Analyzing the Threat to Freshwater Sources and Indigenous Lands by Hydraulic Fracturing in Northeastern British Columbia

Alex Newall; Anna Kaveney; Blakely Browne; Hriday Keshav

GEOB 270 L2D

April 10th, 2018

Acknowledgments

We would like to thank Sally Hermansen, Alexandra Winter-Billington, and Peter Whitman for their help and guidance towards this project, and for our academic term in GEOB 270.

Abstract

This research project examines water consumption in hydraulic fracturing in Northeastern British Columbia (BC), and further focuses on well facilities in the Montney Shale Formation. Our research begins on a macro scale, comparing average well consumption rates in the current unconventional play areas - the zones of accessible tight shale gas reserves. We then shift towards a micro scale, using the Montney Basin as a study area to further examine water withdrawal, culminating in a fresh water impact assessment on current fracking operations surrounding the Halfway River First Nation. To execute this analysis, we added data that mapped First Nation's lands, freshwater sources (lakes, rivers, and aquifers), short term water access permits, and hydraulic fracturing facilities installed prior to 2016. As a basemap, we utilized a BC digital elevation model, along with an outline of Alberta. Combined, this data allowed us to produce a multifaceted representation of the current status and impact of hydraulic fracturing in Northeastern BC on Indigenous groups. In conclusion, we found, 87.9% of wells in the Montney Basin are within 2km of a fresh water source, as well as, 227 wells and 75 waste disposal sites, within 15km of the Halfway River First Nation.

Contents

Project Description

The deceptive yet common perception of Canada's freshwater abundance enables a dangerous policy approach that ignores intense industry water consumption. Furthermore, Indigenous peoples in Canada lack the legal right to safe or adequate drinking water; the current provision of guidelines ignores indigenous peoples, their cultural and traditional governance, environmental water quality management, and the control of water resources on their land (Van der Porten 2014). Subsequently, conflicting consumption demands and threats to safe water persist, as the BC and federal government continue to prioritize private resource extraction over the protection of this vital resource (Parfitt, 2017). This report aims to focus on the intersection of threats to water and energy development, highlighting the water-energy nexus of hydraulic fracturing and the disregard of Indigenous people's right to safe drinking water. Much of the shale natural gas and oil reserves are found in the Northeastern corner of BC, as well as many First Nations communities, including Fort Nelson, Halfway River, Blueberry River, and the Saulteau Nation. We aim to learn about the true extent of hydraulic fracturing water consumption, the natural sources it draws from, the effect on First Nations people, and ultimately concluding in a freshwater impact assessment for the Halfway River First Nation.

Methodology

Acquire

We acquired data for the major geographic features from DataBC. This data includes aquifers, rivers and lakes in British Columbia. Indigenous reserve boundary data was also acquired data from DataBC. Our digital elevation model (BC_DEM) base layer raster was retrieved from GeoBC. We retrieved the data regarding hydraulic fracturing activity (waste disposal sites, unconventional play trends, short term water use permits and well facilities) from the BC Oil and Gas Commission's open data.

Parse/Filter

The largest of our files, BC_DEM, was used as a base layer for each of the three maps to plot our target area, the unconventional play trends (UPT) onto. Initially, our rivers layer data was sectioned into two mutually exclusive sets of polylines, rivers_dense and rivers_sparse, so an intersection was performed to compile the complete data set into one file for simpler analysis later on. For each subsequent map, the layers: aquifers, lakes, rivers, Indigenous reserves (INDG_reserves), wells, short term active permitted water use areas (STWU), wells, and waste disposal sites (WDS) were all clipped to the project area, UPT.

Mine

For map 1, external averaged water consumption data was retrieved for the four target river basins, added to the attributes table, color-coded, and used to display the general extent of hydraulic hydraulic fracturing operations' trends in Northeastern BC.

In order to determine the number of well facilities, short term water access points, and waste disposal sites within a close proximity to freshwater sources and Indigenous lands for maps 2 and 3, we began with creating a buffer for each source. Before doing this, we unioned the Lake_clip, Riv_clip, and Aqu_clip layers together, creating the Water_Bodies layer. After this, we buffered for a 2 km radius (the horizontal extent of hydraulic fracturing) from the new Water_Bodies layer, and used the *select by location* feature to find out the number of well facilities, short term active permitted water use areas, and waste disposal sites within the buffer. We then created a new layer from this selection. We followed a similar process for determining the number of well facilities, short term active permitted water use areas, and waste disposal sites within a 15 km radius of Indigenous lands. For our final map, we selected for only the Halfway River Nation, created a new layer from it, *buffered*, and selected for wells, water permits, and waste disposal sites within just the 15 km area surrounding this land.

