GEOB270 Final Project Report
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Environmental Impact Assessment of Mining Sites in British Columbia

An analysis of mining site disturbance on wildlife habitat areas for species at risk/regionally important wildlife due to river contamination

Abstract:

British Columbia (BC) has 28 major mining sites located throughout the province, these are mostly metal and coal mines. Mining of both metals and coal has been linked to adverse environmental and health effects. This project analyzes BC mines in proximity to valued components including poor/marginal water quality sites, wildlife habitat areas and First Nations communities. Since water pollution impacts both the abiotic and biotic environment, further analysis was done to compare poor and marginal water quality sites and mining zones to BC wildlife habitat and First Nations communities to account for potential harm as a result of poor water quality and proximity to mines. This project determined that for the 28 mines, it could not be concluded that mine presence directly resulted in poor and marginal water quality levels. That said, a large presence of wildlife habitat was found within close proximity to mine locations as well as to sites of poor and marginal water quality. Upon analyzing First Nations communities, there were three significant sites that were found to be close to mines and to sites that received poor and marginal quality ratings. This investigation found that although mining causes environmental impacts, more research is required to determine their extent.

Project description:

This project offers an environmental impact assessment (EIA) of 28 major mining sites in operation within British Columbia, Canada. A focal point of the study area is the Southeastern region of the province, where the proximity of mining sites to valued components (VCs) (including poor and marginal water quality sites, First Nations communities and wildlife habitat areas for species at risk/regionally important wildlife) is the most prominent and/or significant. Poor and marginal water quality sites have been identified based on properties of contamination/ inadequate levels of some or all of the following: Cadmium, Chromium, Copper, Nitrogen, Oxygen, pH, Phosphorus, Temperature, Arsenic, Lead, Selenium and Zinc. A proximity analysis of poor and marginal water quality sites within 25km of mining sites will determine the potential correlation between mines in BC and adverse environmental impacts of aquatic ecosystems. Similarly, a proximity analysis of wildlife habitat areas within 25km of mines and poor and marginal water quality sites will be conducted to determine sites requiring additional impact mitigation and monitoring to ensure high ecosystem standards that protect keystone species and ecosystem functions. The final valued component and data set included in this study is First Nations communities. The inclusion of this dataset will enable for a proximity analysis of First Nations communities that fall within 25km of mining and poor/marginal water quality sites, thus signifying social and environmental (in)justice due to mining impacts. The identified VCs are indicative factors which will ultimately determine the ecological sensitivity of areas in close proximity to mines, as well as the subsequent impact of mining sites on environmental justice for First Nations.

Maps produced for EIA:

1. Map 1: *Mine_River_Potential_Contamination*
    a. Buffered water testing sites against mines to determine potential water contamination due to mining projects. Areas with poor or marginal water quality signify potential exposure to mining impacts.
2. Map 2: *Mining_Wildlife*
    a. Buffered mining and poor/marginal water quality sites against wildlife habitat to determine potential threat to valued biotic components.
3. Map 3: *First_Nations_Communities_Proximity*
    a. Buffered mining and poor/marginal water quality sites against First Nation communities in order to determine communities under threat of potential adverse mining effects.

Methodology:

All data utilized for the mapping of Environmental Impact Assessment of Mining Sites in BC has been sourced from DataBC and Government of Canada. Downloaded data includes: Freshwater atlas of rivers, permitted major mines and selected major mine projects in British Columbia, Water quality in Canadian rivers, Wildlife Habitat Areas - Approved, First Nations Community Locations, and the Province of British Columbia. All aquired data was converted to UTM 1983 NAD Zone 10. Data clipped to the BC province dataset include: Freshwater river atlas, wildlife habitat areas, and First Nations Community Locations. The buffer tool was utilized on permitted major mines and selected major mine projects in BC, as well as water quality in Canadian rivers to offer a proximity analysis. A 25km buffer has been appointed to this study to provide visual and identification ease for proximity analysis. The study of pollutant transportation and/or diffusion is extremely complex and contingent on numerous factors such as permeability of soil, river flow, run off, climate factors, diffuse sources of contamination, and many more. Thus, it is extremely challenging to select one range that could account for all of these factors (Freeze, R. A., & Cherry, J. A. (1979)). Subsequently, a 25km buffer was selected not only for visual and analytical aid, but also to account for diffusion and leaching under the precautionary principle commonly applied in Canadian impact assessments. Refer to *Table 1: Table of Dataset* for specifications on data acquisition, parse filter, data analysis and representation. Refer to Figures 1, 2 and 3 for flowcharts documenting the GIS analysis workflow.

Discussion and Findings:

