“Why would you release fish into a body of water that can’t sustain them?” A community-based experience on the environmental health impacts of hydro dams in O-Pipon-Na-Piwin Cree Nation, Manitoba.

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Abstract

This project emerged as an opportunity to document Indigenous knowledge and strength-based solutions to address the environmental and health impacts of hydroelectric dam projects in the O-Pipon-Na-Piwin Cree Nation. As documented in the pages that follow, Hydro dams adversely affected local food production in these communities in particular traditional hunting and trapping grounds, fisheries were devasted, water quality was impaired, and shorelines were eroded. Members of OPCN have shared stories and narratives about the ways they have experienced the health impacts of hydro dams such as diabetes, cancer, heart attacks and skin diseases that emerged when hydroelectric projects entered the OPCN territory.

This thesis was collaborative research with a hydroelectric dam-impacted community, OPCN. The research objective was to provide an opportunity for the O-Pipon-Na-Piwin Cree Nation (OPCN) community members to document their hydro dam experiences. The research aimed to understand the spatial temporal implications of hydroelectric dam projects in Northern Cree communities before and after hydroelectric dam operations, and how communities experienced the changes in their environment. The research used qualitative research methods to achieve the research goals. Qualitative methods are used here as narrative-based methods and in this thesis, ~~they~~ were undertaken through interviews with Elders, Knowledge Keepers and Users, Fishers, Hunters and Trappers in OPCN.

According to OPCN community members' experiences, the cumulative impacts of hydroelectric dams' increased health and well-being problems. These cumulative impacts have been voiced by the OPCN community through different platforms such as social media, newspapers, conferences and recently at the United Nations Permanent Forum on Indigenous Issues (UNPFII) held on the 17th of April up to the 28th of April 2023 in New York, USA. The 2023 UNPFII theme was focused on "Indigenous Peoples, human health, planetary and territorial health and climate change: a rights-based approach." (Cultural Survival, 2023).

This thesis will document community experience and perspectives on the environmental health impacts of hydroelectric dams and present the impacts to non-community members, and decision-makers including governments, and it will highlight collective solutions used to address such impacts. The maps in this thesis will help communities to understand the changes brought by

hydroelectric dam projects on the environment such as changes in land use and flooding. Location-based narratives presented in ArcGIS Storymaps(A web-based digital platform that integrates text, pictures, videos, audio, maps and legends to help users explore the content (Esri Documentation, n.d.)) will help non-community members understand community members' experiences. This thesis is part of a larger, Indigenous-led project, Wa Ni Ska Tan Alliance of Hydro-Impacted Communities[1], and Kitatipithimak Mithwayawin[2] which are working to increase awareness of hydro impacts.

[1] https://hydroimpacted.ca/ Wa Ni Ska Tan Alliance of Hydro-Impacted Communities.
[2] https://covid19indigenous.ca/ Kitatipithimak Mithwayawin

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Chapter 1: Introduction

1.1 Background: Hydroelectric dam projects

Globally, hydroelectric power is now advertised as clean and renewable energy, with China as the largest producer followed by Canada (IEA, 2021). Such projects have had devastating impacts that adversely transformed ecosystems as well as the lives and livelihoods of communities (Elkaim, 2020). It is anticipated that global electricity demand will increase in 2022 (Lorenczik et al., 2021). The world's first hydroelectric project was capable of lighting a single lamp (IHA) in Northumberland, England in 1878. Four years later, the commercialisation of hydropower was opened. The first commercial power plant began operation in 1882 (Gilded Age, 1878; IHA, n.d.; Nunez, 2019) and it was located across Fox River in Appleton, Wisconsin, USA (Gilded Age, 1878-1882)

Hydro dams originally were meant to create water storage for electricity generation, supply water for agriculture, and industries, assist river navigation and mitigate flooding (Gilded Age, 1878; Rosenberg et al., 2000). However, the efficiency of dam technology in delivering these services has been questioned and heavily debated widely to the extent that 3 450 dams have been removed in Europe (Sweden, Spain, Portugal, United Kingdom, Switzerland and France (Moran et al., 2018).

> "Large dams and river diversions have proven to be primary destroyers of aquatic habitat, contributing substantially to the destruction of fisheries, the extinction of species, and the overall loss of the ecosystem services on which the human economy depends. Their social and economic costs have also risen markedly over the past two decades. (Postel, 1998, p636)."

Dam construction produces global-scale environmental effects such as water diversion, exploitation of groundwater aquifers, stream channelization and inter-catchment water transfer (Rosenberg et al., 2000).

1.2 Hydro dams in Canada

In Canada, hydroelectric projects started as early as 1885 along Montmorency Falls to provide lighting to the city of Quebec (Bellavance, 1991). In Montreal, hydroelectric projects started in 1892 along the Lachine Canal. In Manitoba, the Minnedosa River plant was the first hydropower generating station which was completed in 1900 and the Buntzen Lake Plant in Vancouver began production in 1903 (Robson, 1990). New Brunswick built its first hydropower generating station in 1904 along the Meduxnekeag River and five years later Alberta developed its first hydropower plant.

Focusing on the belief that hydro projects bring progress for the "common good" (Waldram, 1988), First Nations communities across Canada have to deal with problems associated with flooding, dam construction and river diversion. Even today, Indigenous communities still debate the issues of relocation, compensation, retraining and the general socio-economic upheaval surrounded by hydro dams (Dawkins (2019); James (2019); Robson, (1990)).

1.3 Hydro dams in Manitoba

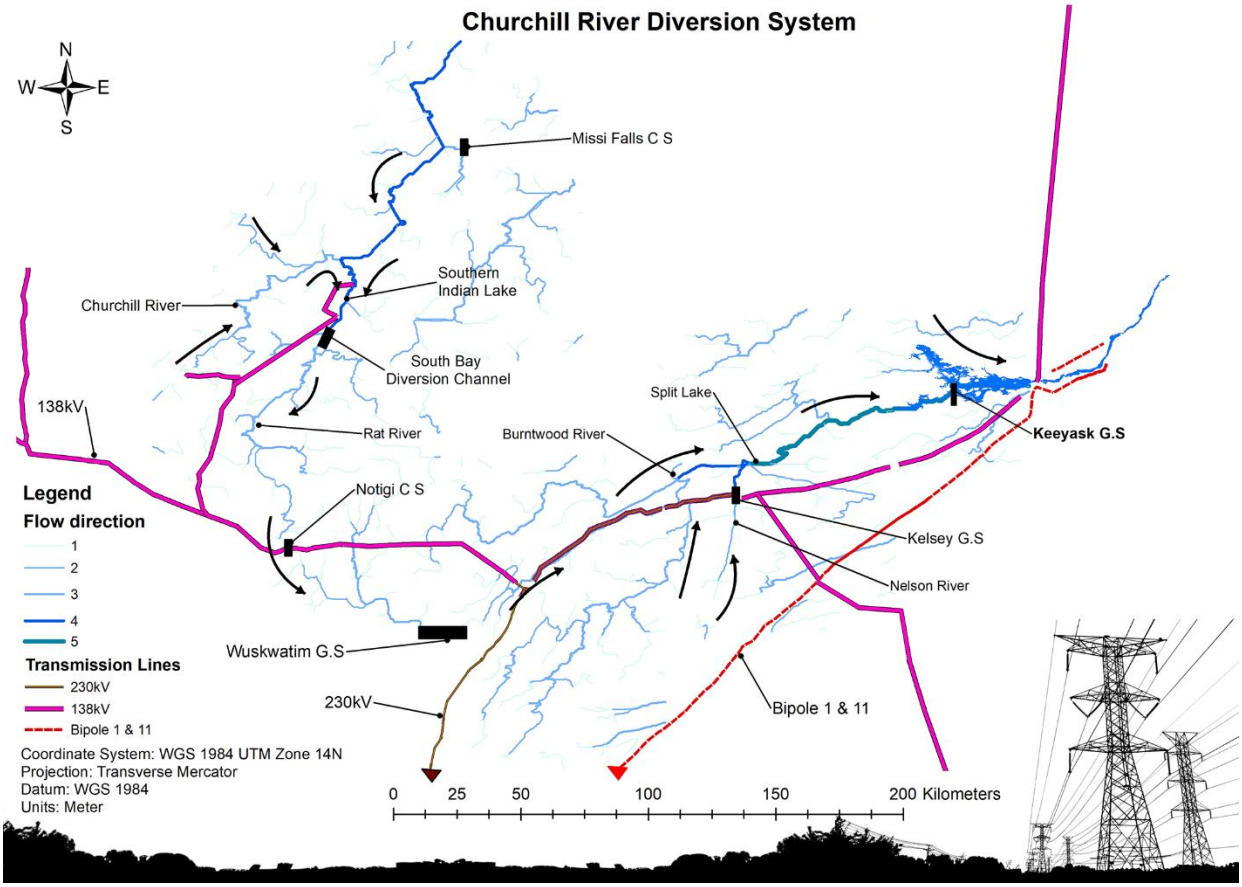
In the history of hydroelectric generation in Manitoba, generating stations were meant to support small population centres like Brandon (https://www.hydro.mb.ca/corporate/history/). However, the early 1960s marked the introduction of hydroelectric mega-projects that not only provided power to Manitoba alone but could potentially supply energy to other provinces and even beyond provincial borders like the United States (Kulchyski, Aboriginal Rights 133).

In Northern Manitoba, the first hydroelectric project to significantly impact First Nations was built in 1961, known as Kelsey Generating Station. Kelsey GS particularly impacted TCN. The hydro dam that directly impacted local First Nations was the Grand Rapids Dam which was built in 1965, located along the confluence of the Saskatchewan River and Cedar Lake. This period marked the beginning of arguments between Manitoba Hydro and Northern Cree Nations because little to no consultation of the Indigenous communities living along the river systems took place (McClullum & McClullum 104; (Kulchyski, 2004). According to Kulchyski, (Aboriginal Rights 132), Manitoba Hydro failed to address the harm by not meeting/addressing the needs and expectations of the affected communities (Kiakness, 2000; National Talk, 2009). Manitoba Hydro

did not consult affected communities in their proceedings, and they did not seek their consent. Their projects are labelled as “Projects of death” (W. James, 2019) because of the associated adverse impacts on the traditional way of life, culture and the environment.

The Grand Rapids generating station construction started in 1960 and completed in 1968 and the station generates 479 megawatts (Manitoba Hydro, 2021) (Manitoba Hydro). However, the planning and construction of the dam made the people of Chemawawin Cree Nation move by force to Eeasterville by the government of Manitoba (Waldram, 1988). After the Grand Rapids project was completed (Waldram, 1988), the government shifted attention to the Churchill and Nelson Rivers to further increase hydroelectric generation. The Churchill River Diversion (CRD) project emerged in this era.

Figure 1: The Churchill River Diversion System and Transmission Lines



Source: Gerald Beta

The CRD was meant to divert the natural Churchill River flow in South Indian Lake through Rat River and Burntwood River into the Nelson River system. The CRD was made up of three main components i) The Missi Falls ii) The South Bay Channel and ii) The Notigi Control Structure. The other CRD component, the Issett Lake man-made corridor diverts water from the south bay of SIL to Issett Lake creating a new outlet which flows into Rat River, Burntwood and Nelson River. The Issett Lake corridor floods NCN (Engineers Geoscientists Manitoba, 2016). The Missi Falls and Notigi are not generating stations, they are control structures. Their purpose is to control the movement of water in both directions, either upstream or downstream depending on Manitoba Hydro's needs (OPCN community member, 2022). There is no natural flow of water between the Missi Falls and the Notigi control structure. The South Bay Diversion Channel is a 9.3 km long man-made channel, filled with concrete to allow Churchill River to flow into the Rat River. Following the same Grand Rapids style, the community of South Indian Lake was made to relocate and re-establish itself in the post-flood environment by the government. These displacements were not compensated and later these two communities suffered grave environmental and health impacts.

Another hydroelectric mega-project, the Wuskwatim generating station was built between 2006 and 2012 along the Burntwood River at Taskinigup Falls (NCN, 2019). It is a 200-megawatt run-of-river hydroelectric generating station located in the Nelson House Resource Management Area (Nisichawayasihk Cree Nation (NCN)). It is owned by NCN and Manitoba Hydro, jointly known as the Wuskwatim Power Limited Partnership (WPLP). The main purpose of the generating station was to increase hydroelectric energy to harness export opportunities. The station had negative impacts on NCN and the Tataskweyak Cree Nation (NCN, 2019).

Currently, the newly built Keeyask generating station along Nelson River can produce 695 megawatts and produce 4,400 gigawatts of hours of electricity each year (https://keeyask.com/, 2010). The Keeyask project is located in the Split Lake Resource Management Area. It is a partnership between Manitoba Hydro and four Manitoba First Nations: Tataskweyak Cree Nation, War Lake First Nation, York Factory First Nation, and Fox Lake Cree Nation. The Keeyask generating station had a major disruption of both traditional livelihoods and cultural and spiritual identity (Buckland & O'Gorman, 2017).

Before hydroelectric development, affected communities survived from land-based produce such as hunting and gathering; techniques inherited from their lineages. Therefore, well-known social and economic activities that sustained and strengthened the inter-connectedness among First Nations have been disrupted. Food production has been compromised (Behrens, 2021), traditional hunting/trapping grounds disrupted, fisheries devasted (Buckland & O'Gorman, 2017), water quality impaired (Gillian and Thomas, 1994; Rosenberg et al., 1997), the fish quality deteriorated, habitat fragmented (Dynesius & Nilsson, 1994), heavy metals (mercury) contaminated lakes, reduced water levels, unstable ice, eroded shorelines, involuntary displacements and health and wellbeing compromised. These health and environmental impacts continued to increase even after 50 years.

The increasing need for hydroelectric projects amplified inequality between Indigenous and Non-Indigenous individuals and communities. The noticeable impacts of hydro projects include fluctuating water levels (Behrens, 2021; Buckland & O'Gorman, 2017; Dynesius & Nilsson, 1994), loss of floodplains and riparian zones, adjacent wetlands and loss of river deltas and ocean estuaries (Rosenberg et al., 1997). In some cases, these effects have been further exacerbated by cumulative impacts of multiple dams and infrastructure along with single catchment areas (e.g., Churchill River Diversion and Jenpeg in Northern Manitoba). Hydro projects involuntarily displaced community members – which made them 'nomads'/'foreigners' in their territories. In many areas, multi-sector and regional support networks have become essential in strengthening communities to advocate for and help mitigate the adverse effects of dams. Here in Winnipeg, an Indigenous-led partnership called Wa Ni Ska Tan – An Alliance of Hydro-impacted Communities supported and worked for the rights of hydro-impacted communities across the province and elsewhere in Canada.

Similar works and research across Manitoba, for example, the 'Death of a Delta' Film Frontiers, 1972 provided thought-provoking impacts of mega-hydro projects in British Columbia like the drying of small lakes and oil floating on top of lakes, during the construction of the W.A.C Bennet dam (1963). This thesis research also collated with recent Canadian works on the impacts of mega hydroelectric development projects by acknowledging what already exists and has been published. This includes the works conducted by Buckland & O'Gorman, (2017), who collate community voices on the negative impacts of hydro dams on people and the environment, the state

of erosion (Elkaim, 2020), unstable ice and flooded memorial sites/grave yards (Bergen, 2020), destruction of traditional county food webs (Behrens, 2021), impaired water quality (Tahsin, 2021) and more recent personal opinions through social media platforms like LinkedIn and Facebook from Les Dysart (OPCN), Robert Spence (TCN) and Angela Levasseur (NCN). They shared their experiences on how mega hydroelectric projects are disconnecting people from the land.