Represent

For our first map, we utilized the BC_DEM file, as well as the UPT file to display the intensivity of water usage in water basins within BC in which hydraulic fracturing is present. After ensuring the appropriate scale, we attributed a different color to the amount of water being taken from each basin, then added a north arrow, data framework/source, legend, title, scale bar, and titles for each individual water basin.

For our second map, we added the BC_DEM file, UPT file, FNR_clip, STWU file, Lake_clip, Aqu_clip, and Riv_clip. We utilized graduated symbols to display the intensivity of water usage in the Montney Formation. Then, we added the same features as are seen above.

For our third map, we added the Well_activ layer and WDS_water layers, then added the rest of the legend features as seen above. We also made the symbols for each facility type easily visible.

Layer / datafile name	Source	Uses	Entity/data model	Attributes	Modifications
Aquifers / All aquifers in BC	DataBC	Full BC map of major aquifers	polygon	Names of aquifers	Clipped to 'Fracking Sites'
INDG_Reserves / All indigenous reserves in BC	DataBC	Full BC map of indigenous reserve lands	polygon	Saulteau Nation, Fort Nelson Nation, Halfway River Nation, Blueberry River Nation	Clipped to 'Fracking Area'
Wells_Proposed / Proposed wells to be constructed after 2016 in BC	BC Oil and Gas Commission	Northwestern BC proposed fracking sites	polygon	Oil company names, dates of application submission	Clipped to 'Fracking Area', radial buffer of 15km to determine nearby 'Existing Fracking Sites'
UPT / Unconventional Play Trends in BC	BC Oil and Gas Commission	Full BC map displaying areas where Fracking practices occur	polygon	Liard Basin, Horn River Basin, Cordova Basin, Montney Basin	Project area boundary used for clipping, set transparency to 50% to visualize underlying 'Elevation'
Rivers / All rivers in BC	DataBC	Major and minor rivers	polyline	Individual river names	Intersected the two files, then clipped to 'Fracking Area'
STWU / Short term active water permits	BC Oil and Gas Commission	Locations permitted for short term water use in	point	Active, terminated; total extraction volume of water	Clipped to 'Fracking Area', locations selected by active

		drilling operations			
Wells_Pre2016 / Wells constructed pre-2016	BC Oil and Gas Commission	Currently existing fracking locations	point	Oil company names	Clipped to ‘Fracking Sites’, 2 mile radial buffer zone created
BC_DEM / BC Elevation	GeoBC	Full BC digital elevation model, used for determining topography and river flow direction	raster	Height values	Clipped to ‘Fracking Sites’, converted from raster to polygon, hillshade surface tool applied
Lakes / Lakes in BC	DataBC	Full BC map of lakes	polygon	Watershed names	Clipped to ‘fracking sites’
WDS / All waste disposal sites from fracking in BC	BC Oil and Gas Commission	Map of waste disposal sites from fracking in BC	point	Well name, proponent company	Clipped to ‘fracking sites’, selected by location for waste disposal sites within 15km of reserves

Discussion and Results

Results

Our analysis elucidates the extent of hydraulic fracturing in Northeastern British Columbia, with an additional macro-scale case study on the Montney basin focusing on the substantial capability of oil and gas companies to extract water from local sources, the close proximity of waste disposal and well sites to both water sources and Indigenous reserves, and the sheer magnitude of the hydraulic fracking industry in Canada.

Figure 2 shows the volume of total water permitted to be extracted from different water sources throughout BC for well operations. Water was permitted to be taken from surface water sources such as dugouts, lakes/ponds, or rivers and streams. Of the 196 permits currently active within the Montney basin, 91% (179/196) of is to be taken from dugouts, 8% (15/196) from streams/rivers, and 1% (2/196) was permitted from lakes and ponds. A weakness of our analysis here is that we were only able to find data on how much water was permitted to be extracted, rather than actual figures on what was extracted. Moreover, this data lacks information regarding groundwater or non-disclosed sources, such as corporate owned water licenses or privately owned wells.

Our analysis displayed what we could consider to be a dangerously high level of waste dump sites and well facilities in close proximity to both Indigenous lands and freshwater sources in northeastern British Columbia. Of the 7072 wells within the Horn River, Liard, Cordova, and Montney Formations, 6214 or 87.9%, fell within 2 km of a freshwater source, defined as rivers, lakes, or aquifer. Of the 2355 waste dump sites, 2014 fell within this range. Short term water access permits were largely granted within these 2 km boundaries as well, with 148 of the 196 falling in this buffer zone. This number may be higher in reality, as the rivers layer we utilized did not include minor tributaries.