Map 1 (*Mine_River_Pontential_Contamination*) investigates the relationship between water quality in rivers and approved mines/mining projects in BC. As of 1846, with the signing of the Oregon Treaty, BC became open for resource exploration. A complex geological history consisting of a major subduction zone between the Pacific and Juan de Fuca Plate lead to the formation of major orogenic belts and the Cascadian magmatic arc. This magnetism is associated with the formation of copper, zinc, lead, silver, molybdenum and gold deposits (Ministry of Energy (2019, July 10). Overview of BC geology). BC also has extensive sedimentary coal bearing deposits. Currently, there are 28 major permitted mining projects in BC, the majority of which are metal and coal mines (Ministry of Energy. (2019, April 12)). Overview of coal in BC). Although the mining of these deposits have been extremely lucrative for BC—nearly a four billion dollar industry per year (British Columbia Mine Information. (n.d.))— the extractive industry has some serious potential environmental consequences. To illustrate, coal mining discharges massive quantities of acidic water which can greatly increase the acidity of the surrounding bodies of water and lead to an increase in dissolved solids and the precipitation of heavy metals (Tiwary, R.K. (2001)). Metal mining also contributes large amounts of acidic and metal rich water which can result in significant, adverse water pollution if tailings are released (BCcampus. (2014)). To account for areas at significant risk of water contamination, Map 1 applies a 25km buffer to all 28 BC permitted mines and poor to marginal water quality sites and in order analyzes the percentage of river systems that fall within this range. It also depicts the proximity of poor and marginal water quality sites to mine sites. It is estimated that about 3.8% of BC's rivers fall within 25km of a major mine site, and are thus at higher risk of water contamination. The Canadian water quality data set was relatively limited for BC but of the three sampling locations that were of poor/marginal water quality range (indicating that their levels of Arsenic, Copper, Lead, Nitrogen, Oxygen, pH, Phosphorus, Temperature, and/or Zinc levels were outside of those set by Environment Canada) one (the Craigmont Nicola Mine) was within 20km of a poor/marginal site. A minute percent (0.00012%) of BC's river area falls within a poor or marginal quality site. However, this result may not be sufficiently accurate as there were a limited number of water quality testing sites across BC. Essentially, no major conclusions about water quality in close proximity to BC's mines can be drawn because of the scarcity of water quality data, but with the knowledge that mining can result in adverse environmental consequences makes it crucial to have to have a concept of how BC's river may be affected.

In maintaining the precautionary principle for the impact assessment of mining sites, Map 2 (*Mining_Wildlife*) provides insight into valued biotic components most at risk to potential mining impacts. This map showcases wildlife habitat areas for species at risk/regionally important wildlife that fall within 25km of a mining and/or poor and marginal water quality sites, it aims to identify areas that require greater surveillance to ensure impact mitigation and

adequate monitoring programs. It is found that more than 29% of wildlife habitat areas fall within 25km of a mining site. This figure raises a 'call to action' for increased surveillance of mining sites, as a significant area of wildlife habitat is in close proximity to extraction sites capable of producing devastating biotic impacts if managed improperly. In addition to close proximity to mining sites, Map 2 displays the close proximity of wildlife habitat areas to both mining sites and poor/marginal water quality sites. In particular, the North Western segment of *Significant Site 1* in the *Mining_Wildlife* map (near Quesnel and Williams Lake) raises significant concerns for the well being of wildlife habitat areas VC that is reliant on healthy terrestrial and aquatic ecosystems. As previously discussed, it is possible that there is a correlation between the existence of particular mining sites and poor/marginal water quality sites. Subsequently, it is critical that the correlation between these south-central BC mining sites (Gibraltar, Mount Polley and Bonanza Ledge) and the proximal poor water quality site be investigated to ensure the protection of ecosystem functions and maintenance of keystone species/significant wildlife area threatened by potential adverse impacts of extraction.

The impact on wildlife is not only important for conservation and biodiversity reasons but because the impact extents beyond wildlife as well. The other VC that was studied is shown in Map 3 which (*First_Nations_Communities_Proximity*) analyzes the impact of mining activity on water quality with specific focus on First Nations communities within BC. There has been increased media coverage showcasing the disparity between First Nations communities and the rest of Canada where water has played a major role in the issue. Indigenous access to clean water has been determined as a major focal point for health authorities and organizations such as the Assembly of First Nations (Assembly of First Nations). There has been a long history documenting the importance of not only the connection to land that Indigenous people share but the cultural and physical keystone it plays in the traditional diet and lifestyle, thus analyzing the impact of development is crucial to ensuring the livelihood of these communities. For this map it was decided that First Nations communities should be chosen for the investigation rather than using the established Treaty boundaries because established First Nations communities were felt to be more representative and even today, certain Treaty boundaries may still be perceived as historically controversial and non-inclusive. After analyzing the dataset, three sites have been deemed of special significance as they are both in close proximity ($\leq$25km) to a mine and/or poor or marginal water quality site. Additionally, all of these three sites are near or situated close to rivers, which further impacts their ability for pollution. The three sites of significant concern are Site 1: Alexandria Indian Band *(?Esdilagh First Nation),* Site 2: Splatsin *(Spallumcheen)* Band and Site 3: Tobacco Plains Indian Band. Site 1 is not only within close proximity to a poor water quality site, but also falls directly within 25km of Gibraltar mine and is directly adjacent to two additional mines: Mount Polley and Bonanza Ledge. Sites 2 & 3 are not directly within 25km of mines, but are located within greater proximity to numerous mines and are located near rivers

with poor or marginal water quality. It is important to note that there may be numerous other First Nations communities situated near mines and may also be close to tested sites which were of poor and marginal quality but these communities were not analyzed within this investigation. There may be a significantly greater number of communities that are being impacted not only by poor water quality but also through disruptions of surrounding wildlife. Dependence on wildlife and high water quality levels are necessary to support the traditional lifestyles of Indigenous populations (Assembly of First Nations).

To summarize, it has been determined that while no major conclusions about VCs in close proximity to BC's mines can be drawn, the knowledge that mining can result in devastating adverse environmental consequences makes it critical to utilize this study as a basis for further investigations into how BC's rivers, and subsequently wildlife habitat areas and First Nations communities may be affected. Ultimately, the high prevalence of ecologically sensitive valued components that intersect with mining sites calls for increased provincial surveillance of mines to ensure impact mitigation and adequate monitoring programs. A greater range of BC water quality data analysis is recommended to produce more a more definitive and detailed impact assessment.