1.4 Health impacts of hydroelectric dams

The contamination of the land and water through hydroelectric dam projects influences the health of both communities living upstream and downstream of the reservoirs. Modification of water flow, water circulation and salinity due to stagnation of water provides conducive environmental conditions for water-related and vector-borne diseases to flourish, especially in tropical or subtropical regions (Brantly & Ramsey, 1998; N'goran et al., 1997; Stanley & Alpers, 1975; Trussart et al., 2002). In Africa, Hydro dams increase the prevalence of schistosomiasis, malaria, encephalitis, hemorrhagic fevers, gastroenteritis, intestinal parasites and filariasis (Lerer & Scudder, 1999). Hospitals normally report diseases outbreaks such as diarrhoea (Burr et al., 1978), skin disease, louse-borne diseases (Thacker et al., 1980) and malaria (Gagnon et al., 2002; Pontes et al., 2000), from hydro-impacted communities in the Caribbean, South America and Africa.

It is anticipated that more than 90 per cent of Canadian Hydroelectric projects are expected to increase substantial concentrations of the neurotoxins methylmercury in food webs (Leah, 2016). The decomposition of soil and organic matter from flooded lands and forests increases levels of mercury methylation which consequently biomagnifies into food trophic food web making fish unsafe to eat (Forsberg et al., 2017).

In Manitoba First Nations, communities are heavily concerned about how their land-based food chain has been compromised by hydroelectric dams (Pepper-Mackena, 2018; Tahsin, 2021). Hydro-flooding biomagnified and accumulated heavy toxins (mercury) across all hydro-impacted First Nations lands and waters. Methylmercury is a neurotoxin that bioaccumulates in food webs and negatively impacts individuals who rely on local ecosystems for country food (Bodaly et al., 1997). According to Zheng et al., (2019), mercury exposure can produce teratogenic, neurotoxic effects and reproductive toxicity in fish which harms cells, tissues, proteins, genes, survival,

growth and behaviour of fish. Indigenous communities rely on local fishes that carry a substantial amount of these toxins' elements.

> "One thing people do not understand is the water quality is not the same anymore. Control of water flow changes the season or the adaptation cycle of everything living in the water, [and] the fish do not taste the same." Elder Thomas Spence, OPCN (Craft & Blakley, 2022).

Consumption of mercury-intoxicated fish causes serious health problems associated with brain problems, alzheimer, autism, depression, high blood pressure, increased heart attacks and anxiety (Bastos et al., 2006; Fillion et al., 2006; Guallar et al., 2002; Halbach, 1990; Yoshizawa et al., 2002). "The human and ecological impacts associated with increased methylmercury exposures from flooding for hydroelectric projects have only been understood retrospectively after the damage is done," said Elsie Sunderland (Calder et al., 2016). In the same manner, (Robson, 1993, 115), mercury intoxication become a way of life.

In Our Backyard by Craft and Blakley, (2022), "The same way when CRD was constructed many communities, lakes and hunting and fishing areas were affected, Keeyask is going to either intensify the loss or keep it the same. It is not going to make things better for us." Elder Willian Dysart of OPCN. The entire boreal forest river system is interconnected, thus the disturbance to the ecosystem through damming, weirs and control structures causes havoc to both living and non-living entities. The contamination of the entire life cycle influences the health of the people, country foods and land quality (Calvin Baker, OPCN Fish plant manager). Wild-caught country food is the central food source of many Indigenous cultures and traditions (Arquetter et, al 2008). Yet these wild country foods are threatened by hydro contaminants (McLachlan, 2013). For instance, the fragmentation of the Churchill River system increased water contamination and fish mortality resulting in the loss of freshwater fish species and contributing to health impacts such as diabetes and heart diseases (McLachlan, 2013). There is widespread community concern over high rates of reported cancer cases that are attributed to exposure to environmental problems. Some hydro dams related impacts reported by communities include cardiovascular diseases, and respiratory diseases (Phung et al., 2021). On the other hand, the unusual water flow patterns create artificial high freeze-up ice which is dangerous and a fall hazard for snowmobile travelers. The risk of travelling ultimately turns into stress, depression, and anxiety for snowmobile travellers.

1.5 Research questions/objectives

1.5.1 Goal

The overall goal of this thesis is to document the health and environmental impacts associated with hydroelectric power projects in and with O-Pipon-Na-Piwin Cree Nation, Manitoba.

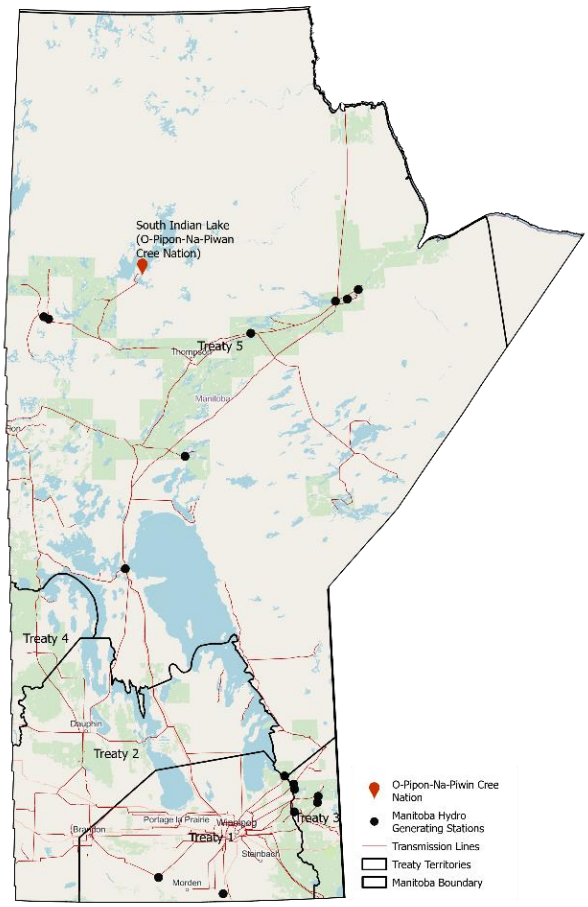
1.5.2 The specific objectives

1. To map the spatial temporal changes in the environment due to hydroelectric dam projects in O-Pipon-Na-Piwin Cree Nation.
2. To understand the implications of these spatial-temporal changes on community livelihoods.
3. To present and share these community experiences using ArcGIS Storymaps, a web-based tool that allows users to combine text, audio, videos, and maps to present information.

1.6 O-Pipon-Na-Piwin Cree Nation community profile

O-Pipon-Na-Piwin Cree Nation also known as South Indian Lake was formerly governed under Nisichawayasihk Cree Nation (Nelson House) and it was declared an official First Nation reserve in 2005 (Kamal et al., 2015) and got its status as a standalone Cree Nation (Internet Archive, 2006) with an approximation of 1 100 members in total. The majority of OPCN members transferred their membership from Nisichawayasihk and became residents of OPCN. Despite OPCN receiving their First Nation designation in 2005, they have lived in the area for a very long time and their presence predates 1960. The OPCN community was located along the SIL shorelines. Following the announcement made by the government concerning the new CRD design phases, the community was requested to relocate to the post-flood environment. They strenuously fought hydro plans but because most of the residents were treaty Indians with no separate band status (Kulchyski, 2004) /reserve community, the community was in a relatively weak negotiating position (Waldram, 1988). In 1973, Manitoba Hydro was granted permission to start CRD construction under the Water Power Act Interim license (Dysart & Spence, 2021). By 1976, the CRD was completed and in operation. Although community residents were assured minimal environmental disturbances (Peter, 2004), it turned out to be the opposite.

Figure 2: Map of Study location map



Source Gerald Beta

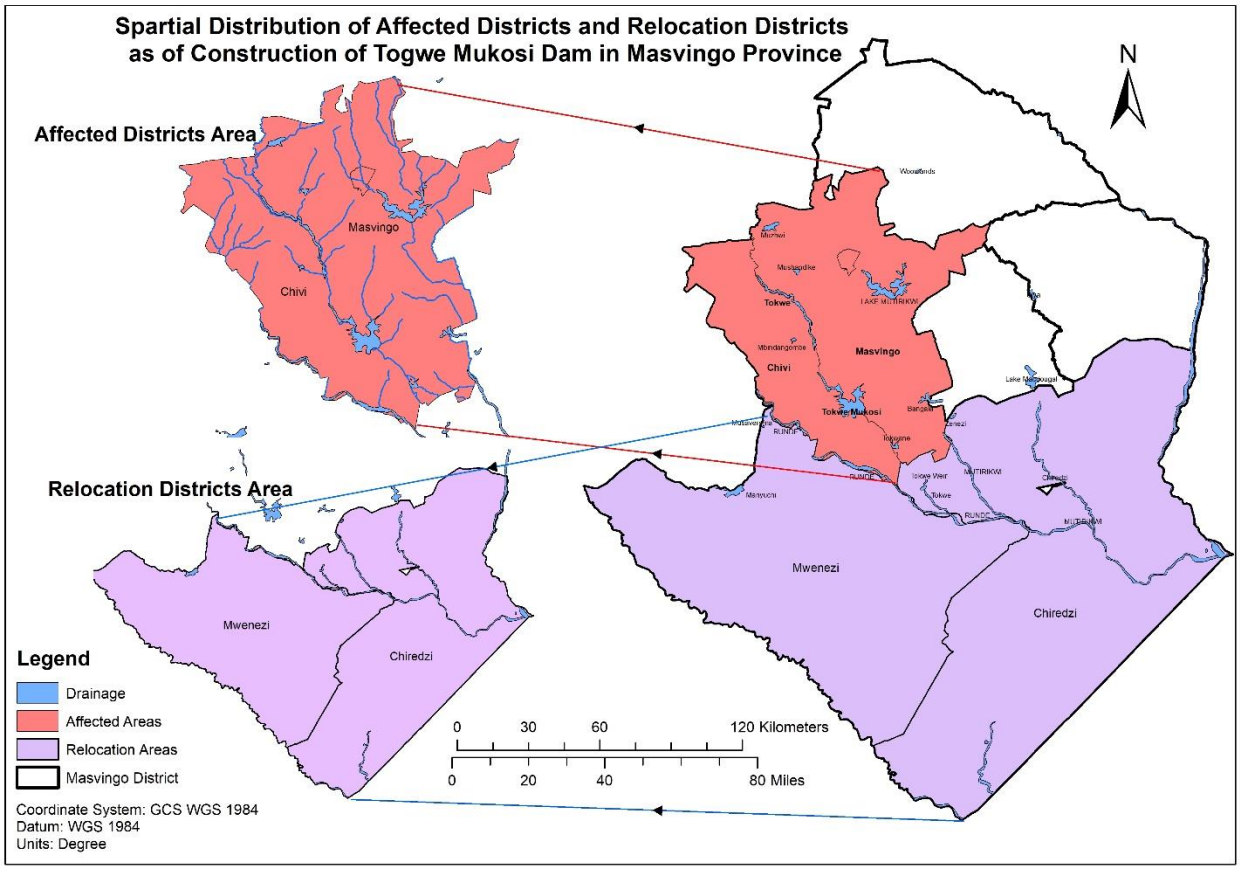
OPCN is situated in Treaty 5, 1078 km away from Winnipeg and 130km (81 mi) by air north of Thompson. It is geographically located along 56^0 46' 29.39" N Latitude and -98^0 55' 29.39" W Longitude in Manitoba, Canada. The community is dominated by spruce, pine, poplar, and birch. According to Waldram, (1988), the OPCN people by tradition sustained their lives through land-based activities such as fishing, trapping and hunting. They also traded furs and back in 1942, OPCN operated a commercial fishery and it was the second-largest white fish fishery industry in North America (Waldram, 1988). Their daily livelihood was made up of vibrant culture, respect, honesty, loyalty, wealth and an abundance of wildlife, fish, and medicines. In other words, they had a pimatisiwin (a Cree word for life (Settee, 2013) for a good life characterized by long expectancy.

1.6.1 Researcher Background

I am a newcomer to Turtle Island, from a landlocked country in southern Africa, Zimbabwe, whose geographic landscape is characterized by extensive outcroppings of Precambrian rock and predominantly savanna (tropical grasslands). Zimbabwe enjoys subtropical conditions as it lies north of the Tropic of Capricorn and because of its high altitude, it enjoys fine weather. The beautiful climatic conditions of Zimbabwe influenced me to study environmental management – as I understand the need to preserve the natural environments for future generations around the world, not just in my home country. While I had been learning more about environmental sustainability topics through my education at Midlands State University, most of the courses I took portrayed hydroelectric projects as an alternative solution to fossil fuels – as

"green energy". The concepts made a lot of sense as globally, countries were and are still fighting against climate change. In Zimbabwe, I participated in fieldwork that focused on evaluating the community experience living with the Togwe Mukosi dam in their territory. At that time, I had never critically thought about the negative impacts that hydro projects could have in the Chivi and Masvingo districts. I assisted in conducting open-ended interviews with communities who were relocated from the Chivi and Masvingo districts to the Mwenezi and Chiredzi districts to pave the way for the Togwe Mukosi dam.

Figure 3: Affected and relocated districts of communities affected by Togwe Mukosi dam.



Source: Beta, 2023.

The responses received from the participants in the Zimbabwean project were all negative and full of broken promises. I could not understand the negative responses because I had never lived and experienced life surrounded by hydro dams. After the community visits, I created maps that showed communities that were affected and relocated because of hydro activities (Map 3). At that

time, after listening and reflecting on the community experiences, I began to grow more interested in the impacts of hydro dam projects.

A few months later, I was trained the ISO 14001:2015 Environmental Management Systems, developing and implementation by the Standard Association of Zimbabwe. The course enlightened me on how project planners or developers should meet the needs and expectations of interested parties before conducting projects. In this case, interested parties can be community members, legislation, and regulations. As someone who deeply cared about people and the environment, I began to reflect on what I had learned during the hydro project. My questions were "Did the project developers or planners meet the needs and expectations of the communities before constructing the hydro dam?" My question was never answered as there was no one to ask whether there was any consultation that was done with the impacted communities.

A year later after completing my bachelor's degree in 2019, I relocated to Canada to begin my master's program at the University of Manitoba. In the winter of 2020, I officially began my master's program. In the first year, I completed coursework and I familiarized myself with literature on the impacts of hydro projects in Northern Indigenous communities. My real knowledge of hydro dam devastation began when I worked as a Student Researcher with the Wa Ni Ska Tan Alliance of Hydro-impacted Communities. As the year progressed as a Student Researcher, I had an opportunity to meet and learn from many individuals impacted by hydroelectric dams. The learning process was made possible by attending workshops, presentations, conferences, and Indigenous land-based camps for example the 20 Mile camp organized by the University College of North and the youth camp in Swan Lake. I also had an opportunity to visit and camp in NCN which is one of the hydro-impacted communities in Manitoba. During the NCN community visits, I did boat tours along the hydro-impacted rivers and the experiences gave me the confidence to start my master's project. This thesis work was achieved through collaborating, learning, actively listening, reflecting, and building long-lasting relationships with the communities.

1.7 Research design

1.7.1 Research Methodology

A research methodology is defined as a procedure to identify, collect data, organize data, and prepare information to answer research questions and resolve the research problem (Murairwa, 2010). This project adopted a mixed-methods research methodology to evaluate the environmental health impacts of hydro projects in OPCN. The mixed-methods research methodology allows researchers to use both qualitative and quantitative methodologies in a single study (Tariq & Woodman, 2013), to answer research questions that cannot be answered using a singular method (Doyle et al., 2009). It gives the researcher a variety of approaches to address questions. According to Tariq & Woodman (2013), mixed methods have the potential to remove the strengths and weaknesses of both qualitative and quantitative research methods.

The qualitative research method involves the process of collecting and analysing non-numerical data such as text, video or audio to understand opinions (Bhandari, 2022). Qualitative research methods make use of observations, interviews, focus group discussions, surveys, and secondary research. Observations involve recording what the researcher has seen, heard, and encountered without attempting to modify the subject being studied. It gives the researcher a real picture of the phenomenon under study. Interviews are a two-way communication between the researcher and the respondent (Murairwa, 2010). It involves asking questions in face-to-face conversation, it is flexible, it gathers precise answers, and it is associated with high response rates. However, it is expensive and prone to interviewer bias. Secondary research involves collecting existing data in the form of texts, pictures, video recordings and audio (Bhandari, 2022).