In Figure 3, we focus on our case study area displaying well facilities, waste dump sites, and short term water access permits surrounding the #227 Halfway River First Nation reserve. Our map displays a large concentration of these features within a critical proximity to the area - of 196 short term water access permits granted, 5 fell within the 15 km range, as well as, 227 of well facilities, and 75 waste disposal sites. There are four key wells that may pose a certain threat to the Halfway River Nation. These are the Painted Pony HZ waste dump site, operated by UGR Blair Creek Ltd., the Suncor Kobes D, Suncor Kobes A, and Petro-Canada Kobes A well facilities, and a water access permit for Canbriam Energy Inc. These five facilities are located just upstream and along the banks of the Halfway River, which flows through the Indigenous reserve. Hydraulic fracturing sites, such as the two operated by Suncor, have the potential to contaminate local water sources, and their proximity to an aquifer threatens to create issues revolving around long-term access to adequate quality water. The ability to access 100,000 m^3 combined of water from the river by these four well facilities additionally has the potential to lower flows of water in this area, potentially causing ecological issues regarding sensitive aquatic species and fish migrations. The closest threats, are the two well facilities located directly in the reserve and to the side of the river, the 3075704 Halfway and 3075704 Halfway operated by the Nova Scotia Company.

Facility Type	W/in 2 km of water	W/in 15 km of Indigenous lands	W/in 15 km of Halfway River FN
Well	6214/7072	443/7072	227
Water Access Permit	148/196	9	5
Waste Site	2014/2355	103/2355	75

Table 1: Feature proximity analysis of hydraulic fracturing components within 2km of a water source, 15km of indigenous lands, and 15km of the Halfway River First nation.

Discussion

Buffer Ranges

As presented in *Table 1* alongside our additional figures, there are not only a significant amount of well, waste, and short term water access facilities in the Montney Basin, but also a large concentration within a critical proximity to many Indigenous reserves, such as the Halfway River First Nation. The figures of 15 km from a reserve, and 2 km from a fresh water source, are critical ranges for the following reasons: on average, 15 km is equivalent to 15 minutes driving time, and given the extent of the required infrastructure--labourer housing, large machinery, waste sites, waste removal, construction areas, and the transporting of goods to and from these areas- this distance is inclusive of the potential effects on a surrounding community. Furthermore, this range is considered conservative regarding downstream externalities such as surface wastewater, loose construction materials, and seismic activity to an extent of 100 kilometres, as illustrated in Miles Wilson's UK study on the relationship between hydraulic fracturing and anthropogenic earthquakes (2015). We chose the parameter of 2 km from a water source because it represents the mean horizontal underground extent of any hydraulic drilling operation (Uhlman, 2018). It is important to keep in mind that all of these operations are capable of possible shale fracture - permitting any extracted chemical to reach the water table (Wilson, 2015).

Water Use Concerns

As shown in Figure 2 and explained previously, short term water use permitted for hydraulic fracturing operations originates from a variety of sources including groundwater, streams/rivers and lakes/ponds. Our analysis showed that a high proportion of water was permitted from dugouts, with significantly less permitted from lakes/ponds and rivers/streams. However, long term water sources also exist. The 2014 Annual Report on Water Use for Oil and Gas Activity revealed that only 27.8% of water used for hydraulic fracturing comes from these short term permits, while 33.9% comes from private water licences (BC Oil and Gas Commission, 2014). The remaining proportion originates from saline and fresh water source wells, flowback, municipal waste and private acquisition of water. Thus, our analysis most likely underestimates the amount of water being extracted in Northeastern BC for hydraulic fracturing.

Moreover, the same report from 2013 details the difference between short term water source permit approved withdrawal locations and actual water withdrawal. While only 15.1% of the approved Section 8 short term withdrawal locations is from streams/rivers, 37.6% of the water volume is approved from streams/rivers and 48.2% of the total water withdrawal volume comes from streams/rivers (BC Oil and Gas Commission, 2014). Comparatively, 75.7% of the approved Section 8 short term withdrawal locations is from water source dugouts, 59.4% of the water volume is approved from dugouts and 43.2% of the total water withdrawal volume comes from dugouts (BC Oil and Gas Commission, 2014). Although both stream/river and water source dugout extraction total withdrawals were well beneath their water approval volume, the proportion was higher from streams/rivers than from dugouts, even though dugouts had a higher water approval volume. This shows that our data likely does not properly represent the exact proportion of water actually being extracted and used in hydraulic fracturing.

Concerns Specific to Indigenous Rights

Our analysis of the proximity of many of these facilities to the Halfway River First Nation draws attention to the threat these facilities pose for Indigenous people's health and ability to access a quality means of life. Under Section 35 Article 1 of the Constitution, the Canadian government allows hunting, fishing, and trapping, but also claims priority over Indigenous lands, detailing that they may be "taken up from time to time for settlement, mining, lumbering, trading or other purposes" (Government of Canada, 1982). We suppose that the case of the Halfway River Nation must fall under this umbrella term, though deem it vital to question this aspect of the constitution as truly constitutional, as it continues to put marginalized members of society in a space of which they suffer disproportionately high health risks.

