturbance and water use of oil sands development. Natural gas consumption can be reduced if bitumen is gasified to produce natural gas required for steam production. Water use can be reduced for *in situ* recovery using solvent injection and *in situ* combustion. Storage can be used to mitigate water use of oil sands mining during low flow times. Yet, from a broad perspective, it is apparent there are many areas where information is conflicting and controversial.

Though technology can reduce impacts, governance mechanisms can both drive technological change and mitigate impacts in the meantime. This review provides an outline of the governance challenges and successes related to environmental impacts of oil sands development in Alberta. This may be used more broadly to develop strong policies and regulations in other regions that are experiencing similar environmental impacts from growing unconventional fossil fuel production. Learning from such experiences, policies can be implemented that best serve society not only in the present, but well into the future.

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