The research will also use GIS and Remote Sensing techniques to complement qualitative data analysis, which will make a unique contribution. GIS refers to a process of creating, collecting, managing, analysing and presenting all types of map data (Esri Documentation). GIS connects location data (where things are) to a map to answer descriptive information (what things are like there). Remote Sensing refers to the acquisition of information from a satellite or aircraft without physical contact with the observed object on the earth's surface (NOAA, 2022). The combination of GIS and Remote Sensing in environmental studies helps resource users understand environmental changes (Esri Documentation, n.d.; NOAA, 2022).

Hydro dams' impacts are multi-faceted hence they require a different approach to fully address how and to what degree First Nations have been affected. This requires a sensitivity to patterns of settler colonialism and how these impact Indigenous health and the environment. The project collaborates with researchers and community partners with knowledge of fishery collapses, environmental dispossession, medicine picking and the community-wide importance of these impacts and solutions. This requires researchers and community partners who can speak to what the patterns in data mean in collaborative ways, and it requires synthesis by the disciplinary team as it all will uncover diverse impacts that need to be thoughtfully summarized.

The proposed approach is rooted in principles of decolonizing methodologies, two-eyed seeing, community-based research and participatory GIS mapping (see, for example, Kovach, 2009; Smith, 199; Tuck and Yang, 2012; Wilson, 2008).

Documenting Indigenous knowledge and perspectives regarding environmental health impacts is the main purpose of the research therefore Indigenous participants are directly involved in the leadership and development of the project, including aspects of data collection, analysis, dissemination, and management of the findings. Hence the project is guided and controlled by OCAP principles proposed by the First Nations Information Governance Centre (FNIGC). The principles assert "that First Nations have control over data collection processes, and that they own and control how this information can be used" (First Nations Information Governance Centre). OCAP stands for ownership, control, access, and possession of data collected in the community. The principles were used as a tool to support First Nations data sovereignty.

1.7.2 Two-eyed Seeing Research Methodology.

Two-Eyed Seeing was introduced in the mid-2000s by Mi'kmaw Elder Albert Marshall to complement Western science's ways of knowing with Indigenous science's ways of knowing (Broadhead & Howard, 2021). Elder Marshal describes Two-Eyed Seeing as, "To see from one eye with the strengths of Indigenous ways of knowing, and to see both from the other eye with the strengths of Western ways of knowing, and to use both of these eyes together" (Bartlett et al., 2012). Peltier, (2018), interprets the concept "as the synthesis of Indigenous methodology and participatory action research situated within an Indigenous paradigm of relevant, reciprocal, respectful, and responsible research". In this time of reconciliation, this research approach seeks

to achieve meaningful and respectful research which presents Indigenous communities as experts in their knowledge. Way back, researchers employed a "helicopter approach" where they visit communities, collect data, analyze data and interpret their own data; without any community participation or representations and rarely return to the communities (Hall et al., 2015; Smylie et al., 2004).

1.7.3 Participatory Action Research Methodology

Participatory action research can also be referred to as community-based participatory research (CBPR), participatory health research (PHR), participatory action research (PAR) and emancipatory research. PAR is widely known as a research approach that seeks to combine theory/knowledge and practice to understand and address vital community and social issues together with people who lived or are living the experiences (Bradbury, 2015). PAR focuses on four factors which include the context, quality relationship, quality of action research process and the outcomes (Shani & Passmore, 2017). The research generates local wisdom hence the researcher needs to be well knowledgeable of the context prior to the research. The quality of the relationship between community members and the researcher is important hence the research approach is built on trust, honest conversations, respect, and humility. The quality of the action research process enables community members to develop a deep reflection on the issue being examined. The outcomes of the action research develop new knowledge and provide some level of sustainability developed out of lived experiences (Shani & Pasmore, 2017). This research approach is grounded in people's practices (i.e., experiences) hence it gathers the cause-and-effect dynamics between factors.

PAR differs from other conventional research methods because it is grounded in data collection, reflective cycles and action that aims to determine what action should follow (Baum et al., 2006). Through collaboration and consultations, the resultant accomplishment is then further examined, and an iterative reflective cycle continues data collection, reflection, and action as in a spiral action. PAR pays vigilant commitment to power relationships, advocating power to be deliberately shared between the researcher and the researched. It seeks to distort the line between them until the investigators become the investigators (Baum et al., 2006). The investigated cease to be objects and become allies in the entire research development including selecting the research

theme, data collection and analysis and determining what action should happen because of the research findings.

1.7.4 Participatory Geographic Information Systems (PGIS)

> "The action of producing a map of a certain location together with or by the residents, often featuring local knowledge and resources" (Petersson et al., 2020).

A participatory geographic information system is a process of map creation that empowers local communities to capture local knowledge and culturally significant information spatially on a map layer (Beverly et al., 2008). It is a process that involves participation, learning and action (PLA) with geographic information systems (GIS) (Corbett et al., 2011). PGIS has been used for knowledge documentation, planning, and sharing to understand the past, present, and future of locations. PGIS is a qualitative research approach that captures people's experiences, attitudes and interactions with the environment (Bryman, 2016). PGIS is a widely known research methodology that is used in understanding natural resource utilization and governance (Mapedza et al., 2003), health mapping, knowledge transfer and translation, education and community planning in local communities (Chambers, 2017; Okotto-Okotto et al., 2021). According to Brown & Fagerholm, (2015), PGIS has been used to map ecosystem services especially cultural services within local communities demonstrating the relationship between landscapes (such as land use) and their influence on human well-being.

PGIS plays a crucial role in empowering the participants of the study, especially the equity-seeking groups by providing an opportunity to generously share their thoughts and experiences with the subject matter. The research approach gained momentum in the early 1990s. According to Chambers, (1994), PGIS can be referred to as a top-down to bottom-up approach that moves away from extractive survey questionnaires on communities by outsiders instead of the insiders, the community people themselves. The PGIS approach and methods have been called,

> "An approach and methods for learning about rural life and conditions from, with and by rural people." (Chambers, 1994).

Sometimes the preposition has been reversed to an approach "by, with and from," community themselves. The approach is more than just learning, sharing, enhancing and analysing

community knowledge and life conditions, but leads to planning and action (Chambers, 1994). PGIS can be applied in different forms such as paper-based (like hard copy/printed maps, cartographical/topographical maps), 3D modelling and electronic/digital mapping technology (web application, computer software e.g. Google Earth) especially using internet map services such as Google® (Chambers, 2017; de Groot et al., 2010). However, the quality of information obtained from PGIS depends on the relationship between the facilitator and the respondent, and the behaviour and attitude/s of the people facilitating the mapping activity because if participants feel unsafe with their information, they become hesitant to share. The nature of outcomes also depends on who is taking part in the mapping activity for example their ability to read and use maps. The idea of PGIS is to empower the local communities.

1.8 Methods

This thesis uses PAR methods and PGIS methods to conduct interviews and mapping activities with community members from OPCN. The targeted participants have experienced the environmental health impacts of hydro dams in their communities. The research method processes evolved from establishing long-lasting relationships, planning, visiting communities and reflecting.

1.8.1 Qualitative Interviews.

To understand the environmental health impacts of hydro projects that OPCN is experiencing, face-to-face qualitative interviews were conducted. Interviews are flexible hence they enable both the interviewer and interviewee to ask and clarify unclear questions thereby obtaining relevant responses (Babbie, 1992). The interview questions were open-ended questions which provided respondents with the opportunity to express their opinions, thoughts and understanding of the subject (Dawer, 2019). All interviews had four open-ended questions (included in Appendix A) and they took an average of 30 – 40 minutes. The interview questions were aimed at documenting community experiences and the history of hydro projects before and after they came into the OPCN territory.

A total of 9 interviews were conducted with 9 OPCN participants and 1 OPCN interpreter. All participating OPCN community members with different socio-economic cultural activities

including Elders, Community Knowledge Keepers and users, Community Leaders, Fishers, and Hunters. The interviews were conducted in the Fall of 2022 (September and October) and Winter of 2023 (April). A list of 14 potential interview participants were selected by my Community Connector and 9 were picked on the list. A purposive sampling method was used to select the 9 interview participants. The interview process phase 1 took five months to complete, as I started by establishing relationships with Community Leaders (the Band and Council), meeting the Community leaders in Mile 20 camp which was organised by UCN, being invited to send an advertising poster seeking for participants in OPCN (Included in Appendix B) and visiting the community for interviews. With permission to video record the interviews from the Elders, Knowledge Keepers, Hunters and Fishers, the interviews were conducted on the devasted lands and waters.

When all the interviews were completed, the audio recordings were transcribed using a web-based application called Otter. Video recordings were edited using a Windows desktop open-source software called Shortcut and Microsoft Clipchamp. Transcribed audio and edited videos were used in this thesis with original quotations to amplify the community's voices and experiences.

1.8.2 Surveys

During the community visits in September and October 2022, I visited part of the hydro-devastated lands, lakes, and waters around OPCN. The boating activity was led by 2 community members who took me on a boat tour along the South Indian Lake. The 2-community members ended up being part of the interviews because they knew where and how the land and water were affected and they were also community resource users. With permission to record, the boat tour was conducted on the impacted landscapes. I geographically captured the route we used and pinpointed the hydro-devastated locations (Included in Appendix C). Most of the recordings (pictures and videos) were all used in digital maps (ArcGIS Storymaps).

However, in-person interviews and community visits almost failed because of COVID-19 pandemic infection rates during the Fall of 2022. I had to observe and follow the University of Manitoba COVID-19 protocols, Manitoba government COVID-19 guidelines and the community

COVID-19 protocols to conduct in-person interviews. The COVID-19 protocols involved self-testing, wearing masks and social distancing were ever possible.

1.9 Data collection

To understand the spatial-temporal changes in environmental health because of hydro dams, the data was collected from Manitoba Hydro which provides Geographic Information System (GIS) information for locations of major Electrical and Natural Gas facilities across Manitoba. GIS information was used to spatially visualise the location of hydro facilities versus impacted communities. After identifying the locations of hydro dams, the environmental changes were evaluated using the United States Geological Survey (USGS) data. USGS provides remotely sensed satellite imagery data from 1972 to 2022. USGS data was used to map selected community land use land cover changes and flooding before hydro projects. GIS data facilitated the spatial-temporal changes across Manitoba First Nations. USGS data was complemented with NASA data sources. NASA provides Digital Elevation model data of landscape status from 2006 to 2015. The data sets were used to generate the direction of flow, watershed delineation, drainage basin etc. For instance, the NASA data helped to identify flooded areas in OPCN along the South Bay Channel.

1.9.1 Data analysis

The spatial dimensions of the community environmental health data within and among other communities will be analysed using GIS and Remote sensing. Manitoba Hydro data, USGS data and NASA data will be analysed using ArcGIS Desktop 2.8, ArcGIS Pro 3.1, and Google Earth Pro software. ArcGIS platforms are commercial software owned by ESRI therefore they require an authentic license to use them. However, changes in water levels and flooding will be analysed and mapped using density slicing techniques, spatial analyst tools and image classification processes (supervised and unsupervised classification).

Density slicing can be defined as a digital data interpretation method using remotely sensed data to assess the information collected using a brightness band (Campbell, 2002). It involves assigning a range of brightness bands into intervals and then assigning each interval to a different

colour (Hamandawana et al., 2006). The colour differences constitute the key to photo interpretation (Rodriguez-Bejarano, 1975).

Image classification is a process of assigning classes on a remotely sensed image known as schema to determine land cover and land use classification system (Esri Documentation). It is a major contribution to remote sensing because it is frequently used in the monitoring of change, and it allows the researcher to map patterns of change i.e., flooding (Chipman, 1643). This process helps to form a basic description of the land cover change, which is a physical, visible manifestation of human-environment interactions (Natural Resources Canada, 2008). This thesis will use image classification techniques like direct blinking and image algebra change detection to identify flooded areas. Direct blinking is easy and immediate, it compares two different images by blinking back and forth (Blaschke, 2010).

1.9.2 Data presentation

1.9.2.1 ArcGIS Storymapping Platform

ArcGIS Storymap is a web-based digital platform/application that enables users to share maps in narrative text and multimedia content (doc.arcgis.com). ArcGIS Storymaps combines a mixed media approach that includes maps, videos, audio, pictures, graphs, and text into a digital online interface. According to Oubennaceur et al., (2021), ArcGIS Storymaps joins informative texts, community stories/ narratives and interactive maps into a simple online interface that is user-friendly and can provide customizable displays. The interactive ability of ArcGIS Storymaps plays a crucial role in dispensing information to people regardless of ethnicity. Online interactive communication tools such as ArcGIS Storymaps are becoming popular in illustrating complex scientific data to specific targets (Oubennaceur et al., 2021).

ArcGIS Storymaps can embed web-based maps that can be static or dynamic depending on the user's preferences. Static maps are widely known as fixed maps meaning they cannot be adjusted or zoomed in or out over a desired location and dynamic maps are widely known as maps that allow interaction in the form of zooming in and out, turning features on or off and moving map sideways depending on user's preference (Oubennaceur et al., 2021). ArcGIS Storymaps play

a crucial role in data presentation and interpretation because elements like legends, colours and embedded pop-ups can be customized to enhance user experience.

Esri platforms that house the ArcGIS Story Map geospatial platform are likened to Microsoft 365 because they all have standalone desktop computer applications and web-based platforms such as ArcGIS Online and Office 365. ArcGIS Storymaps can be used with a non-GIS user for communication purposes, and it is a pick-and-drop web platform that makes it easy to use. The Geospatial web technology does need no coding or programming skills to create a design.

1.9.2.2 ArcGIS Storymap Interface

Figure 4 Story Map template

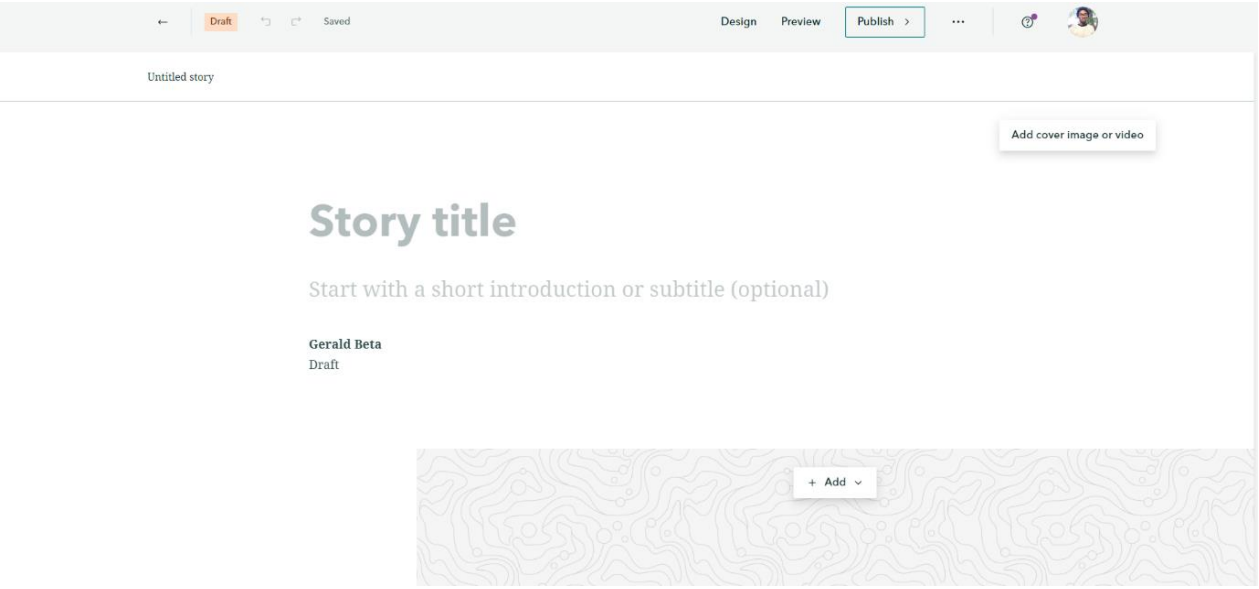


Photo by Gerald Beta: Story Map template showing a quote, video, and location.