The installation of hydraulic fracturing sites has wide ranging effects on local ecologies, seismic activity, and human populations, as access to clean, uncontaminated water becomes compromised. Additionally, the consumption of water in the hydraulic fracturing process, which comes out "laden with chemicals, heavy metals, hydrocarbons and carcinogens", often receives little to no treatment, and is later "pumped deep underground for disposal", causing it to be "lost to the hydrological cycle forever" (Parfitt, 2017). Alarmingly, "The Canadian Centre for Policy Alternatives recently reported that hydraulic fracturing water laced with toxic heavy metals, [...] had not only contaminated groundwater below a site where the highly contaminated wastewater was stored, but that the same contaminants had also been found many kilometres away in a tributary of the Peace River" (Parfitt, 2017). The increasing concentration of hydraulic fracturing in the Montney Basin, one of the largest gas resources in the world (Milelli, 2013), has already seen a large amount of growth in water usage, as "in the two years following 201, industrial water use in northeastern BC climbed by approximately 50 per cent" (Parfitt, 2017). This growth displays how hydraulic fracturing in northeastern BC is a significant issue and will continue to pose environmental threats into the future if regulatory policy remains unchanged.

Overall, mapping the information illustrated the pressing, imminent threats to water supply in BC. It alluded to the continual prioritization of energy development by the federal and provincial government over the guarantee of clean, safe drinking water for First Nations and their constitutionally promised rights of fishing, hunting, and trapping. While we did not delve into the specific ecological effects, focusing on the water threats allowed us to detail the hypocrisy in our government, the continuing neglect and devaluing of First Nations people and the possibly pressing situation of intense water consumption by industry in BC.

Error/Uncertainty

The most common source of error in our project would likely be systematic, and originate from compacting, minute inaccuracies in the data measurement and recording, like our rivers polyline vector data being limited to a finite number of points. Representative of the coastline paradox, the length of the river acts like a fractal, "a complex shape with a highly convoluted perimeter of infinite length (as measured by smaller and smaller rulers) that encloses an area of finite value (Sokac p1, 2017)". Regardless of funding and time alloted to surveying, it will remain impossible to truly chart the course of a river or other similar features -and as we performed proximity and buffer analysis' using this constrained data, our results aren't truly precise. Another source of error is visual, meaning the map's proportions are affected by the type of projection used. Albers equal area, a conical form of projection, is used in maps 2 and 3, and while this map projection has been referred to as the most accurate to use for British Columbia, we cannot sideline the fact that neither shape nor linear scale are completely accurate. Map 1 utilizes a transverse mercator projection, which does not maintain true direction.

Additional to these potential errors, uncertainty exists in relation to the data we acquired regarding well facilities, short term water access permits, and waste dump sites. Our well facilities layer only displays wells established prior to 2016, meaning that the image could be slightly different if data were used from today.

Further Research/Recommendations

Our research was hindered by the lack of data due to the confidential nature of the oil and gas industry and corresponding lack of public availability to data. Generally, further research exploring the environmental impacts of hydraulic fracturing ought to be undertaken in order to build a more complex understanding of this relatively new process. Our analysis would be strengthened by research that provides more context about the extent of contamination from hydraulic fracturing sites and waste disposal sites, like the distance from the sites that these issues occur or characteristics of these sites. In our acquisition of data, we realized that it is possible to access more data from sources like the BC Oil and Gas Commission but it is necessary to apply for such data. Further research conducted with more complete data would provide a more in-depth picture of all the issues we examined and extend analysis to issues we were unable to examine, for example, specific values of depth and volume of injection for hydraulic fracturing sites and depth and volume of injection of waste disposal sites. Analysis of the potential for chemical leakage and contamination from wastewater disposal would provide a more accurate representation of the dangers in BC. From our analysis, we recommend that hydraulic fracturing is slowed, if not halted in British Columbia, at least until further investigation is conducted on its potential environmental and sociological effects. In order to lower the potential risks posed for Indigenous groups and sensitive ecologies, we recommend that all hydraulic fracturing sites are set, at minimum, 2 km away from any form of freshwater source, and at least 15 km from any Indigenous land reserve, unless specified by occupants of this land that they are in agreeance with the construction of facilities within this buffer zone.

Appendix | Bibliography

BC Oil & Gas Commission. (2013). *Water Use for Oil and Gas Activity: Annual Report 2013.* Retrieved from: British Columbia Oil & Gas Commission.

BC Oil & Gas Commission. (2014). *Water Use for Oil and Gas Activity: Annual Report 2014.* Retrieved from: British Columbia Oil & Gas Commission.

Fraser Basin Council. (2012). *Report to BC Ministry of Health: Identifying health concerns relating to oil & gas development in northeastern BC: Human health risk assessment—Phase 1: Compendium of submissions.* Retrieved from: Fraser Basin Council.