Error and Uncertainty

This analysis has found that a major source of error and uncertainty within this study is that correlation does not equate to causation. Thus, it has been difficult to determine any conclusive findings from water quality levels in relation to mine proximity. Further, it has continued to be challenging to correlate the potential of wildlife habitat consequences and human health degradation to mining activity. Though previous research has been done on analyzing the effect of coal and metal mining on health, there has been little data to determine the scale of the impact this has had specifically within BC and it remains unknown at the conclusion of this project. The results that this project has instead determined is that many of BC's valued components (rivers, wildlife habitat, and First Nations communities) are within close proximity to mines and poor and marginal water quality sites could be connected to adverse effects.

Additionally, the water quality site data utilized for this impact assessment is lacking in quantity and specifications on the contributions of proximal intersecting water sources. This investigation has found that there exists either a significant gap in publically available data on water monitoring sites or that there is a substantially minute amount of testing sites within the province itself. Both of these have resulted in ramifications that have impacted this project as the amount of water monitoring sites compared to the VCs being analyzed have resulted in the lack of conclusions able to be determined. Furthermore, it is recognized that time stamp data does not align for all data. Thus, in order to improve the accuracy and modernity of this analysis, it is

recommended that future analysis be conducted on more recent data sets across the province to be able to show not only historical patterns but also current and future trends.

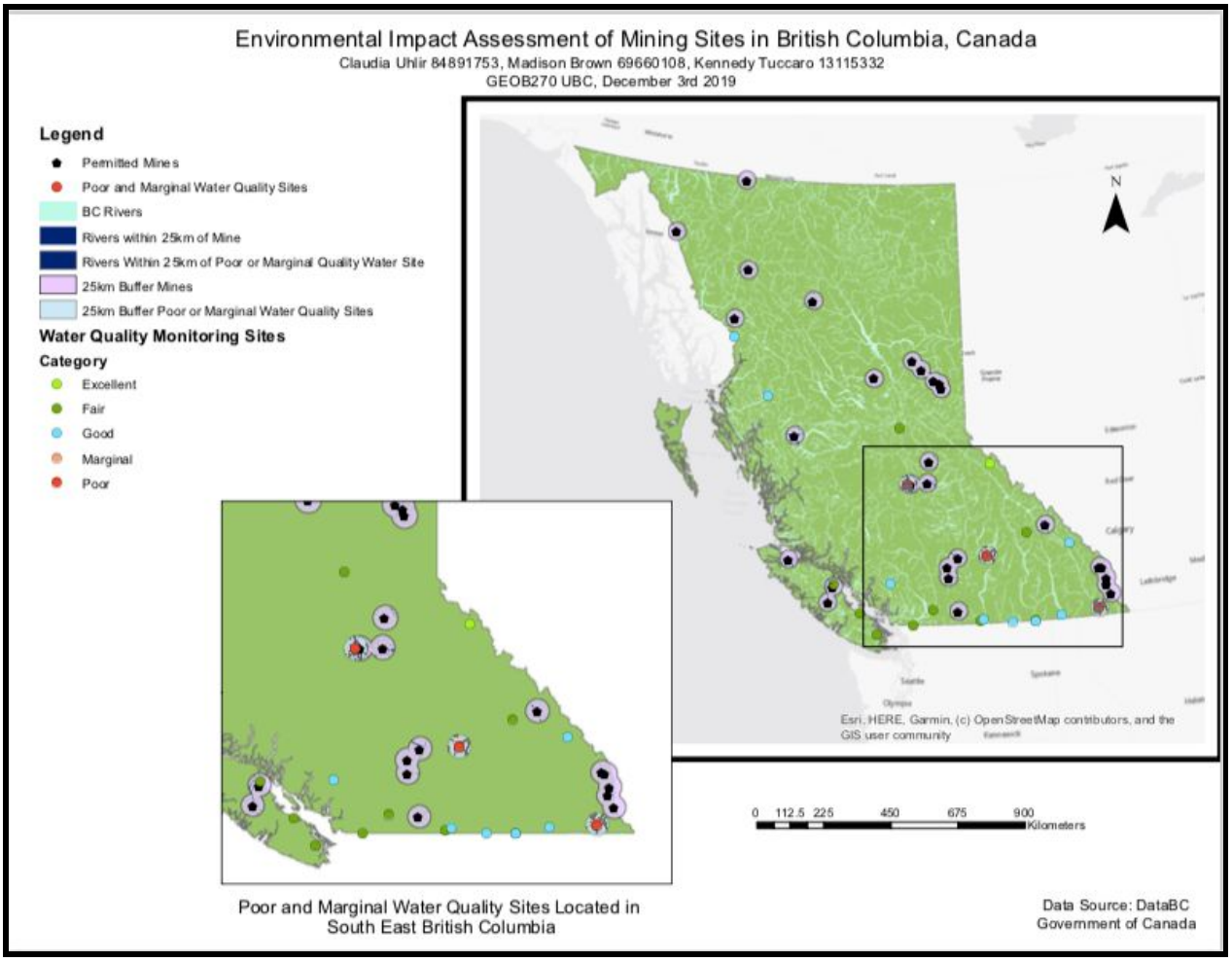
Another source of error that may have significantly impacted the conclusions drawn in this paper is the distance of the buffer that was applied to mines and monitoring sites. The choice of a 25km buffer was somewhat arbitrary, however a scale could not be effectively found that was able to satisfy a range of natural conditions that would be impacted by effluvial contamination. This buffer choice impacted every conclusion that was determined from this investigation and a larger/smaller distance would have resulted in a significant difference in results and the inclusion or exclusion of data points. A last source of error and uncertainty within this project is the data surrounding water quality in First Nations communities. This is because Health Canada monitors and tests all drinking water quality data and though this project did not directly examine drinking water, it provides another frame of consideration into the amount of degradation within areas. However, Health Canada monitors every First Nation community water quality south of 60° except for BC. BC has put in place its own institution for testing, the First Nations Health Authority, and this fragmentation may help explain the gap in available data surrounding First Nations communities, which impacted the results garnered from this analysis (Simms, 2015).