Figure 4 shows an ArcGIS Story Map template interface that enables the story map designer to name the story map title, provide a short introduction or subtitle, add multimedia content such as images or videos, change the design, preview the story map and publish the story map (doc.arcgis.com).

Figure 5 Story Map design templates

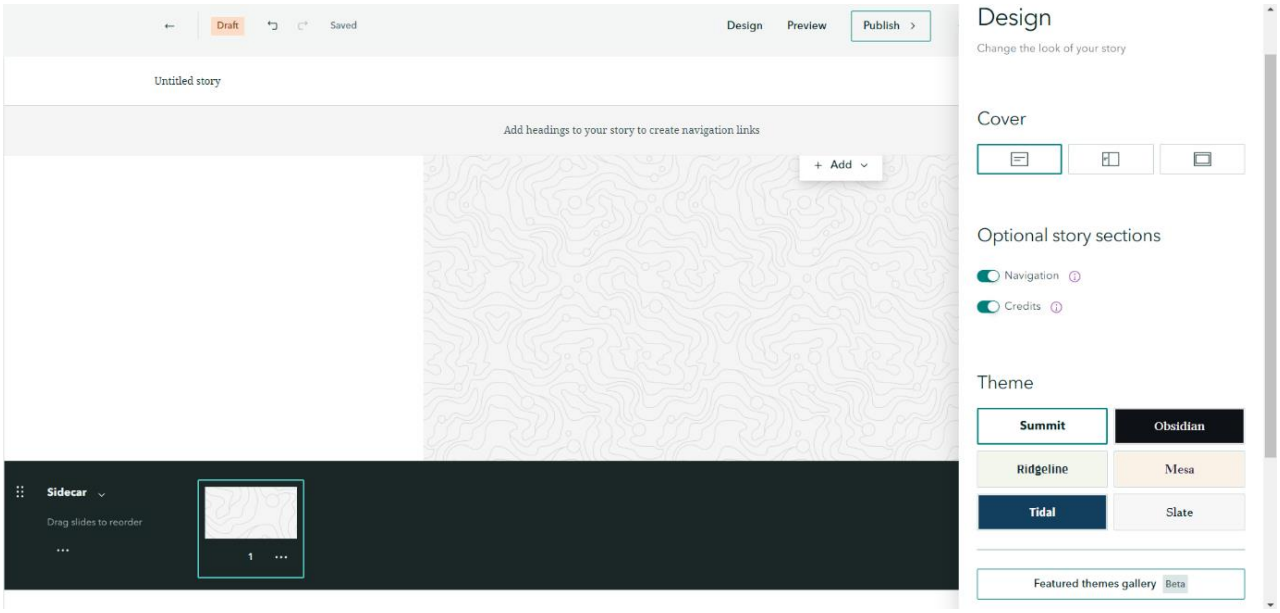


Photo by Gerald Beta

Figure 5 shows different story map cover layouts that a designer can pick first before adding content to the story map. Esri provides three kinds of covers such as the minimal cover (1st), the side-by-side cover (2nd) and the full layout cover (3rd). Also, the story map designer has the flexibility to choose or pick the desired theme from the ready-to-use default themes provided by the ArcGIS Storymap platform. The Story Map platforms also enable the story map designer to customize theme colours, fonts, and styles.

Figure 6 Story Map basic and media functions

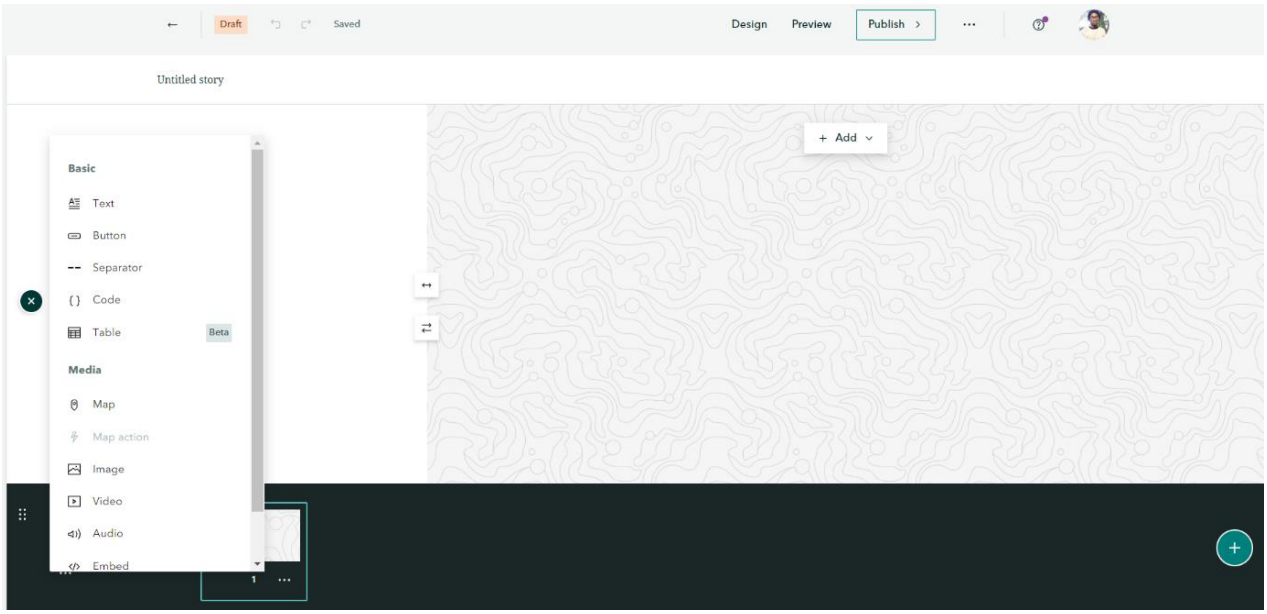


Photo by Gerald Beta: showing ArcGIS Storymap functions

Figure 6 shows a template of ArcGIS Storymap basic and media functions that can be utilized when creating or adding multimedia content on the platform. For example, text, button, separate, code, table, map, image, video, and audio. The text function is used to add text, the button function enables the story map end user to turn on and off features being shown on the map and other functions also enable the story map designer to add content.

Figure 7 Additional Story Map functions

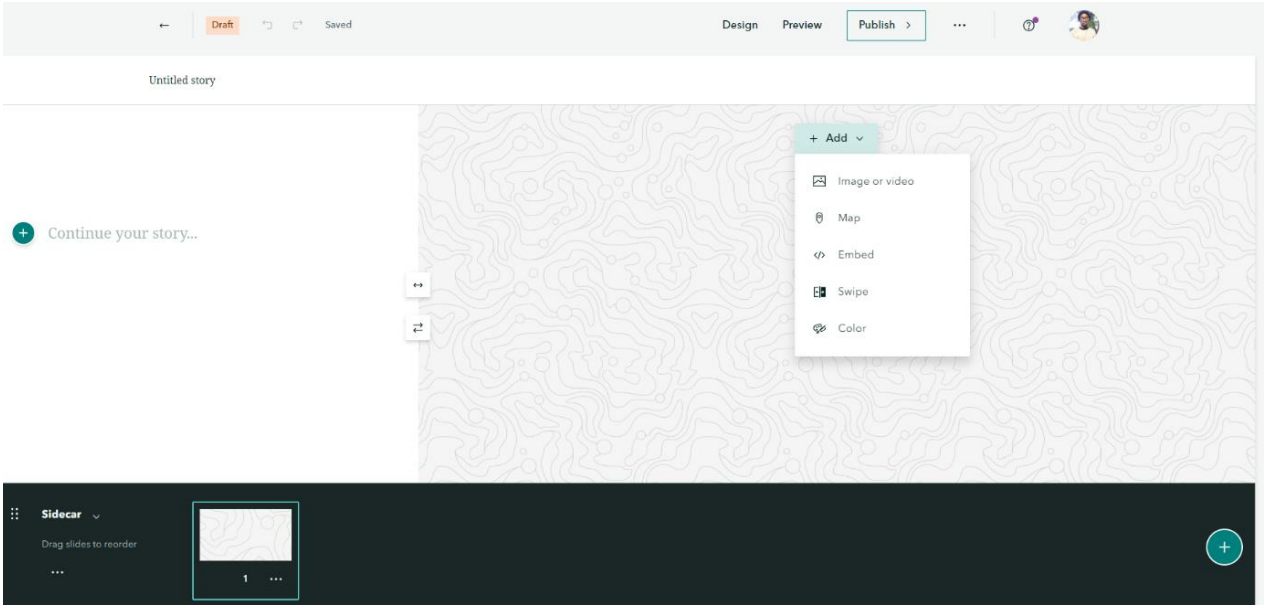


Photo by Gerald Beta showing additional functions to add colours, swipe, and maps.

Figure 7 shows additional functions to add colours, swipe and maps when creating a story map. The swipe function allows the story map designer to add 2 different images of the same location or map results that can be compared either to visualize the similarities or differences. The same swipe function allows the story map end user to swipe in the left and right directions to visualise the changes that the story map designer is communicating.

Figure 8 Publishing Story Map

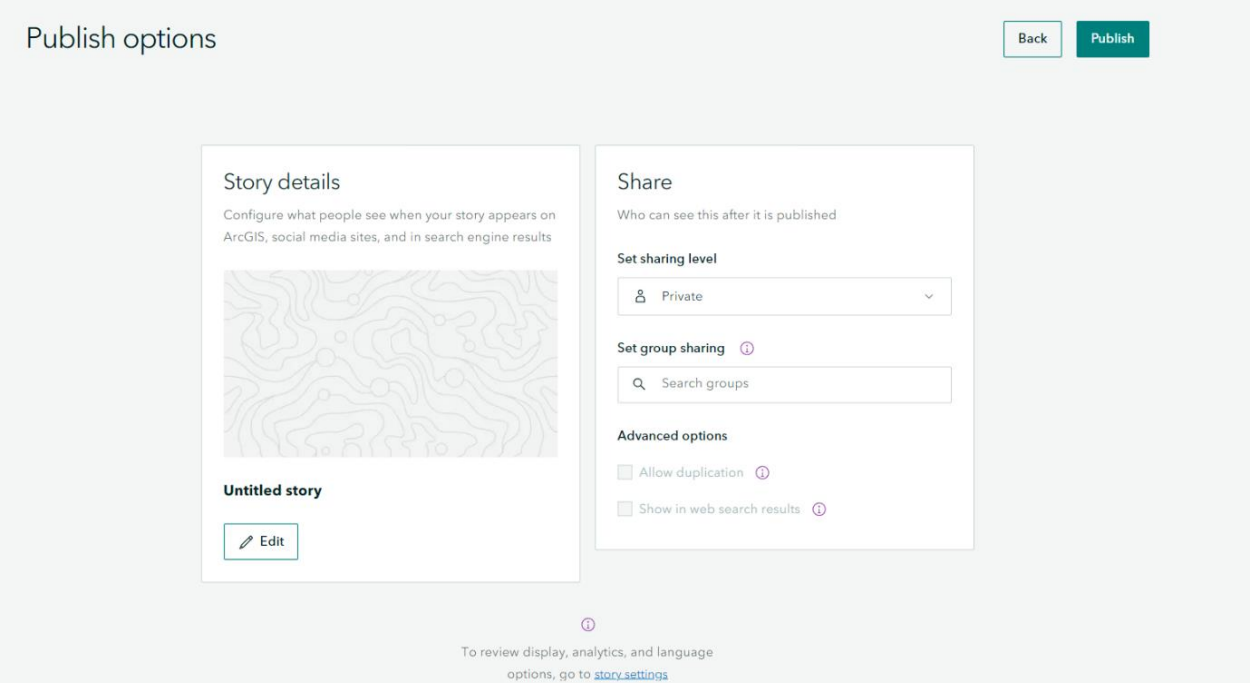


Photo by Gerald Beta showing Story Map publishing options.

Figure 8 shows ArcGIS Storymap publishing options provided by ESRI. After designing and adding content to a story map interface, the story map designer can publish meaning sharing the finished work with either the public (everyone), group sharing (organisation) or private (only the designer can view). After publishing the story map, a web link will be automatically generated that the map designer will use to share and communicate their research results, interventions, presentation aids, projects etc.

1.9.3 Thesis writing

The thesis writing occurred in late 2022 and throughout 2023. The writing process was influenced by ongoing involvement in Indigenous land-based camps organized by the University College of North, youth camps organized by the Kis Kin Ha Ma Ki Win program, community visits in collaboration with UCN and UofM, and attending book launches like In Our Backyard by Aimee Craft and Jill Blakley. The ongoing community engagements shaped the whole thesis through learning and knowledge sharing for the past two years.

Chapter 2: Literature Review

2.0 Introduction

The thesis chapter acknowledges the Canadian history of colonisation concerning Indigenous people in Canada by highlighting the pre-colonial Indigenous societies, European contact and exploration, colonization, and Indigenous Land Dispossession, the Indian Act of 1876 and Reservations, Residential Schools Systems, Truth and Reconciliation, Contemporary issues/ challenges, and lastly moving forward with strength-based solutions to revitalise Indigenous culture and traditions. In the 2nd section of this thesis chapter, I focus on the environmental impacts of hydroelectric dams in Indigenous communities such as soil erosion, water pollution, flooding, dissemination of fisheries, biodiversity loss and economic impacts.

2.1 Colonialism and Indigenous Land Dispossession

Colonialism is known as the practice of dominance (Kohn & Reddy, 2006), which involves the suppression of one group by another. Colonialism is an act of controlling one group of people to another by incorporating adjacent territory and settling in people's conquered territory, which is not a modern phenomenon (Kohn & Reddy, 2006). It is mainly supported by power, frameworks, theories of justice, contracts, and natural law to support a particular worldview or social structure for dominance. Modern colonialism started as early as the 16th century due to the advancement of technology that enabled people to travel on oceans to connect around the world. Colonialism is widely known as associated with violent dispossession, repression, racism, settlement, political domination, and inequality among equity-seeking groups (Bear, 2000). Additionally, research by Kohn & Reddy, (2006) highlights that the term colonialism is often used as a synonym for imperialism even though both terms are forms of invasion that promoted the Europeans economically and strategically. In Canada, colonialism started by calling Indigenous people Indian while rejecting their identity as members of specific nations (Facing History & Ourselves, 2019b).

Dating back to the 1800s, colonization was the first intent of French and British settlers under the Doctrine of Discovery which Europeans claimed rights of sovereignty, property, and trade in regions they explored in the age of expansion (Reid, 2020). The land ownership claims were made without consultation with the resident people in these territories and the Discovery

Doctrine laws would not allow Indigenous people to claim ownership of their land but only the rights to occupy and use the land (Miller et al., 2010; Reid, 2020). Europeans traded with thousands of Indigenous hunters, trappers, processors, and guides for about 300 years in the discovered territories. The French and English also developed the terra nullius meaning vacant land to further expand their claims to land sovereignty over the newly discovered lands (Reid, 2020). Regardless of the subsistence patterns of non-Europeans, failing to use the land according to European expectations was regarded as vacant land and the Europeans would establish symbolic acts of planting crosses and flags (Miller et al., 2010; Reid, 2020). Trading with mutual benefits declined when Europeans discovered gold, coal and oil, mining became the dominant economic activity (Facing History & Ourselves, 2020). By the 1830s and 1840s, colonization and First Nations land dispossession continued when Europeans established laws such as the Indian Act to control and manage the groups of people they encountered. Therefore, it marked the birth of the reserve system which was a strategy that existed also in Africa among British colonies to control people who questioned the politics and economic endeavours of the European settlers. Canadian colonization was characterised as deadly and destructive because Indigenous people were killed with blades and guns while European diseases such as measles, smallpox, and influenza also killed Indigenous people in big numbers because they had no immunity over foreign diseases (Daschuk, 2013)[3]. Additionally, factors of colonization such as land dispossession, forced removals and exploitation of natural resources also came into play. By the mid-19th century, European settlers took everything, and they needed no local partners for gold, minerals, wood, fisheries, and land.