Garvie, K. H. (2013). *Beyond consultation: First nations and the governance of shale gas in British Columbia* (Master's thesis). Retrieved from: http://www.collectionscanada.gc.ca/.

Garvie, K. H., & Shaw, K. (2016). Shale gas development and community response: Perspectives from treaty 8 territory, british columbia. *Local Environment, 21*(8), 1009-1028.

Government of Canada. Part II of the Constitution Act, 1982, being Rights of the Aboriginal Peoples of Canada, Act 35 section 1.

Milelli, S. (2013). New Report Doubles Previous Estimates of Montney Formation Natural Gas Reserves in British Columbia and Alberta. Retrieved from: http://www.canadianenergylawblog.com/2013/11/14/new-report-doubles-previous-estimates-of-montney-formation-natural-gas-reserves-in-british-columbia-and-alberta/

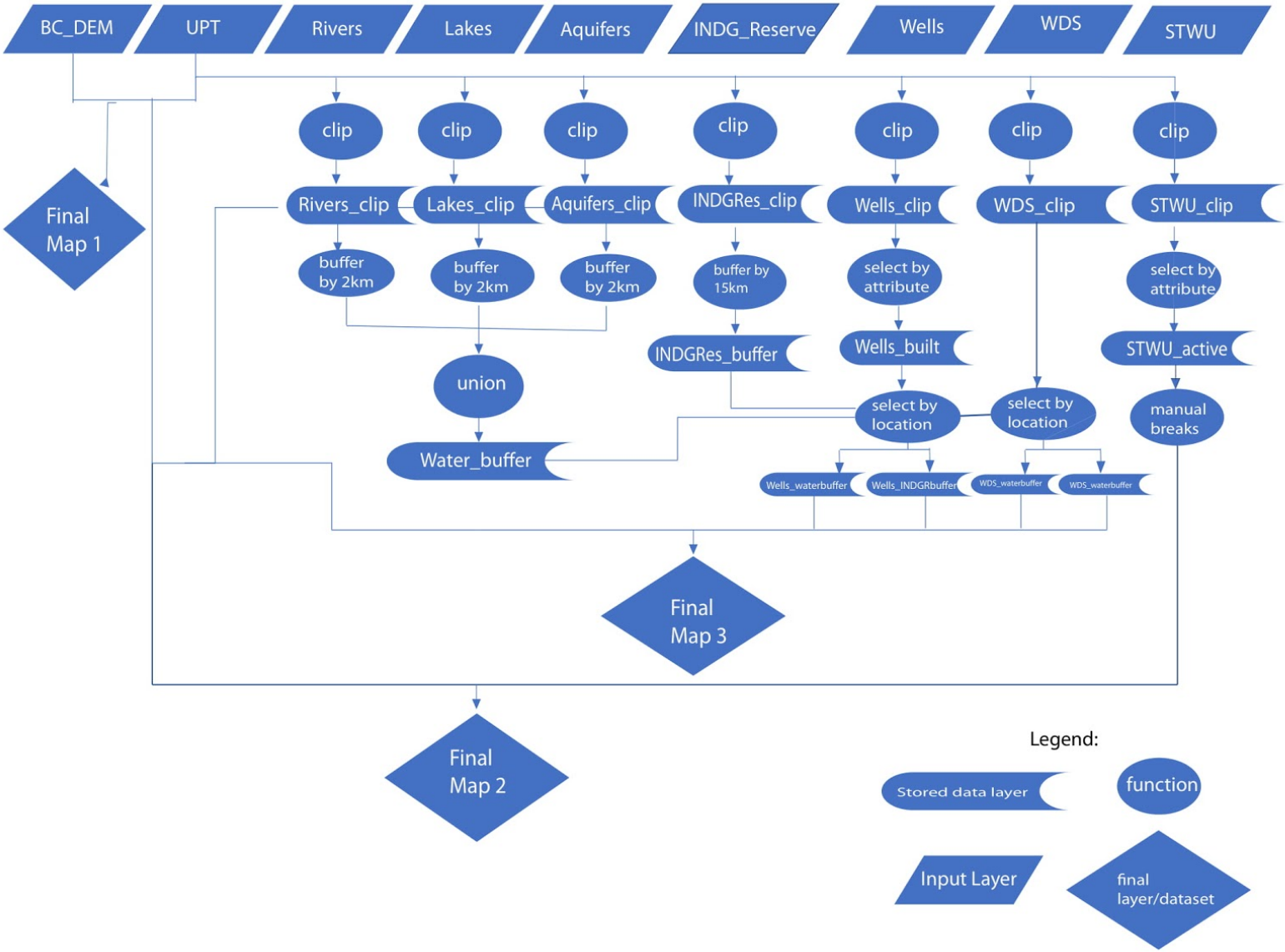
Parfitt, B. (2017). Fracking, First Nations and Water: Respecting Indigenous rights and better protecting our shared resources. *Canadian Centre for Policy Alternatives*. Retrieved from:https://www.policyalternatives.ca/sites/default/files/uploads/publications/BC%20Office/2017/06/ccpa-bc_Fracking-FirstNations-Water_Jun2017.pdf

Sokac, A. (2017). Seeing a coastline paradox in membrane reservoirs. *Developmental Cell, 43*(5), 541-542.