Further Research/recommendations:

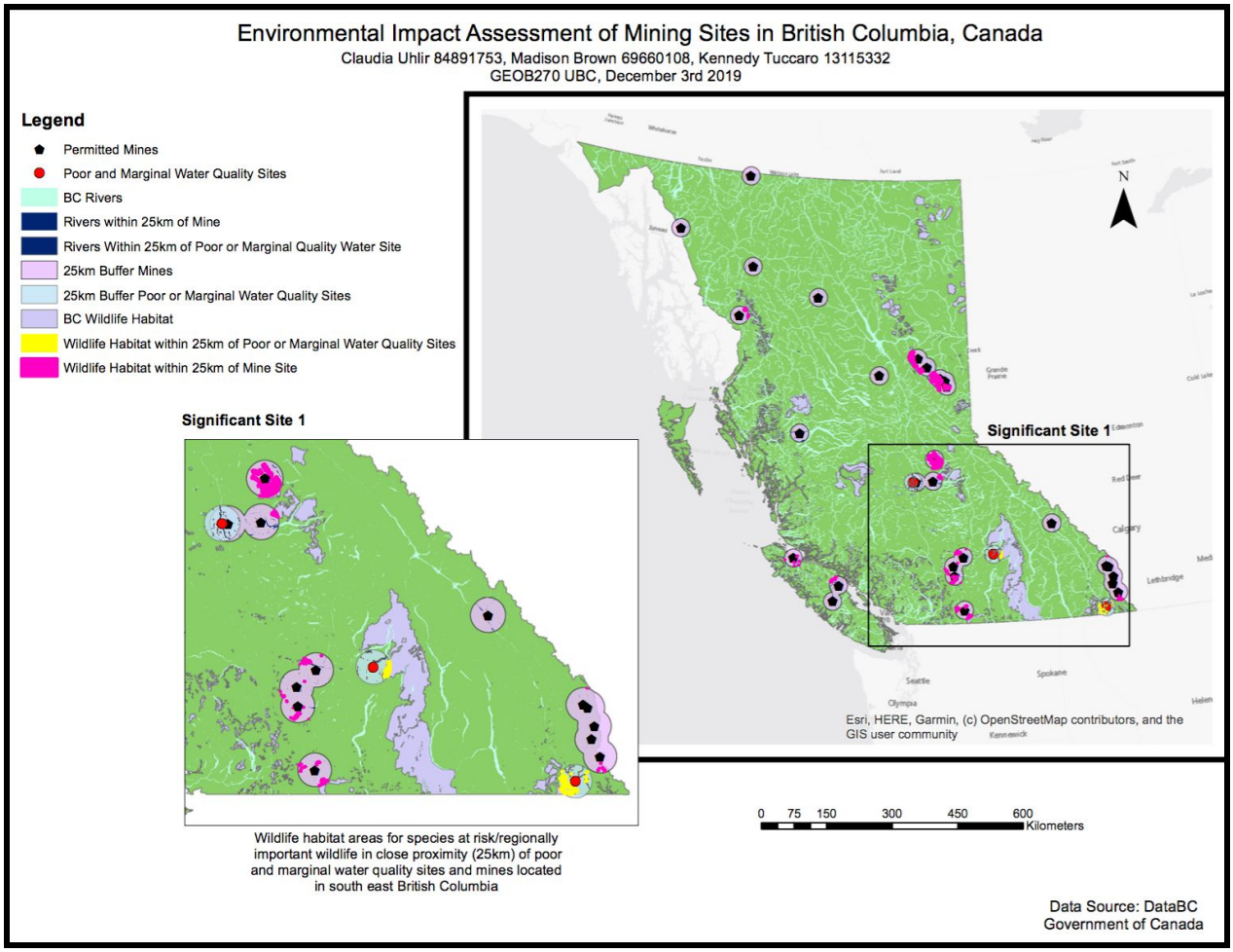
This project has made solid groundwork in initiating a provincial environmental impact assessment for mining sites. However, a gap exists where this project leaves off and the potential for significant impacts and benefits that this research may provide. Therefore, this project has numerous recommendations for further research. Firstly, it is recommended that the province testing water quality at various points along rivers but also for other surface water and also include ground water testing near mines. This data as well as individual impact assessments for each mine should then be publicly accessible to everyone and to the communities directly impacted by it. Next, the province should allow First Nations communities to exercise water governance in addition to the inclusion of a stakeholder position to address issues and be accountable to the Indigenous community and the general public. Additionally, data should have improved time stamps, be kept up to date. It should be noted that the Government of BC does not provide any reasoning for water quality level variance across regions. Therefore, further research would need to be done in order to locate a specific underlying causes and determine the extent that mining activity has impacted the surrounding water sources. In conclusion, should these recommendations be achieved, there would be significant public benefit and an increase in overall accountability and collective responsibility in protecting valued components and provincial natural resources.