2.2 The Indian Act and Reservations

> "The great aim of our legislation has been to do away with the tribal system and assimilate the Indian people in all respects with the other inhabitants of the Dominion as speedily as they are fit to change" John A. Macdonald, (1887).

The Canadian government took control over the social, economic, political and environmental aspects of the First Nations people following the signing of the 1876 Indian Act

[3] "When Canada Used Hunger to Clear the West," The Globe and Mail, July 19, 2013. For more, see Daschuk's Clearing the Plains: Disease, Politics of Starvation, and the Loss of Aboriginal Life (PCS) (Regina: University of Regina Press, 2013).

(Hanson, 2009). The Indian Act allowed the government to manage all the Indigenous people's housing, health services, environments and other resources on reserves (Facing History & Ourselves, 2019a). Since 1830, the British authorities and the Canadian government had set up Reserves where First Nation peoples would be forced to live. The Indian Act forced First Nations peoples to move from productive land into Reserves which were often unproductive and small pieces of land. Following the amalgamation of the Gradual Civilization Act of 1857 and the Gradual Enfranchisement Act of 1869 into the Indian Act of 1876, the 'Indian' registered status under the federal jurisdiction emerged (Facing History & Ourselves, 2019a). The new legislation controlled the Band membership[4], reserve infrastructure and services, systems of governance, culture and education of the Indigenous people living on Reserves (Hanson, 2009). In order to be recognized as a "Status Indian", first; They had to be any male person of Indian blood reputed to belong to a particular band; 2nd Be any child of such person; 3rd Be any woman who is or was, lawfully married to such person" (Indian Act, 1876; Milloy, 2008). The Status of Indian was determined by male affinity to a particular band meaning an "Indian" (or First Nations) woman marrying out would lose their status and rights whilst a non-Aboriginal woman married to a First Nations man would gain the status of Indian (Indian Act, 1876; Milloy, 2008).

2.3 Residential School Systems

The residential schools have been classified by Facing History & Ourselves, (2019) as not learning places for Indigenous people but schools to forcibly unlearn and destroy mother tongues, community values, traditional beliefs, spiritual practices and group identities. According to a survivor of Port Alberni Residential School in BC,

> "The government wanted to turn us into white people. Our cultural family units were broken apart. Also part of becoming 'white' was to speak English….." Rosa Bell[5].

In addition, According to the United Nations Educational, Scientific and Cultural Organisation (UNESCO), more than 70 Indigenous languages spoken by First Nations, Metis and

[4] A "Band", or "Indian Band," is a governing unit of Indians in Canada instituted by the Indian Act, 1876. The Indian Act defines a band "for whose use and benefit in common, kands, the legal title to which is vested in Her Majesty, have been set apart. https://indigenousfoundations.arts.ubc.ca/bands/

[5] Linda Jaine, Residential Schools: The Stolen Years (Saskatoon: University Extension Press, 1995), 10, quoted (but misattributed) in David R. Gaertner, "Beyond Truth: Materialist Approaches to Reconciliation Theories and Politics in Canada" (dissertation, Simon Fraser University, 2012), 62.

Inuit people in Canada are considered at risk and endangered (Moseley, 2010). According to The Truth and Reconciliation Commission of Canada (Volume 5, 2015), the risk is attributed to the intergenerational. impacts from colonial policies such as the residential schools that destroyed the Indigenous cultures and languages (Robertson, 2023). According to Facing History & Ourselves, (2019), "language was the connective tissue between past and present, between experience and meaning", that taught practical lessons on ways to interact with the environment. Destroying the language destroyed the culture and identity of the Indigenous people who spoke the language. In the 1880s, 150 000 Indigenous children were forcibly taken from their communities to attend residential schools where they were forbidden to speak their language (Truth and Reconciliation & Commission of Canada, 2012) and they endured physical (Woods, 2013), emotional and sexual abuse (Kennedy, 2015).

European settlers associated First Nations customs and cultural practices such as the sun dance and potlatch with superstitions, myth and magic therefore part of the residential school system's intent was to ban all the Indigenous ways of living through legislation (Dei, 2008; Facing History & Ourselves, 2019b). Residential schools forcibly removed all forms of Indigenous ways of knowing and doing such as passing values, beliefs, customs, spirituality, lifestyle, and skills to Indigenous children (Forsyth & Giles, 2012; Woods, 2013). In North America, Australia, Asia, Africa and parts of Europe, Indigenous knowledge is a bridge between human beings and their environments therefore it influences the lived world that informs and sustains people who make their homes in a local area (Akena, 2012). Indigenous knowledge embraces ancestral knowledge, cultures, identities and histories (Dei, 2008). Therefore, the newly introduced Western Knowledge branded Indigenous Knowledge as primitive, superstitious and inferior, especially the undocumented ways of teaching and practises (Dei, 2008). Western knowledge emphasises providing basic knowledge such as the ability to read, write, math, and algebra, for all children as a new skill requirement for labour in many trades (Facing History & Ourselves, 2019b; Woods, 2013). The residential school system disrupted the Indigenous ways of their living. The school structure crumpled the connection between Indigenous students and their communities.

> "When the school is on the reserve, the child lives with his parents who are savages; he is surrounded by savages, and though he may learn to read and write, his habits and training

and mode of thought are Indian. He is simply a savage who can read and write." Prime Minister McDonald[6] (Kennedy, 2015).

2.4 Truth and Reconciliation

The last Residential School closed in 1996 and Indigenous people are still dealing with the legacy of the schools which was associated with mass violations of human rights such as sexual abuse, emotional abuse, and physical abuse in all the residential schools (Facing History & Ourselves, 2019b). Although some of the government-run schools continued to operate till 1990, the last residential school was closed in 1996 (James, 2012). The survivors of the residential school system both children, families and communities fought for inquiries for investigations and publicizing the acts which were associated with the schools. The residential schools separated children from families and eradicated indigenous languages and traditions. National Truth Rencinciliation became popular in the 1970s when all the commissions provided spaces for harm reduction, healing, and places to offer victims solace and reassurance of not repeating trauma. Following a series of lawsuits, the Canadian government publicly acknowledged their past errors against its citizens by setting up a Truth and Reconciliation Commission (TRC) in 2008 to reflect and address all the injustices made to Indigenous people (Facing History & Ourselves, 2019b). The Canadian TRC offered an open discussion with victims of residential schools to establish relationships, document the historical knowledge and impacts of the schools on Indigenous people and review the history to provide a way for reconciliation and healing.

The TRC used the bottom-up approach to hold community events to gather narratives about the schools from the residential school survivors themselves. The grassroots approach used both traditional and contemporary ways of documenting the history of residential schools in the form of artistic expressions such as poetry, writing, painting, sculpting, bead or bottom work, quilting, song, writing, films or plays (James, 2012). Community events included Indigenous history workshops such as drum making, regalia making, design and development of toys and games, drama plays, songs, exhibitions, displays, histories, documented stories, movies, books, elder and/ or youth presentations, taping of elders speaking their language and cultural camps (International Center for Transitional Justice, 2013; James, 2012). The main role of the TRC was to promote

[6] Truth and Reconciliation Commission of Canada, They Came for the Children (Winnipeg: Truth and Reconciliation Commission of Canada, 2012), 6

awareness and educate the Canadian public about the suffering of the IRS survivors as the first step to reconciling with Indigenous people (International Center for Transitional Justice, 2013). Additionally, the United Nations Declaration on the Rights of Indigenous People was adopted on September 13, 2007, as an international instrument to protect the rights that "constitute the minimum standards for the survival, dignity and well-being of the Indigenous peoples of the world" (United Nations Human Rights, 2007), declared the right to provide culturally appropriate education to Indigenous people everywhere (Truth and Reconciliation & Commission of Canada, 2015).

2.5 Contemporary issues and challenges

2.5.1 Social, economic and environmental disparities

Indigenous people in Canada make the 5% of the total population and the distinctive group is made up of First Nations, Inuit and Metis people and are known formally (legally) as Aboriginal Peoples (Batal et al., 2021). Despite Canada being known as a prosperous country with a track record of best public safety nets, Indigenous people still face challenges such as shortage of housing, access to clean water, access to healthcare services, job prospects and systematic discrimination compared to non-Indigenous people (Batal, 2021; Rosanne Blanchet et al., 2020). The long-term colonial history of Canada deprived Indigenous people of managing their natural leading to substantive environmental degradation from settler mining activities and the establishment of hydroelectricity dams (Kuhnlein & Chan, 2000). For example, in Northern Manitoba, Indigenous communities continue to face land dispossession and lack of control over the natural resources due to ongoing settler mining and hydroelectric dam projects.

Overexploitation of natural resources from industrialization such as hydro-electricity, mining and forestry during the colonial governance era contributed to substantial environmental degradation which was linked to water pollution and biodiversity losses (Batal et al., 2021; Rosanne Blanchet et al., 2020). For instance, the current ongoing cumulative impacts of hydroelectric dam projects devasted the water quality of the community to a level that remote communities have no access to clean tap running water. Many of the indigenous communities currently depend on bottled water and water delivered in tanks.

2.5.2 Health disparities, and food insecurity

One of the many reasons why rural Indigenous communities in Canada experience food insecurity is because of reduced access to traditional foods due to substantial environmental degradation caused by industrialization. Before the colonial era, traditional foods were the only source of food for First Nations people (Kuhnlein & Chan, 2000). Indigenous communities have reported being forced to travel areas far from their traditional areas because most of the traditional foods in nearby areas are mercury and oil contaminated from mining and hydroelectric dam projects (Batal, 2021). Today, Indigenous communities depend on store-bought processed foods which are expensive, unhealthy and have been linked to chronic diseases such as obesity and diabetes compared to their traditional foods (wild fish, game, fowl) (Rosanne Blanchet et al., 2020; Willows, 2005). The cumulative impacts of settler governance assimilated Indigenous culture and traditions such as hunting, fishing, trapping and knowledge transfer into the Western sedentary lifestyles and diets such as inadequate consumption of fats, carbohydrates, sodium and other nutrients (Willows, 2005). The Western lifestyles coupled with inactivity, compromised land-based activities that kept the Indigenous people active and healthy (Willows et al., 2012).

Land privatization and overexploitation of natural resources from industrialization contributed to the shortage of housing especially in remote Indigenous communities leading to overcrowding and health inequalities (Terbasket, 2019). The systematic discrimination of Indigenous communities also leads to a lack of access to professional healthcare workers and traditional plant research. Research by Ries, (2020) and the Assembly of First Nations, (2019), supports that it is difficult to secure funding that specializes in the health effects of traditional plants and herbs, and research that seeks to answer questions related to traditional plants is inconsistent. Some communities are inaccessible by road therefore transporting building materials and health services is expensive. For example, during the COVID-19 pandemic, strategies like social distancing were more challenging to practice in OPCN because of poor living conditions such as overcrowding and lack of access to clean running water. In Norway House Manitoba, Chief Larson Anderson feared COVID-19 in his community because of overcrowding,

> “If the pandemic hits and the houses are overcrowded and [in] bad conditions, then we don’t know what the impact is going to be, but it’s not going to be pretty.” Norway House First Nation Chief Larson Anderson in CBC News (Grabish, 2020).

2.5.3 Moving forward

Despite the colonial policies and regulations such as the Indian Act of 1876, the Residential School System and land dispossession made efforts to assimilate the Indigenous culture and tradition by separating children from families and communities. The colonial system devasted the environment by logging, farming, mining and fishing which affected traditional food systems (Terbasket, 2019). Today, Indigenous people are putting much effort into revitalizing their traditional food systems (harvesting, trapping, hunting) as well as the transmission of cultural knowledge to younger generations (Batal, 2021). Additionally, to offset food insecurity, especially in remote areas, programs like 'Nutrition North' have been established since 2011 to subsidies perishable and nutritious food items in Indigenous communities (Nutrition North Canada, 2014). Indigenous-led initiatives like land-based education continue to play a significant role in promoting culture and physical activity. Furthermore, a program called Wanuskewin Heritage Park[7] in north Saskatoon guides groups of people demonstrating how traditional plants were used for centuries to treat ailments (Markewich, 2017).

2.6 Data sovereignty

Data sovereignty refers to the perception that data is governed according to the laws and structures of a country, region, or specific area. Data is a timely subject matter, it acts as a mediator that connects our lifeworld while sovereignty is understood as the ability to give authoritative claims within institutional arrangements, international regimes and in other states (Hummel et al., 2021). Data sovereignty is "the right of a nation to collect and manage its own data" (Rainie et al., 2017). Data sovereignty is very important, especially in today's digital era, where a large amount of data is collected, generated, processed, accessed, and stored in the cloud. Different countries or regions have different legal and regulatory frameworks that control data access, security, and privacy. Data localization refers to the type of data that a country or region might require to be stored within their borders for the protection of sensitive data. However, because of increased cloud services (such as Microsoft One Drive and Google Drive) and cross-border data flow due to the nature of internet connectivity, many companies and organizations face challenges of storing

[7] Wanuskewin Heritage Park website; https://wanuskewin.com/

data in data centres located outside their country borders which most of the time creates conflicts with data sovereignty laws. As a technological solution to ensure data sovereignty, most organizations, countries, or regions use encryption and access controls to ensure data protection and control even if it's housed in other regions or countries. Data sovereignty is very important in today's digital age because of globalisation around the world where there is sharing of data across political borders.

2.6.1 Indigenous data sovereignty

Indigenous data sovereignty, "means that Indigenous People have the right to own, control, access, and steward data about their communities, lands and culture" (Mukunda, 2023). Research by Garrison et al., (2019) identified "Indigenous data sovereignty as the right of indigenous peoples and nations to govern the collection, ownership and application of data about their peoples, lands and resources". Indigenous data sovereignty ensures that data collection, management and use should align with the Indigenous Nation, community or people's practices and culture that are being represented by the data. Indigenous communities have been subject to unethical behaviour, lack of transparent consultation, and lack of respect for cultural and sacred beliefs by Western science and research for decades (Garrison et al., 2019). Therefore, to ensure data sovereignty when doing research, Indigenous people, Nations, and Indigenous individuals should be partners in the whole research process. Indigenous data can be grouped into three categories 1. Data about resources and environments such as land management, history, geological data, wildlife data and water sources 2. Data about Indigenous people, nations, or communities such as demographics, health information, employment, or education statistics 3. Data from Indigenous communities such as ancestral knowledge, language, songs, stories, oral histories, and pictures (Mukunda, 2023). Indigenous people experienced a lack of community engagement, inadequate informed consent, exploitation and harm during the colonial era therefore Indigenous sovereignty seeks to rebuild strong relationships, establish community engagement and open dialogue with Indigenous Nations and communities when doing research(Garrison et al., 2019).

2.6.2 OCAP principles

The OCAP standard principles for conducting research using First Nations data was created by the First Nations Information Governance Centre in 1998 to guide the development of the First Nations Regional Health Survey (FNRHS) which was the first First Nation-governed national

health survey in Canada that collected information about First Nations living on-reserve and Northern Communities (FNRHS, 2013). The principles provide guides on why, how and by whom First Nations data be collected, used or shared (Yao, 2014). The First Nations principles of ownership, control, access and possession widely known as OCAP articulates that First Nations have control over data collection processes and that they own and control how the information can be used while minimizing harm (FNIGC, 2014, 1998; Yao, 2014).