Uhlman, K., Boellstor, D., McFarland, M., Gholson, D., & Smith, J. (2018). *Texas A&M AgriLife Extension*. *Twon.tamu.edu*. Retrieved 11 April 2018, from http://twon.tamu.edu/media/619617/sc-012__fracking-cxd_pta-3may1.pdf

Von der Porten, S., & de Loe, R. (2014). Water policy reform and indigenous governance. *Water Policy, 16*(2), 222-243.

Wilson, M. P., Davies, R. J., Foulger, G. R., Julian, B. R., Styles, P., Gluyas, J. G., & Almond, S. (2015). Anthropogenic earthquakes in the UK: A national baseline prior to shale exploitation. *Marine and Petroleum Geology, 68*, 1-17.


BC_DEM
UPT
Rivers
Lakes
Aquifers
INDG_Reserve
Wells
WDS
STWU
clip
clip
clip
clip
clip
clip
clip
Final Map 1
Rivers_clip
Lakes_clip
Aquifers_clip
INDGRes_clip
Wells_clip
WDS_clip
STWU_clip
buffer by 2km
buffer by 2km
buffer by 2km
buffer by 15km
select by attribute
select by attribute
union
INDGRes_buffer
Wells_built
STWU_active
select by location
select by location
manual breaks
Water_buffer
Wells_waterbuffer
Wells_INDGRbuffer
WDS_waterbuffer
WDS_waterbuffer
Final Map 3
Final Map 2
Legend:
Stored data layer
function
Input Layer
final layer/dataset