Appendices

Map 1: Mine_River_Pontential_Contamination



Map 2: Mining_Wildlife



Map 3: First_Nations_Communities_Proximity

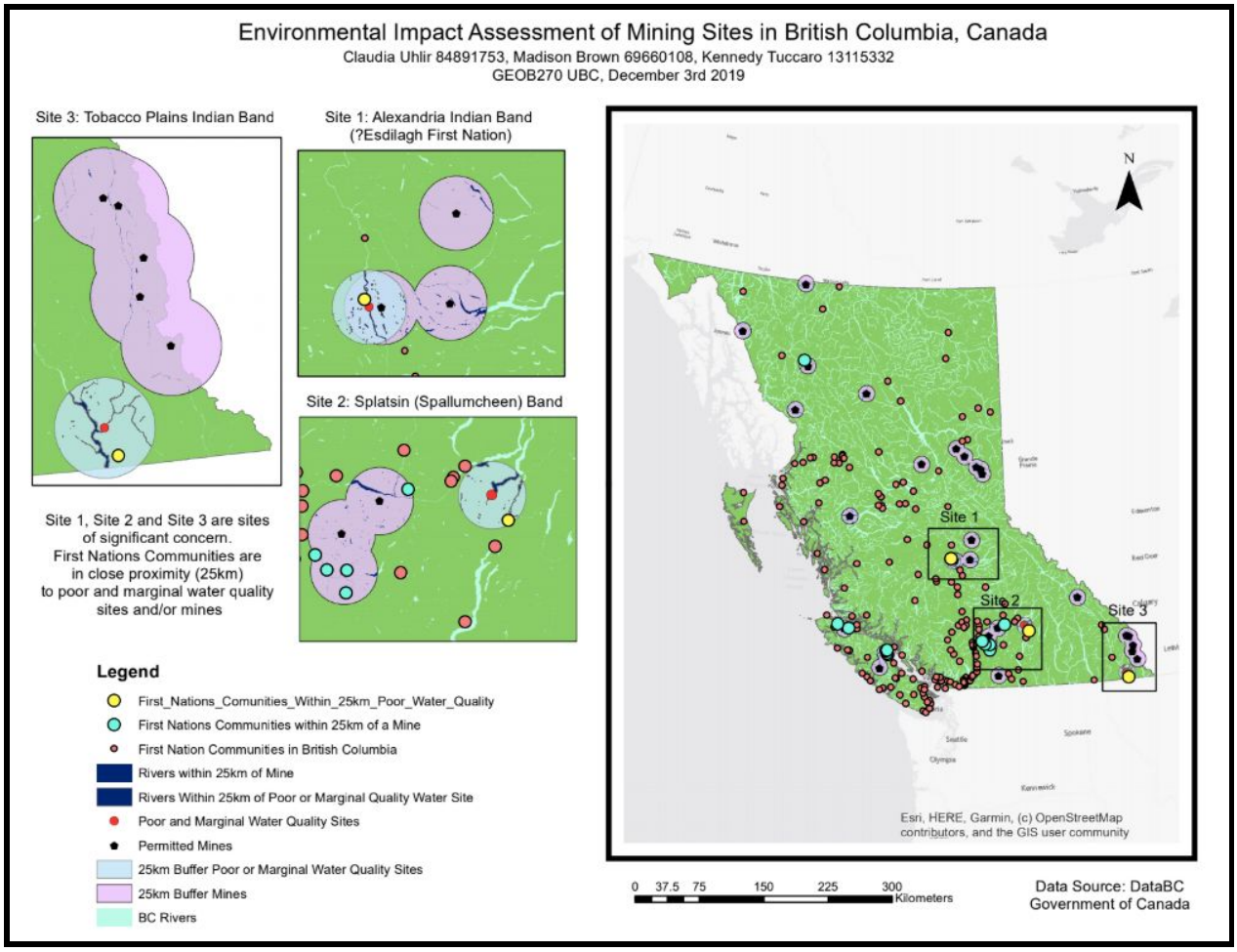


Table 1: Table of Dataset

Layer / datafile name	Source	Uses	Entity/data Model	Attributes	Modifications
Freshwater atlas rivers	http://data.library.ubc.ca/	*Use as reference for water quality testing sites *To compare river boundaries with overlapping with mine buffer zones and poor/marginal	Vectors (line)	OBJECTID*, SHAPE, HYDROUID, NAME, PRUID, Shape_Length, Shape_Area	*Clip to BC *Convert UTM 1983 NAD Zone 10
Permitted major mines and selected major mine projects in British Columbia	https://catalogue.data.gov.bc.ca/dataset/permitted-major-mines-and-selected-major-mine-projects-in-british-columbia	*	Vectors (point)	Fid,Shape,NAME, (original Layer had descriptions)	*Convert UTM 1983 NAD Zone 10 *Add 25km buffer
Water quality in Canadian rivers	http://indicators-map.canada.ca/App/CESI_ICDE?keys=Water_Quality&GoCTemplateCultur=en-CA	* Do a proximity analysis with mine sites and buffer to see proximity to wildlife habitat, and first nations communities	Vector (point)	Latitude, Longitude, Category, Shape, Site name, Tested substances	*Convert UTM 1983 NAD Zone 10 *Add 25km buffer
Wildlife Habitat Areas - Approved	https://catalogue.data.gov.bc.ca/dataset/wildlife-habitat-areas-approved	*To compare wildlife boundaries with overlapping with mine buffer zones and poor/marginal water quality sites.	Vector (polygon)	FID, Shape, HAB_AR_ID, WHA_TAG, APRV_DATE, NOTICE_DAT, FEAT_NOTES, FCODE, ORG_ID, COMMON_NAME, LEGAL, HARVEST, HECTARES, OBJECTID, FEAT_AREA, FEAt_LEN	*Convert UTM 1983 NAD Zone 10 *Clip to BC