A report by FNIGC, (2014) articulates that OCAP can be described as "a political response to colonialism and the role of knowledge production in reproducing colonial relations" (Espey, 2002). The OCAP tool was created because no law or concept in Western society recognised community rights and interests in their information (FNIGC, 1998). Historically First Nations had a problematic relationship with researchers, academics, and other collectors because researchers used to visit communities, collect data, interpret their data without the involvement of the communities and publish the data without community review approval. The phrase "We've been researched to death" is widely used by First Nations meaning they have been subject to too much research by non-First Nations from universities, government and industry (Espey, 2002). Some of the research done on First Nations was for the personal interests of the researchers rather than the interests of the First Nations concerns. For example, in 2001 Health Canada released First Nations' information on recipients of health services and goods such as treatment drugs, medical transportation and dental care, to Brogan Inc., a health consulting and analysis firm that then sold the data to pharmaceutical companies for their research use. Even though Health Canada removed personal identifying information, community identifiers remained (FNIGC, 2014). Therefore, the OCAP was formed to protect and govern research processes from start to finish, in First Nations communities.

Ownership refers to the relationship between an individual owner and their resources or property, therefore the same concept also applies to the relationship between Indigenous people's data to their cultural knowledge and information (FNIGC, 1998; Mukunda, 2023). The principles emphasise that the community or group of people owns their information collectively (FNIGC, 2014).

Control – affirms that Indigenous communities and Nations have rights to control their data over all stages of research processes from start to finish, and control over the information that

represents them (FNIGC, 2014). The concert also gives the power to control resources, review the research process, and the planning process and management of information (FNIGC, 1998; Mukunda, 2023).

Access – the principle affirms that First Nations have access to all information and data about themselves and their communities regardless of where the data is stored (Mukunda, 2023). The access principle allows First Nations the right to make decisions regarding who can access their information through standardized, formal protocols (FNIGC, 1998).

Possession – affirms the physical control of data should be controlled, and managed by Indigenous people or third-party organizations granted permission by Indigenous Nations to control and provide access to their data (FNIGC, 2022; Mukunda, 2023).

2.6.3 CARE Principles for Indigenous Data Governance

CARE principles are Indigenous data governance guides that are used to reflect the importance of data to Indigenous people (Mukunda, 2023). CARE is an abbreviation of Collective benefit, Authority to control, Responsibility and Ethics.

Collective Benefit in broader terms means Indigenous people should benefit from the research and the data collection processes should align with the needs and expectations of the community (Mukunda, 2023). Authority to Control in a larger context means Indigenous people have the right to decision-making towards data access, control, and governance over their data. They have the authority to control how they are represented in the data, and they decide who can access and distribute their data (Mukunda, 2023). Responsibility – Researchers should demonstrate how the use of Indigenous data will benefit the Indigenous Peoples and the evidence of benefits ought to be shared in Indigenous language, worldviews, and ways of knowing and doing (Mukunda, 2023). Ethics – Indigenous people have central rights towards all processes of the research lifecycle. All risks and opportunities must be taken into consideration from an Indigenous viewpoint (Mukunda, 2023).

2.6.4 Colonial discourse for unmapping Indigenous territories

A map can be defined as “A representation, usually on a plane surface, of all or part of the earth or some other body showing a group of features in terms of their relative size and position.” (Thrower, 1996). It is assumed that the earliest map was a mental image and narrative used to

describe an area where ancient people lived (Caquard, 2013). Dating back to 2300 BC, some maps-like characteristics came in the form of cave and tomb art while others came in the form of oral sounds and gestures to pass spatial information about the local environment (Caquard, 2013; Stephens, 2022). The spherical nature of the earth is credited to the Greek geographer Ptolemy who created a world map that marked the earliest cartography and systematized the scientific study of geographical knowledge (Dahl, 2006; Stephens, 2022). The increasing interest in creating maps came to a point where the printing press was invented, and maps became the only source for rich and powerful information about places. The improvements in ship designs and navigation that would allow people to travel from one place to another increased the need for exploration therefore there was a need to fill in the missing parts of the maps. The desire for correct and updated maps contributed to the rise of nation-states and their military expertise which is linked to World War 11 and colonialism (Stephens, 2022).

The history of colonial cartography is characterized by a complex and multifaceted concept that existed for several centuries involving politics, exploration of resources, science, and technology. Colonial cartography played a crucial role in territorial claims and land dispossession among equity-seeking groups dating back to the 15^{th} – 17^{th} centuries, during the European colonial era. In Germany, colonial cartography was called ‘geopolitische kartographie’ or ‘suggestive kartographie’ and it was strictly for political uses (Boria, 2008). In regions such as Great Britain and the United States maps were referred to as propaganda maps or persuasive maps.

The desire for Western Colonialists to claim unknown lands and territories using cartography skills played a crucial role in dominance and control over vast lands in the name of the Doctrine of Discovery (Miller et al., 2010). The Doctrine of Discovery was an international law of European countries and colonialists to conquer vast unknown lands and assets of indigenous people worldwide during the 15^{th} - 20^{th} centuries. The doctrine principles recognized Christianity's superiority over other cultures, religions and races for example Islam, Muslims and Indigenous cultures. The doctrine gave the European nations the right to automatically gain sovereign and land rights over newly discovered lands regardless of indigenous people occupying the land (Miller et al., 2010). Cartography became a European nation's tool for land dispossession among Indigenous people.

The earlier cartographic works of Ptolemy resurfaced in the 15th century when his writings were translated from Geek and later published (Dahl, 2006). Ptolemaic work became crucial in the geographic knowledge of Canada. With advances in cartography techniques and continued exploration of coasts into the heart of Canada, the nature of data collection and presentation also changed. By 1870, the increasing exploration and distribution of fur trading by the Europeans contributed to the establishment of 97 fur-trading posts that were built along the Atlantic Bay with the help of Indigenous traders, hunters, and fishers (Foot, et. al, 2019). According to Ruggles, (1991) without the help of Indigenous people to assist in providing complex operations such as providing tools, and acting as guides and interpreters in exploration, fur-trade and mapping activities would not have developed as it did. Colonial cartography represented Indigenous territory as empty lands and unused space therefore the perception of wasting resources surfaced. During the age of exploration, cartographical practises removed Indigenous identity (culture, livelihoods and settlements) from any published historical maps which resulted in Indigenous lands being mapped with the phonetics of each spoken language (Miller et al., 2010; Ruggles, 1991).

2.7 Concept of GIS mapping in Indigenous mapping

GIS mapping concepts have a long history of being practised for hundreds of years in Indigenous nations before European colonialism. GIS mapping, presented in the form of oral traditions has been used to communicate complex information about politics, culture, and the environment (T. Tobias, 2009). A study by Caquard, (2013) articulates that ancient mapping activities in Indigenous nations were communicated in the form of narratives of particular places and maps were drawn on animal skins, snow and rocks using animal pigment (blood) mixed with plants. Today, some of the rock paintings depict socio-economic activities such as hunting and fishing, that were conducted hundreds of years back. Some of the rock paintings depict specific hunting areas and the type of animals that the Indigenous people caught as well as the type of tools that were used for hunting and fishing such as bows and arrows (Kely, 2014). However, after European contact, the oral traditions and paintings were perceived as primitive which is linked to the disadvantage in negotiating about their lands (Tobias, 2009).

According to Tobias, (2009), the only way to prove ownership of land was by providing evidence that, “I was here, I have a house here, I have a trapline here, I hunt small game over

here….” Today's problem for First Nations and non-First Nations is “How to get started in the right direction so that our maps end up serving our community and nation?” (Tobias, 2009).

2.7 History of Hydro dams: Introduction

Globally, the increasing demand for cheap and clean alternative energy sources contributed to thousands of hydroelectric dams being either under construction or planned (Erdogdu, 2011), yet their controversial ecological footprints are a question of increasing interest. The controversial and provoked heated debates about how green are hydro dams have also led to large-scale protests globally especially with local communities that normally have no say, as the final say is related to technical decisions made by experts (Agostini et al., 2017). Dating back to the first commercial and large-scale hydro-dam construction in Wisconsin USA (IHA), dams have been largely associated and marketed for water storage, irrigation purposes, flood mitigation and clean electricity generation. However, the impoundment of large volumes of water disrupts the natural river flows and it normally affects the communities that rely upon those rivers.

Hydro dams have been largely associated with environmental impacts, social impacts and economic impacts, such that they disrupt fish migration patterns leading to declines in fish populations, changes in water flows and increases in sediment deposition leading to temperature fluctuations. The construction of dams devastates the natural flow of the rivers, impacting both upstream and downstream ecosystems. The impacts of hydro dams incorporated with community experiences are widely well-known, recognised and documented in the literature by researchers, organizations and the communities themselves but sometimes the information is not readily accessible and available. As energy-hungry countries continue to plan and construct hydro-dams in the 21st century, there is a need to further understand how the landscape is ever-changing, how environmental injustices are evolving and how impacted communities are becoming more vulnerable to pandemics and other diseases related to environmental health changes.

2.7.1 Methods

This thesis chapter used a mixed methods research approach for the triangulation of multiple sources of data, theories, and contexts because the approach allows multiple truths and insights to emerge (Winchester and Rofe, 2010). The key words I used for this thesis chapter to acknowledge, learn, and reflect on issues surrounding hydro dams from previous literature are

“Hydro dams”, “Economic impacts of hydro dams”, “Social impacts of hydro dams”, “Environmental impacts of hydro dams”, “Health impacts of hydro dams”, “Landscape changes due to hydro dams” and “Cumulative impacts and resilience on hydro dams”. The environmental impacts of hydro dams were largely gathered from the University of Manitoba UM Space database, Google Scholar, Semantic Scholar, mass media (such as CBC News, The Narwhal, The Canadian Press, Anishinabek, CTV News and APN news) and social media such as LinkedIn and Facebook.

Social media platforms were important in this thesis because many hydro-impacted communities are located in remote areas or rural areas therefore most of them experience connectivity challenges. Thus, several FN individuals from the region were posting updates on LinkedIn and Facebook. Social media platforms were crucial in this thesis because this was the problem where many community voices, concerns, feelings, opinions, insights, and stories were published. During the early stages of the project, all community visits and activities were suspended because of COVID-19 protocols. Social media became an important source of communication during the COVID-19 pandemic. According to Loo (2023), the narratives of Indigenous people in Canada were always told through settlers' perspective allowing the erasure of Indigenous views and promoting biased reporting. Social media platforms provide a “forum within and across territorial borders where Indigenous people can agitate, demand political recognition for Indigenous causes and proffer contesting and challenging views” (Carlson & Frazer, 2016). Social media platforms played a crucial role in this thesis to document and synthesise different perspectives concerning hydroelectric dam projects.

2.8 Reality Checks: Environmental Impacts

Hydroelectric power energy is labelled and presented as the world’s best alternative to renewable energy with about 90% of the world’s countries relying on or using hydroelectricity and it is projected that hydropower is expected to remain the world’s largest source of electricity (IHA, 2018), yet their environmental impacts are subject to increasing concern. For instance, documented hydro dam impacts are associated with high water flow currents, flooding of large tracts of lands and forests and sediment deposition which has been linked to downstream shoreline erosion (Kummu & Varis, 2007) and murky/muddy water (Fredén, 2011). The substantial increase in water levels and sediments reduces the water quality leading to the massive release of greenhouse gases from decomposing flooded lands and organic matter (Moran et al., 2018). Given the growing

concerns that hydropower energy is “an ambitious, yet realistic, energy transformation pathway needed to keep the rise in global temperatures to well below 2^0 C and towards 1.5^0 C during the century” (IRENA, 2020). Numerous studies have highlighted that hydro dam power was meant to reduce greenhouse gas emissions and provide sustainable energy by replacing fossil fuel-powered thermal stations therefore instead of reducing greenhouse gas emissions, hydro dams increase greenhouse gas emissions by decomposing flooded lands and organics. The damming of rivers hinders fish movement patterns to and from upstream and downstream of rivers leading to reduced fish populations, and affecting people’s food systems (Anderson, 2017; Stone, 2016). These insights emphasize the value of understanding the relationships between dams, weirs, diversion channel operations and the environment to ensure sustainable use of resources.

2.8.1 Social impacts

> “People need the electricity. We do need sustainable hydropower. The question is: Who decides how it’s done?” Susanne Schmeier in BBC News (2018).

The global boom and bursting of reliance on hydropower by industries and governments overlooked the needs and expectations of the local communities leading to protests (Agostini et al., 2017). Most constructed and planned dams dating back to the 1900s were built with little or no consultation from local communities because decisions were technically based therefore experts made choices. Between 40 million and 80 million people globally have been involuntarily relocated because of hydro-dams (World Commission on Dams, 2000; (Fendt, 2021; Scudder, 2011). For example, the Belo Monte dam in Brazil’s Amazon rainforest displaced over 50,000 people (Xingu Vivo) which led to street protests in Sao Palo in 2011. The socio-cultural impacts of mega-dams in developing countries' river basins are way greater than in early North America and Europe (Moran et al., 2018). Almost every year, hydro dams are decommissioned and removed in developed countries but in developing countries, the unsustainability nature of such dams is not being recognised (McGrath, 2018).

Research has demonstrated that artificial dam operations are associated with high water currents and gradual changes in water levels which have been linked to soil erosion and water pollution (Ezcurra et al., 2019). For instance, high water currents create dangerous travelling conditions for communities that use the water to access traditional hunting grounds, fishing areas and trapping areas. In regions like Canada where some rivers freeze in winter, the gradual changes

in water levels create gaps between the ice and water causing unstable ice conditions for travel. Some remote communities have no winter roads; therefore, they depend on rivers for travel which is a hazard during thin icy conditions.

The construction of huge concrete dam walls for water storage and electricity generation involves blocking and diverting natural river system flows which has overwhelming socio-cultural interruptions to communities residing near dam sites (Energy Sage, 2019). Indigenous communities experience land displacement and flooding of traditional sacred lands leading to a loss of cultural identity and well-being. Flooding affects traditional practices like hunting, fishing, trapping, and harvesting which negatively affects peoples' food stocks. In 2010, a study estimated that 472 million people living downstream from mega-hydro dams suffer from food insecurity (Richter et al., 2010) because of planned flooding and reduced fish populations (Chaudhari, n.d.; International River, 2011).

2.8.2 Economic impacts

In the 1900s, North America and Europe dominated the hydropower development industries (IHA, 2019). Hydropower was a major sector for economic growth and energy development however their economic impacts extend further than the immediate benefits (Chandran, 2018). Following the 1960s, mega-dam projects reached a peak and slowed down in North America and Europe because of withdrawn funding from the World Bank (Reality Check Team, 2018), the rise of anti-dam movements, the growing socio-environmental concerns (McGrath, 2018) and potential sites were already developed (Moran et al., 2018). Following the slowing down of mega-dam projects in developed countries, the trend shifted to developing countries where multipurpose mega-dams were being built in mega-biodiversity river basins such as the Amazon, the Congo, and the Mekong (Moran et al., 2018). Additionally, Mota, (2022) supported the impacts of hydro dams by highlighting that the U.S. did not keep their ecosystem-devastating technology to itself but exported the dam technology to other countries, selling the projects as templets of modernity yet local communities shouldered their financial burdens and social-environmental impacts.

> “Western companies are coming here because they can’t do new dams in, say, Germany and Norway. They dammed everything – and there’s legislation to keep them away from those rivers. They know they can pull it off here, where there’s no media attention or

legislation like in the European Union." Rok Rozman, a biologist and former Olympic rower from Slovenia in De Launey, (2018).

The World Bank was also heavily involved in supporting mega hydro-dam projects for economic growth, for example, the Three Gorges Dam in China, the Akosombo Dam in Ghana, the Itaipu Dam in Brazil, and the Paraguay and IIisu Dam in Laos (Mina, 2011; Yang, 2022), before concerns of how green are hydro dams questioned. However, with the series of increasing pressure and controversies surrounding the effectiveness of multipurpose dams, The World Bank withdrew its funding from supporting multi-million dollar projects for example along the Narmada River in India (Reality Check Team, 2018).