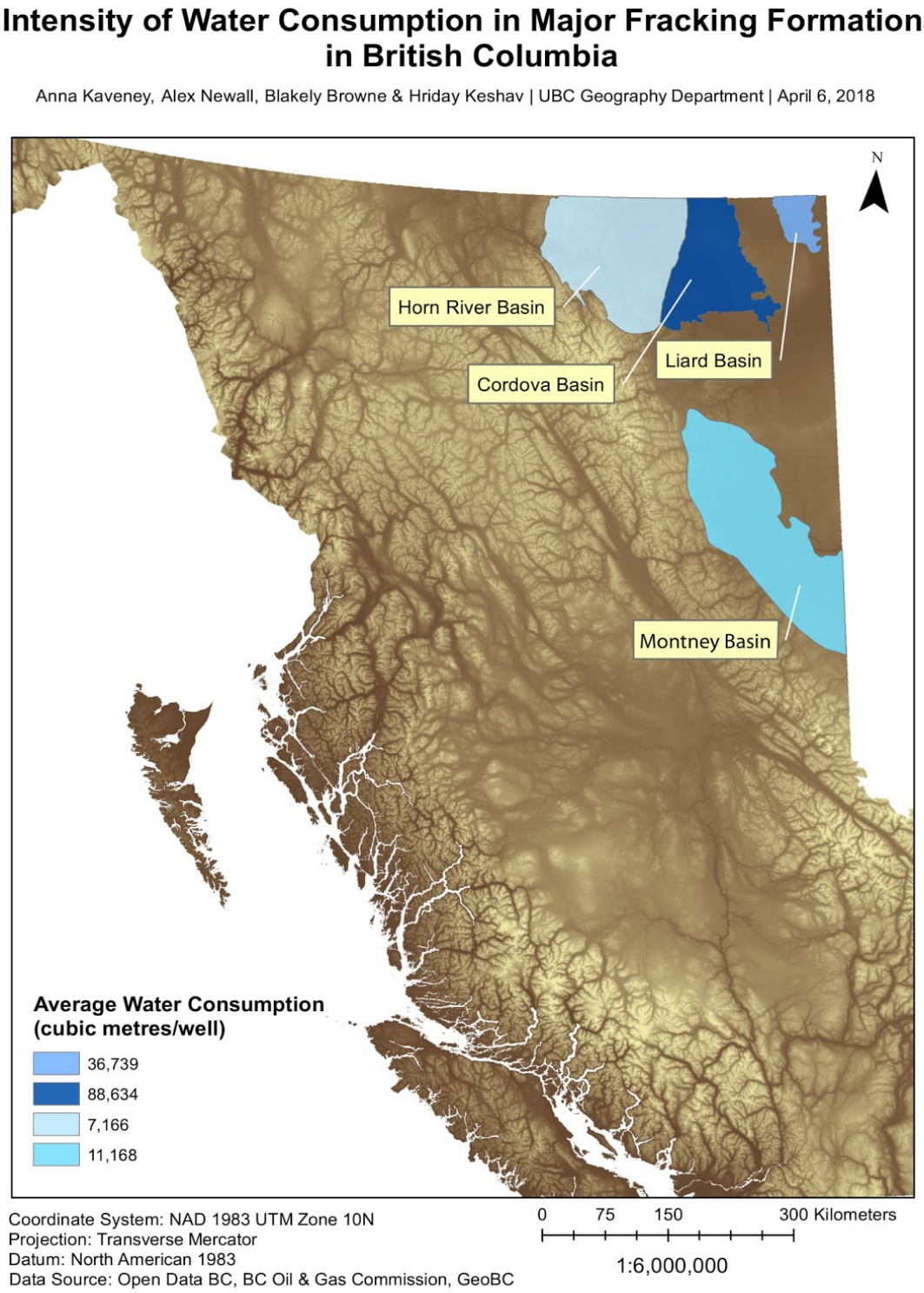


Figure 1: Map illustrating the general extent of hydraulic fracturing water consumption in cubic metres for 4 major river basins of Northeastern BC: Montney, Liard, Cordova, and Horn River.