First Nations Community Locations	https://catalogue.data.gov.bc.ca/dataset/first-nation-community-locations	*To compare first nations communities with overlapping with mine buffer zones and poor/marginal water quality sites.	Vector (point)	FID, Shape, CMMNTY_ID, FN_BC_NAM, FN_FED_NAM, FN_FED_ID, URL_BC, MEM_ORG_NM, LANG_GRP, BC_REG_OFF, ALT_NM1., ALT_NM2, ADDR_LN2, OFF_PROV, OFF_PST_CD, LOC_DESC, SITE_, SITE_NUMSITE_NM, COMMENTS, SHAPE_1, OBJECTID	*Convert UTM 1983 NAD Zone 10 *Clip to BC
(British Columbia) Province	http://data.library.ubc.ca/	*To show province boundaries since BC was the focus of our project	Vector (Polygon)	OBJECTID, Shape, PRUID, PRNAME, PRENAME, PRFNAME, PREABBR, PRFABBR, Shape_Length, Shape_Area	*Query for BC *Create BC layer from Selection *Convert UTM 1983 NAD Zone 10
Basemap	Arcmap	*To Show geographic boundaries	N/A	N/A	N/A

Figure 1-Map 1 Flow Chart

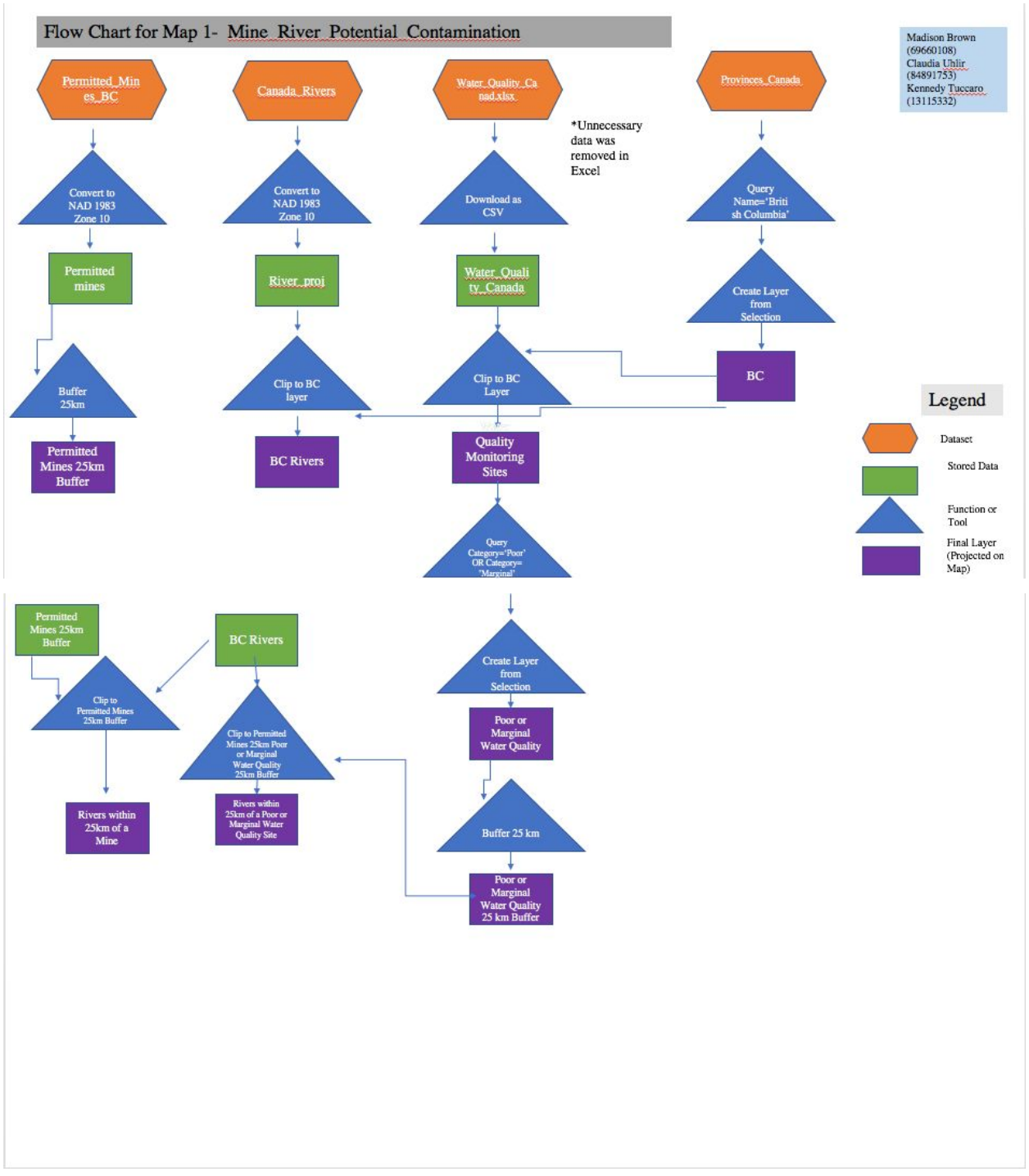
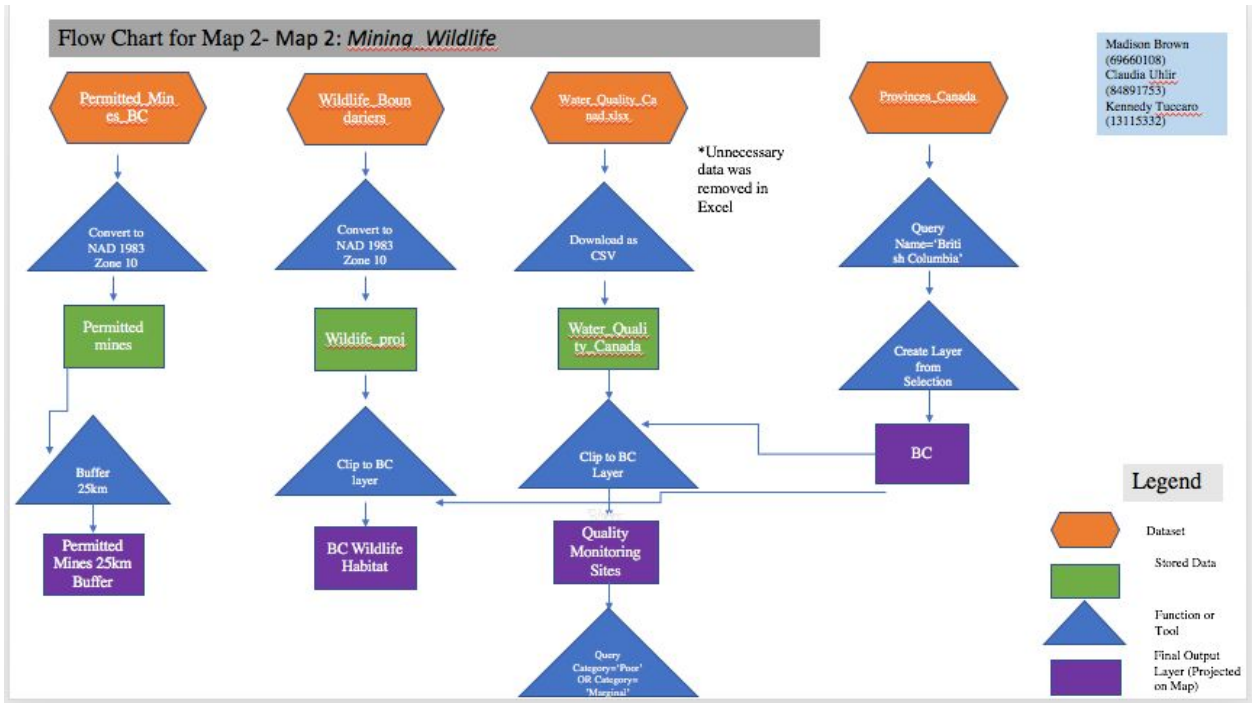