Additionally, the construction of dams changes the river flow and critical sediment dynamics which affects downstream agricultural activities, downstream fisheries, scenic lands and navigation (Ezcurra et al., 2019). According to the Mekong River Commission Report in Chandran, (2018) the retention of sediments behind dam structures triggers higher poverty levels by decreasing downstream soil fertility and fish populations, resulting in reduced agricultural productivity and disrupting fishing economies. In this era of climate change, "hydropower is a risky and insecure energy source that's deeply vulnerable to increasingly severe droughts and floods" (Mota, 2022).

2.8.3 Biodiversity loss and habitat fragmentation

Hydro dam walls impound large amounts of water causing flooding in surrounding areas and leading to loss of aquatic and terrestrial biodiversity (Pokhrel et al., 2018; Stone, 2011). According to Irfan & Alatawi, (2019), aquatic biodiversity is continuously declining due to anthropogenic activities like dam construction which pollute the water and introduce poisonous toxins like mercury in both the freshwater and marine environments. Marcoval et al., (2021) further support that marine habitats are fragile hence they are reactive to variations and modifications in the physical environment for instance small fish react quickly to mercury toxins. The deposited toxins bioaccumulate into water resources (rivers, streams, groundwater, wetlands, lakes) and food systems (Carter, 2018) causing local communities to suffer grave health problems like cancer and kidney diseases. The environmental impacts of Hydro dams destroy wildlife habitats and animal corridors/ routes leading to the extinction of species.

For instance, research by Winemiller et al., (2016) demonstrates how the Amazon, Congo and Mekong river basin advocates are underestimating the effects of biodiversity and fisheries due to the booming of hydro dams. Additionally, the construction of weirs, dam structures, and diversion channels also contributes to sediment accumulation that not only affects aquatic habitats but also contributes to downstream erosion, affecting the quality of water (Brake, 2018) and interrupting fish spawning life cycles (Chandran, 2018). However, some hydro-dam facilities "use trap-and-haul programs to collect fish, transport them past a dam, and release them" (Energy Sage, 2019) whilst other facilities have fish passages/ ladders that allow migration (Chandran, 2018), but most of the passages permit one-way migration.

2.8.4 Health impacts

Hydro dams flood large tracts of land and forests which increases neurotoxin methylmercury due to decomposition of organic matter. The decomposing and dissolving of organic matter produce neurotoxin methylmercury which bioaccumulates through the food chain (Carter, 2018). Once the water is mercury-contaminated, marine species (fish) are contaminated, and the whole food support systems become contaminated which affects the people whose diets rely on fish consumption. According to Guallar et al., (2002), fish intake is a major source of exposure to methylmercury. The consumption of mercury-contaminated fish causes high rates of cancer-causing agents, diabetes, heart diseases, kidney disease, skin diseases and amputation of body parts. The consumption of mercury-contaminated traditional foods forces communities to rely often on processed store-bought foods which have been linked to declines in overall community health (Dysart & Spence, 2021; Rudolph & McLachlan, 2013).

Hydroelectric dams' have negative impacts on the health and well-being of the people and the environment. The increase in water levels and mercury contamination leads to forced displacement or relocation of communities from their traditional lands (International Rivers, 2011; Terminski, 2013; Trussart et al., 2002). For instance, mass media emphasises that displaced communities are normally re-established on unproductive lands, with no access to clean water, overcrowding, poor housing and not even connected to grid lines or provided with cheap electricity (Dawkins, 2019). The majority of displaced communities have limited access to healthcare facilities, no access to professional healthcare officials/workers and poor service delivery (Bazin et al., 2011; Trussart et al., 2002). For example, in the Akomboso Dam project, in Ghana, the

relocated people were provided with the so-called core house, made up of a concrete foundation with one completed room regardless of household size (Miescher & Tsikata, 2009). The occupants were expected to finish their houses alone and because of poor living conditions and limited access to basic health services, hydro-impacted people experience health problems such as nervous system damage, and impaired neurological development in infants and children (Rice et al., 2014), diabetics, cancer, tuberculosis, skin diseases and heart disease (Dawkins, 2019; Frustaci et al., 1999; Harada et al., 1999).

In other parts of Sub-Saharan Africa like Zimbabwe, Mozambique, South Africa and Ghana, scholars have documented health concerns associated with rainfall variability which contributes to disasters such as floods and drought (Thornton et al., 2006). As an adaptation strategy to reduce the impacts of flooding and drought, countries resorted to dam construction without envisioning the health and environmental consequences of dams, which involve the transmission of vector-borne diseases such as malaria and bilharzia. Dams promote habitable conditions suitable for Anopheles mosquito breeding and because of favourable climatic conditions and bio-physical factors, communities living close to dams are at risk of malaria transmission (Sadoff et al., 2015). It is reported that 90% of human global malaria is predominant in the SSA (Bhatt et al., 2015) and annually, it is estimated that 174 million malaria cases occur in SSA (WHO Malaria Report, 2018).

Disruption of traditional foods such as mushrooms, berries, medicine/herbs (Labrador and mint), wildlife, edible fruits etc. within communities increases the dependency on processed/ refined foods which are widely associated with low nutrients (Craft & Blakley, 2022). Shifting from natural traditional foods to store-bought foods affects the overall health of the local communities (APTN National News, 2018). Most contemporary foods known as hybrids, ranging from seeds, plants, fruits, vegetables, meats etc. are genetically modified /engineered, which not only affects the health of the people but also the biophysical environment (Rudolph & McLachlan, 2013). This transition disconnects local communities from the land and it undermines the importance of cultural-spiritual values that encourage physical activity, knowledge sharing and transfer from one generation to another (Buckland & O'Gorman, 2017). Additionally, research by APTN National News, (2018) and Buckland & O'Gorman, (2017) highlights that hydro-dam-related flooding reduces communities' access to their traditional land and water resources therefore

it plunges communities into extreme poverty because their economies are based on the land. It also disrupts communities' land-based activities which promote healthy behaviours.

Chapter 3:

To understand the implications of these spatial-temporal changes on community livelihoods.

3.0 Introduction

The construction of mega hydroelectric dams and control structures on major water bodies creates massive environmental effects and health impacts on local communities surrounded by the dams. In most cases, local communities whose livelihoods are dependent on the devasted water bodies tend not to benefit anything from the hydro projects. On paper and media platforms, hydro dams are branded green alternatives to clean energy but behind the scenes, it's the opposite using the Indigenous community's environmental lens. Environmental impacts of hydro dams are well documented in the literature however, there is little to no focus on landscape changes especially in Northern Manitoba communities and sometimes the information is not easily accessible. Thus, GIS and Remote Sensing tools become helpful to bring the Indigenous knowledge lens for knowledge translation towards understanding how the landscapes have changed. In this thesis chapter, I used GIS and Remote Sensing techniques to understand how the landscapes used to look before hydro dams and how the landscapes changed after hydro dams came into the OPCN territory. PGIS techniques were also used to document and present local experiences of OPCN land and water users to understand how their land-use practices have been affected by hydro dam projects in their territory. In this thesis section, I also demonstrated how the identified environmental changes were heavily supported by community members who had first-hand experience on the land, who had travelled in the lakes and who used the natural resources provided by the devastated land. Lastly, this section will demonstrate Indigenous ways of knowing and doing on their land and the knowledge transmitted will further contribute to a greater understanding of how the associated changes in the environment have contributed to health problems in the OPCN community.

3.1 Objectives

3.1.1 General objective

To map the spatial temporal changes in the environment due to hydroelectric dam projects in O-Pipon-Na-Piwin Cree Nation.

3.1. 2 Specific objectives

a) To map the ongoing physical environmental changes in OPCN including the modifications to land and water bodies due to hydroelectric dams.

b) To leverage PGIS techniques to engage local communities in the documentation and to facilitate the holistic understanding of ecological changes to enable informed decision-making for sustainable resource use.

3.2 Research Method

The thesis was grounded in two-eyed seeing and participatory action research to build relationships and enable community members to take full control of the research. PAR through Participatory GIS allows the researcher to incorporate community knowledge and incorporate diverse participants for knowledge transfer purposes (Ray, 2015). Maps can assist informed decision-making processes and Indigenous communities have effectively used maps to claim land and to achieve self-governance (Sieber, 2006; T. Tobias, 2009; Wainwright & Bryan, 2009). However, the complexity of GIS-driven decision-making processes lives out many types of local knowledge because some of the knowledge cannot be represented spatially on a map (Elwood, 2002).

In this section of the thesis, I utilized GIS and Remote Sensing to systematically document and engage the OPCN community on the ongoing physical environmental changes due to the impacts of hydro dams. I used a combination of Google Earth Pro, ArcGIS Pro and VLC software to conduct the PGIS sessions. By utilizing a combination of historical satellite imagery records dating back to 1972, field observations and remote sensing, this thesis provided a holistic understanding of the evolving physical environmental changes. GIS platforms such as ArcGIS Pro, ArcGIS Online, ArcGIS Storymaps and QGIS are increasingly used in complementing the gap between hydroelectric power projects and historical data on environmental health impacts. GIS techniques I used in this thesis were also used by an Indigenous-led flood mapping project, Green Communities Canada[8] (Chippewas of the Thames FN (COTTFN) et al., 2022) and other studies such as disaster risk reduction processes (Klonner et al., 2021), rehabilitation of degraded watersheds (Ismail et al., 2019) and mapping cultural ecosystem services hotspots that are crucial for societal wellbeing (García-Díez et al., 2020).

[8] Session Four focuses on the development of floodplain mapping using the COTTFN project as an example. Protocols and the importance of understanding and following them will be touched on. It will include an overview of some policies and legislation that can be harnessed to assist in upholding rights and responsibilities to Mother Earth along with some examples of such. Link to webinar slides: https://docs.google.com/presentation/... (Chippewas of the Thames FN (COTTFN) et al., 2022)

3.2.1 Participatory Geographic Information Systems Mapping (PGIS)

The PGIS concept I used in this thesis followed Chief Kerry's moose guidebook for setting up PGIS mapping in communities. The first step I did was to establish long-lasting relationships with OPCN community members in 2021 before proposing the mapping activities. 2021 connections were virtual because of the COVID-19 pandemic movement restrictions. The in-person connection took in September 2022 after COVID-19 infection rates in Manitoba were low and movement restrictions were loosened. My first in-person meeting with OPCN community members took place when I attended an Indigenous-led youth camp in Mile 20, in Manitoba that was organised by the University of College of North. At the youth camp, I met some of the OPCN Chief and Council members and I proposed the mapping activities with their community. That's when I developed a consensus with the community that enabled OPCN members to openly participate in this research project. On the 2nd and 3rd of November 2022, I visited the OPCN community after the youth camp and conducted in-person interviews. That's when I developed a research design and tested the interview guide according to Chief Kerry's Moose guidebook.

Following the development of the research design and testing of the interview guide, the PGIS mapping activity took 3 months to plan and execute after the OPCN community visit. The PGIS mapping second phase of the planning process with the community members involved establishing a community-driven research agenda, identifying the geographic scope, sending invitation letters to the mapping participant, hiring a high-resolution LED projector, dates of conducting the participatory mapping session and documenting community resident interests. The PGIS session was done on the 20th of April 2023 at the University of Manitoba, Environmental Conservation Lab. I created a video sharing the places I visited and my experiences (interviews, boat tours) in OPCN. The video provided the foundation and acted as a starting point where the community members started highlighting areas of special interest to their community for example their traditional hunting grounds and medicine areas. Therefore, interviewing participants and collecting map biographies started the documentation process. This was a face-to-face in-person interview with an OPCN member pointing to places on a map devasted by hydro dams. The OPCN participant began to explain how hydro projects have been changing the community landscapes. I shifted from the video to Google Earth Pro where the community member started pointing out and explaining his personal experiences from childhood, the early stages before hydro came into the

OPCN territory. During the sessions, I was also digitizing and placing points/markers on a map whilst the community member was explaining his experiences. In preparation for the PGIS mapping session, I also acquired historical satellite images of 1972 pre-CRD, 1976 post-CRD and 2019 follow-up of CRD from the USGS website. I processed all the historical satellite images of OPCN by extracting water bodies before and after hydro dam flooding. Using the 1972 processed satellite imagery map, the OPCN participant provided in-depth descriptive statistics on what the maps were showing, what was not being shown on the map and how the landscapes had changed the well-being of the community. I overlayed the 1972, 1976 and 2019 satellite images to show the extra water from the hydro dam flood adjacent to the land after the full operation of the CRD. Then I asked the participants to explain and justify their relationship to the places flooded, for example, the community's traditional homelands that were burnt and flooded, and how they were forced to relocate to nearby lands. With permission to record, this PGIS mapping process was recorded, and the footage was used for digital storytelling in ArcGIS Storymaps.

After interviewing the participants and collecting map biographies, I made two copies of the raw data (maps and videos) on external storage drives to act as my backup copies because many researchers and communities have lost irreplaceable data through the fire, vandalism, theft, water damage and simply losing the interview files (T. N. Tobias, 2000). The following month, I started translating the interview making short video clips, audio and written text or transcript files for Story mapping and thesis writing. The translation process also included the October 2022 interviews I did in the OPCN community. Some interviews I did were in Cree Language, and they were interpreted in English by my community connector. According to Tobias, (2000) interviews conducted in Indigenous languages involve capturing Aboriginal place names, ecological knowledge and expression that can only be expressed using the first tongue. I used a web-based platform called Otter, an online program that requires a subscription for the services for basic audio transcription and Shortcut, an open-source Microsoft video editing software for making short video clips that were embedded in an ArcGIS Storymaps platform.

The PGIS section used Google Earth Pro to place notes, points, lines and polygons containing map biographies, therefore, there was no need for digitizing the data or producing digital composites and overlays as explained by Chief Kerry's Moose guidebook for setting up community mapping (T. N. Tobias, 2000). After the interview transcription, I verified the

community maps referring to the original video recorded during the PGIS session and the Story map collection website link I produced was sent to the OPCN community Chief and Council. As coined by Chief Kerry Moose in the guidebook,

"When people see their community's maps for the first time, they are almost always surprised and delighted." (T. N. Tobias, 2000).

That is what happened with the maps and Story maps I produced from the interviews and PGIS sessions. Previous studies that used GIS and Remote Sensing for mapping flooding were acquired from Google Scholar and UM Space.

3.3 Summary of data source and analysis procedures

Satellite datasets were acquired from USGS Earth Explorer[9], Landsat legacy imagery for OPCN 21 August 1972, multispectral scanner (MSS) 1-5 sensor and resolution 57/60m were used in this thesis. I used the Near-infrared Band 7 to identify the water level due to its lowest reflection value from water. The other reason the thesis used Band 7 (Near-infrared)/Band 4 (MSS 4,5) was because of its ability to separate boundaries between land, water, and landforms (Landsat Mission). The thesis overlayed the 14 June 2019 Landsat 8 satellite imagery, OLI TRS, with 9 Bands and 30m resolution. I used Band 5 (Near-infrared) to identify the water level because it was useful for depicting biomass content and shorelines (Landsat Mission). It is an improved version of the Landsat mission with 9 Bands. Landsat 30m imagery resolution allows finer-scale landscape features from as early as 1982 to the present (Carroll & Loboda, 2017; Vanderhoof & Lane, 2019).