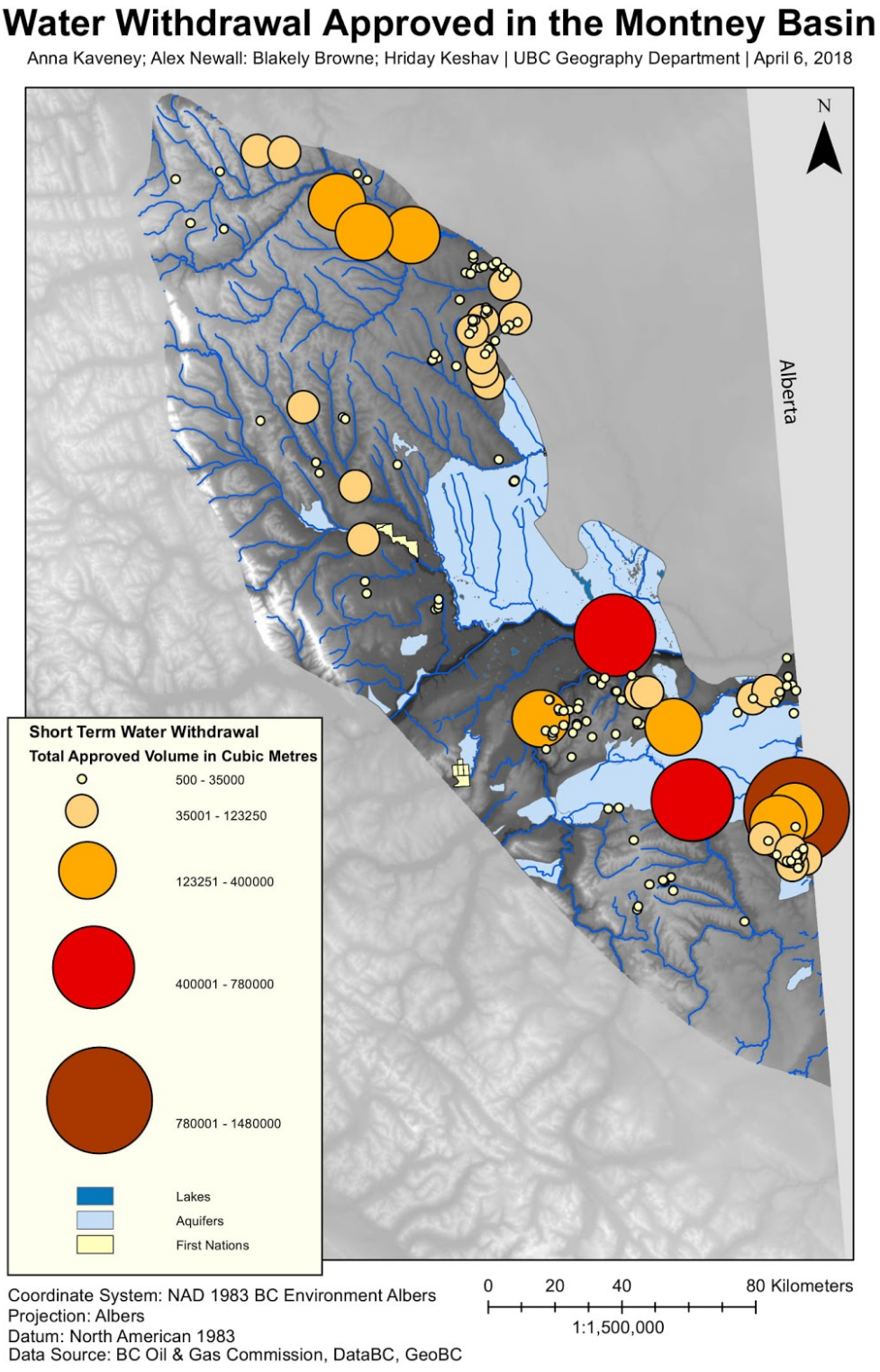


Figure 2: Map illustrating approved short term water withdrawal, measured in cubic metres, for use in hydraulic fracturing practices in Northeastern BC

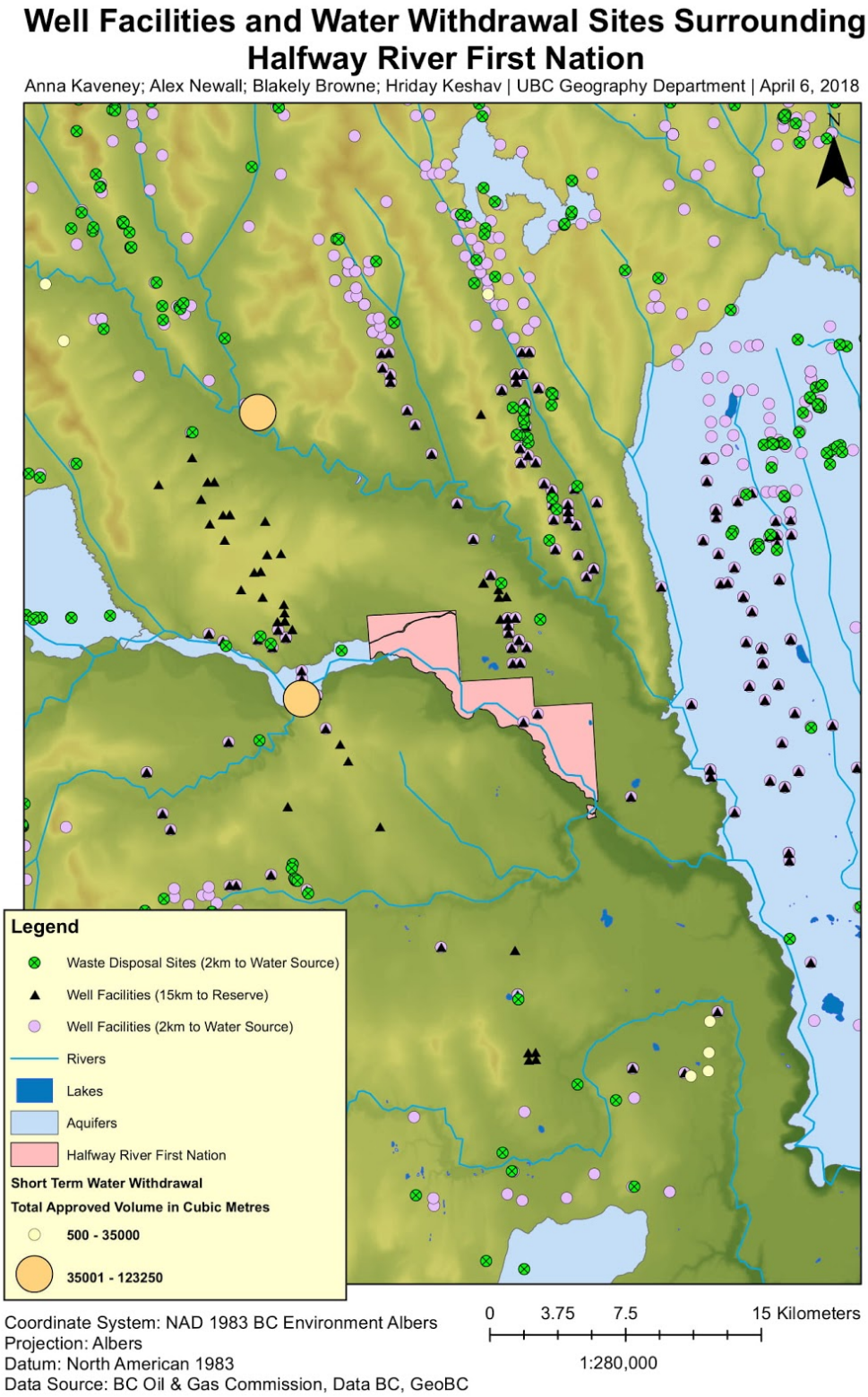


Figure 3: Case study map illustrating the proximity of hydraulic fracturing operations and components within a 15 kilometre radius of the Halfway River First Nation Reserve.