Figure 2- Map 2 Flow chart



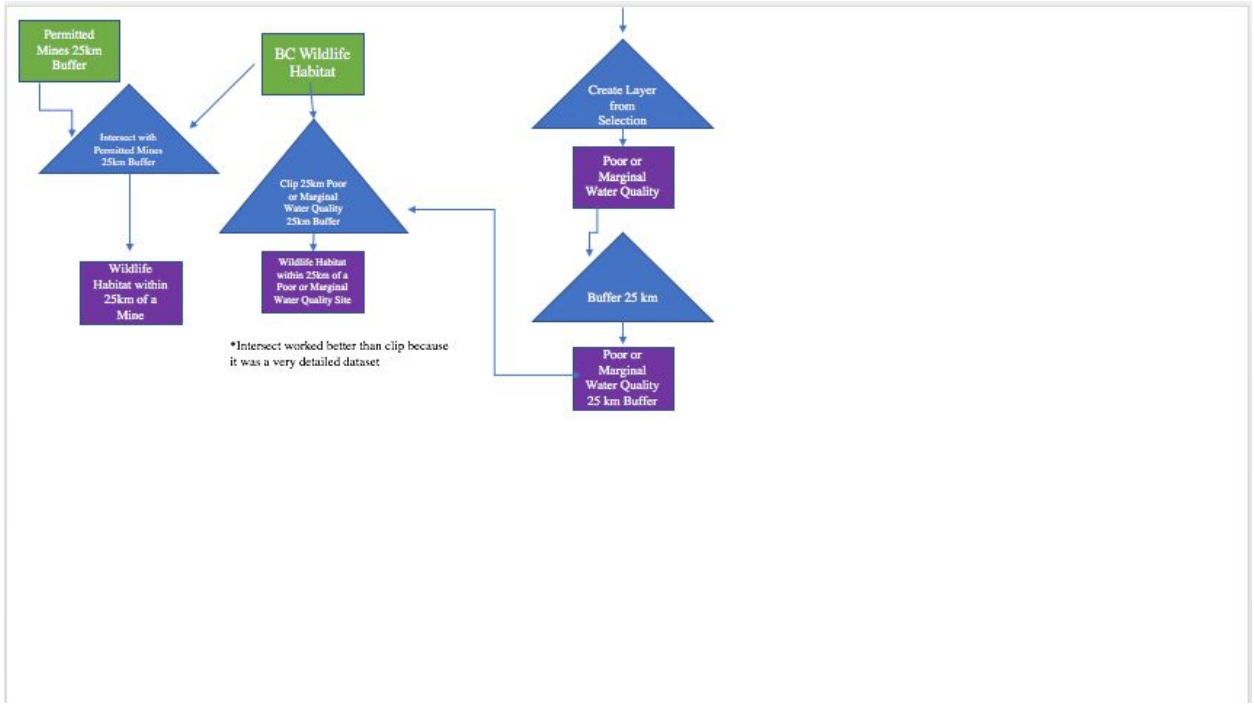
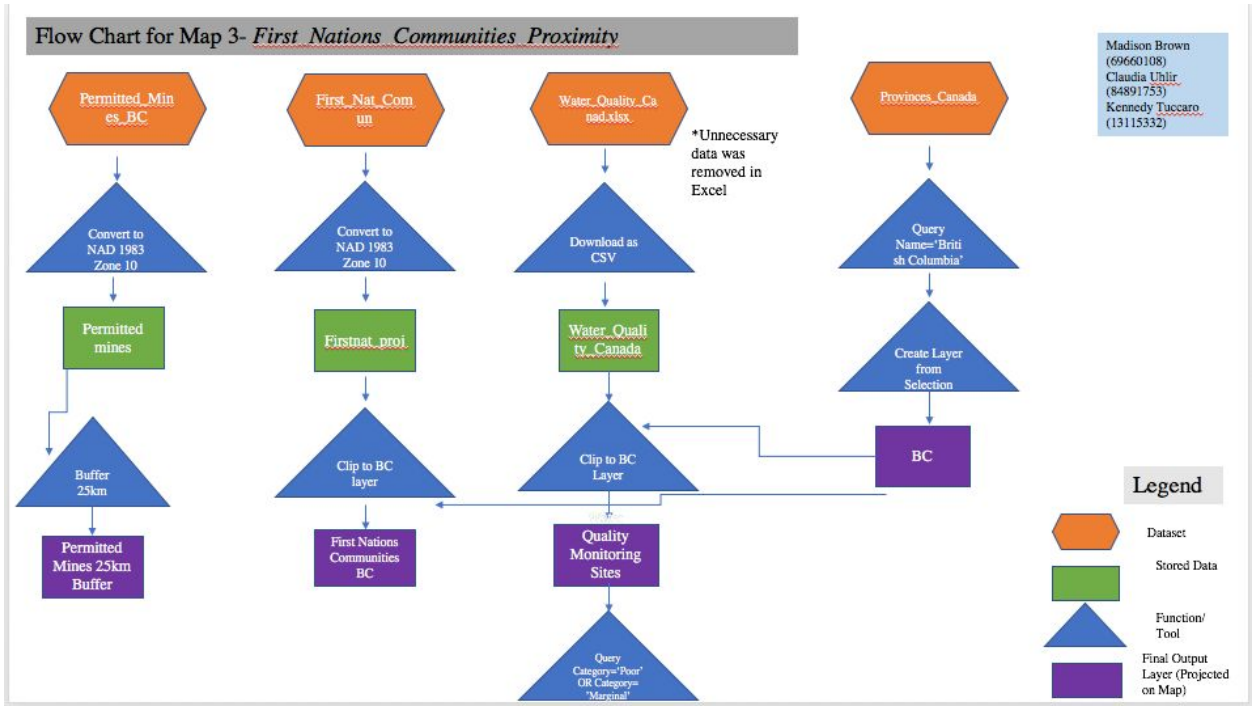
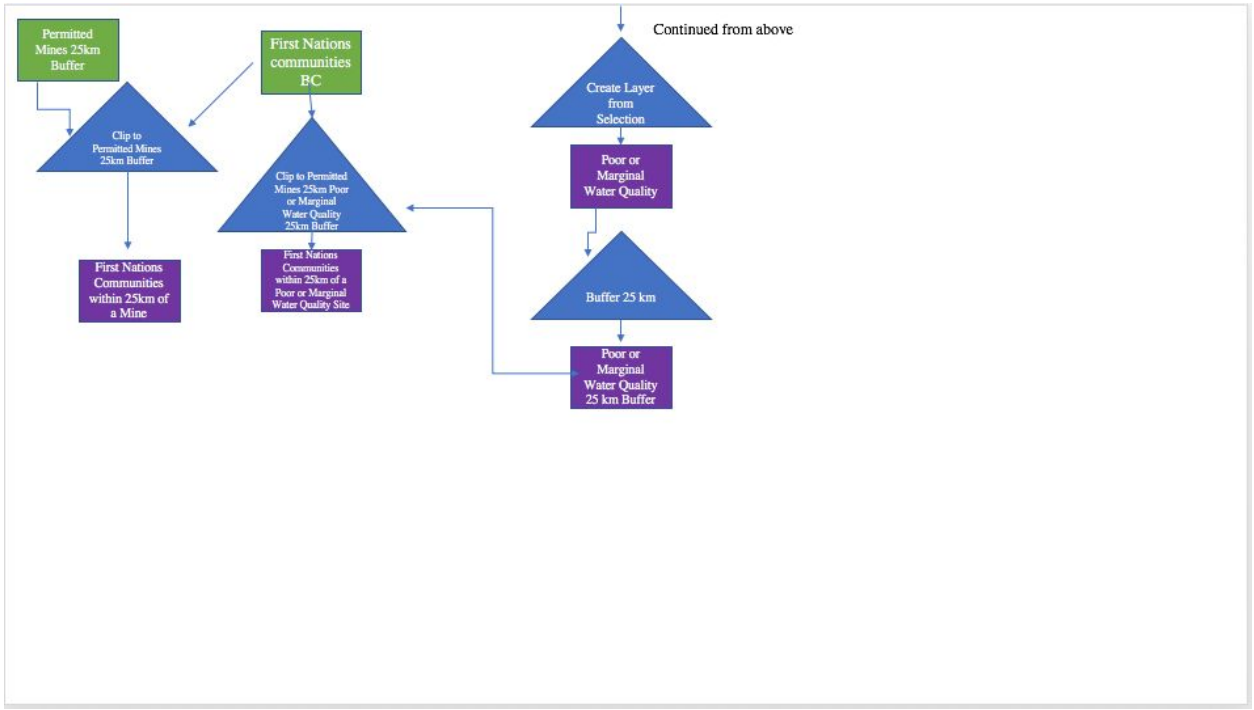


Figure 3- Map 3 Flow chart





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