Maps derived from satellite imagery data can help to improve understanding of surface water and how surface water changes as a function of streamflow (Western Geographic Science Center, 2022). The majority of surface water monitoring especially long-term intensive and flood monitoring efforts rely on Moderate Resolution Imaging Spectroradiometer (MODIS) or Landsat imagery because of the duration of each archive compared to other satellites (Coltin et al., 2016; Tarpanelli et al., 2013). This thesis used Landsat imagery. The techniques I used are widely known for surface-water mapping processes. They make use database of satellite imagery spanning many

[9] USGS Earth Explorer https://earthexplorer.usgs.gov/

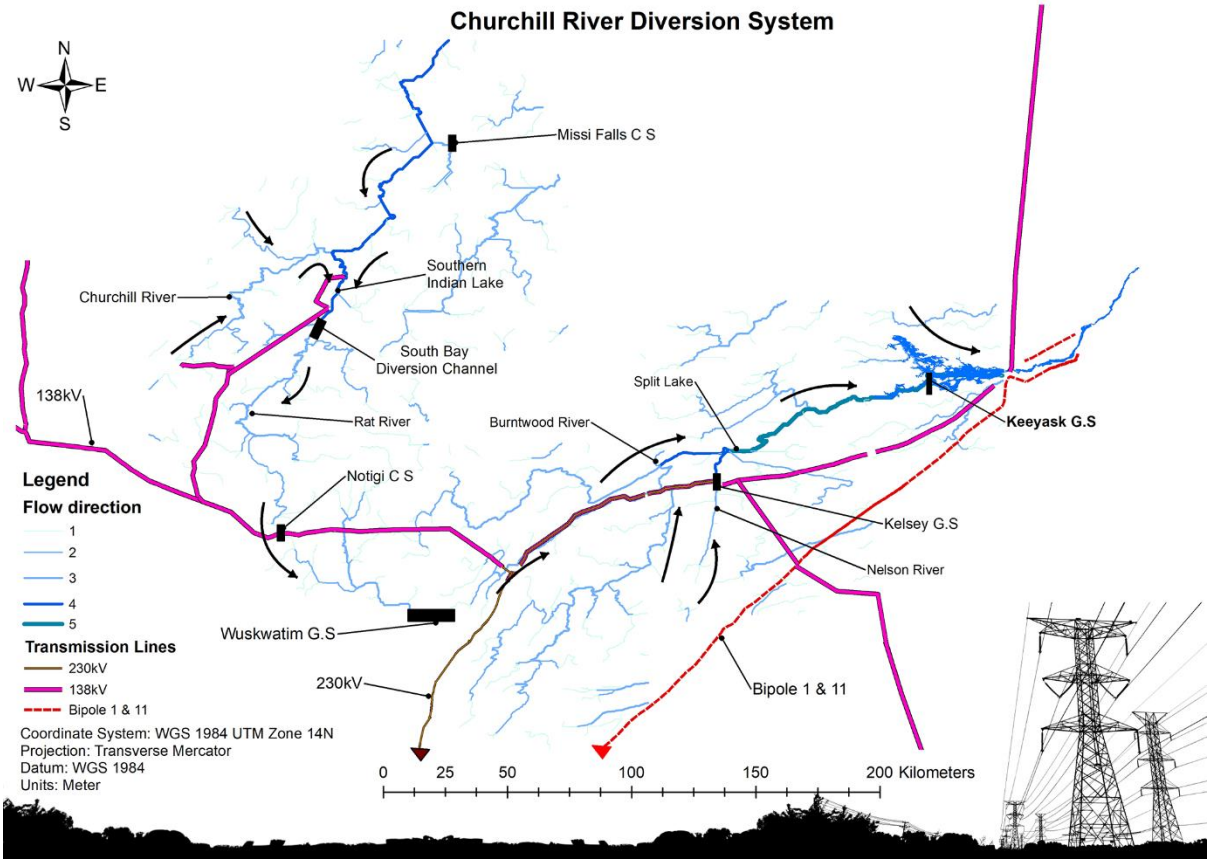
decades and can be applied to map surface water trends (Western Geographic Science Center, 2022).

3.4 Results

3.4.1 OPCN drainage system, the direction of river flow and stream order.

The adoption of GIS and Remote Sensing techniques in this thesis provided me with the foundation for understanding OPCN landscapes. Through PAR and community engagements with Elders, Fishers, Trappers, Hunters, Knowledge Keepers and Medicine Pickers, the interaction provided me with an in-depth understanding and meaning behind the maps and the changing landscapes.

Figure 9: Churchill River Diversion Systems with Transmission Lines



Source: Gerald Beta. Churchill River flows through OPCN and transmission lines.

Figure 9 The Churchill River is the natural river flow located on the left side of the map and it feeds South Indian Lake. Before the construction of Missi Falls, Notigi CS and the South

Bay diversion channel, most of the Churchill River water drained in Hudson Bay further north. After the construction of Missi Falls CS, Notigi CS and South Bay Diversion Channel, 85% of the Churchill River water is redirected and diverted backwards towards the South Bay diversion channel because of the impoundment created by the control structures. The excess water floods into the Rat River system and Burntwood River till it connects with the Nelson River. The Notigi CS helps to direct water into the Burntwood River system. The map in Figure 17.1 also shows Manitoba Hydro's high voltage direct current (HVDC) transmission lines widely known as Bipole. According to Manitoba Hydro, Bipole refers to the positive (+) pole and a negative (-) pole which allows electricity to travel long distances without minimum loss of power. Bipole 1 runs 895km and 11 runs alongside each other for 937km from northern Radisson and Henday converter stations to the south of the Dorsey converter station northwest of Winnipeg.

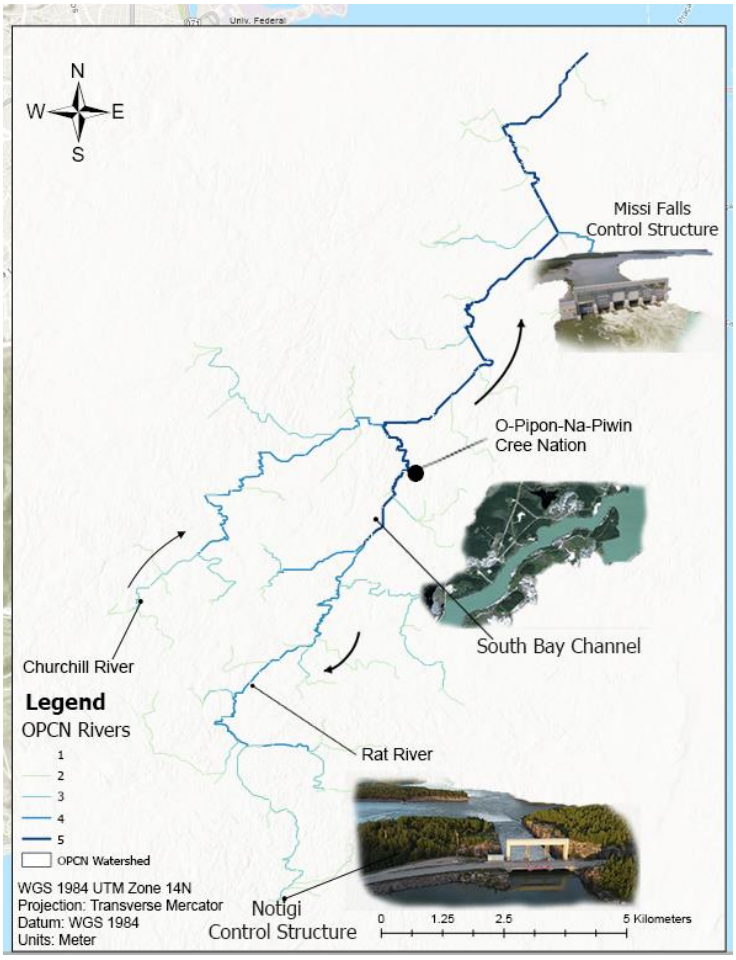


Figure 10 shows a shortened version of how the Churchill River

Figure 10 shows a shortened version of how the Churchill River flows through OPCN (Southern Indian Lake) till it empties in Hudson Bay (not shown on the map), further up north. The drainage system shows the Churchill River tributary (natural flow) and Rat River tributary (the modified river).

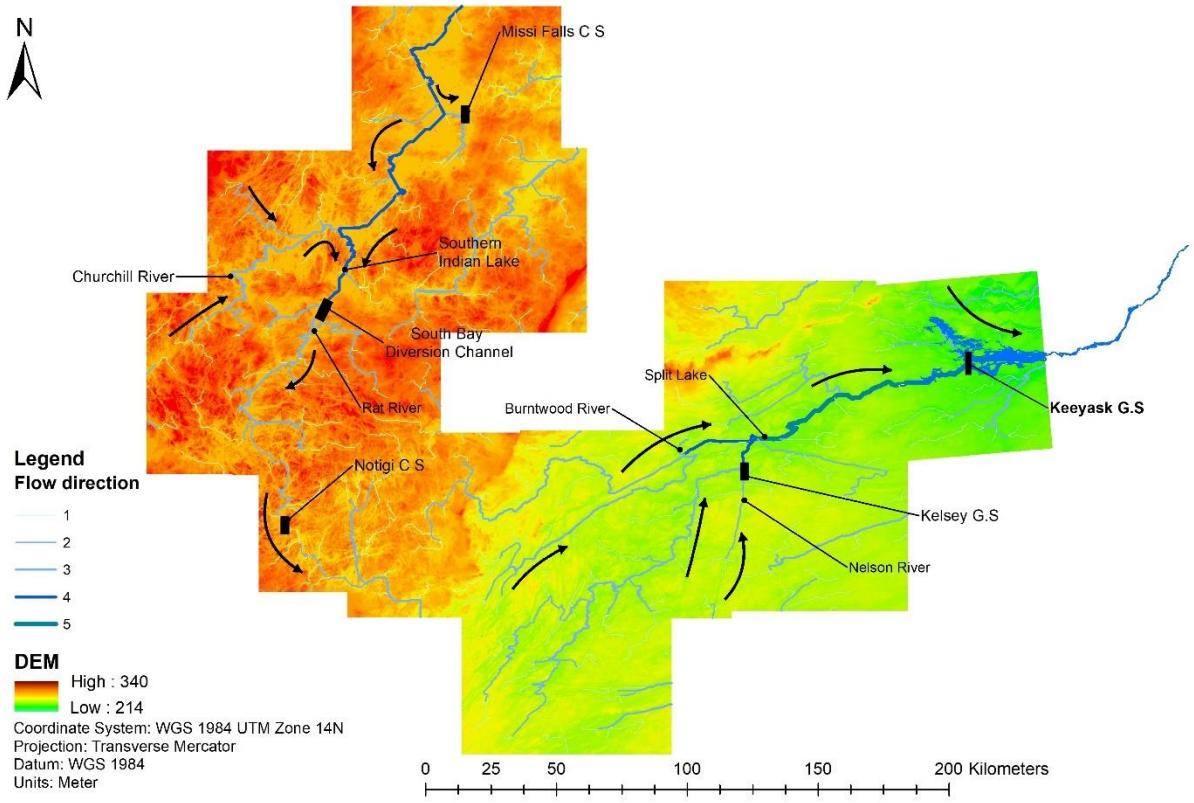
The map in Figure 10 also shows the position where Missi Falls Control Structure, South Bay Diversion Channel and Notigi Control Structure are located. The three are the main components of the CRD that devasted the pristine landscape, waters, and people.

Source Gerald Beta

3.5 The spatial-temporal assumptions behind the construction of the Churchill River Diversion Route channel

From the results I produced through processing the DEM in ArcGIS, the assumption behind the construction of the CRD channel route along OPCN was that the Churchill River area was characterised by highlands and the Nelson River area was characterised by lowlands. It was feasible for Manitoba Hydro to artificially modify the Rat River to increase power generation along the Nelson River because of the landscape composition of the areas. My assumption is further supported by literature that the Churchill River flows from "southeast, east and northeast across the lowlands of northern Saskatchewan and Manitoba to Hudson Bay at Churchill, Manitoba" Marsh, (2021).

Figure 11: Shows the Digital Elevation Model for the Churchill River basin and Nelson River basin

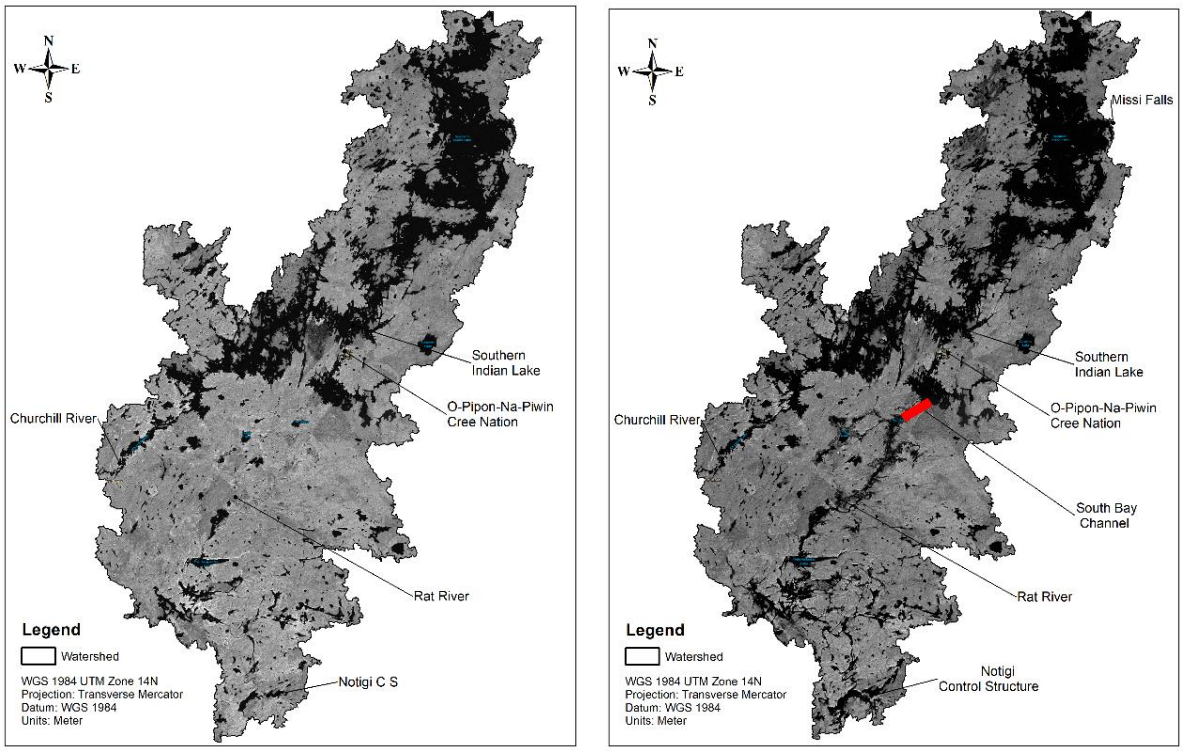


Source: Gerald Beta

Figure 11 shows the digital elevation model of the Churchill River basin up to the Nelson River basin. It shows how it was feasible for Manitoba Hydro to construct the South Bay Diversion Channel route on the Rat River system to artificially manage and control the river flow to the Nelson River system through the Notigi Control Structure. Referring to the Figure 18 legend, the brown-orange colour represents areas with highlands, and the yellow-green represents areas with lowlands. The flow direction represents the stream order of hierarchy which is a way of sorting and organizing stream networks based on their connectivity (Adagala, 2023). The stream order is based on the Strahler order classification system which designates a numeric value to each segment of a river network based on tributaries flowing in it (Strahler, 1952). The first-order stream is a small tributary that needs a confluence of two first-order streams to form a second-order stream. According to Strahler, (1952), streams flow from an area of high elevation to low elevation following areas of less resistance. Based on Strahler's model, I used the stream order for watershed delineation, visualizing flooded areas, erosion modelling, habitat assessment and infrastructure planning.

3.6 Historical satellite images of landscapes in South Indian Lake before and after hydro dams came into the territory of OPCN

Figure 12: Shows the historical satellite imagery of 1972 pre-CRD and 1976 post-CRD.



1972 pre-CRD **1976 post-CRD**

Source: USGS Earth Explorer images, pre-processed by Gerald Beta

Figure 12 shows the spatial-temporal changes in landscapes pre-CRD and post-CRD. Before hydro came into the territory, Rat River as explained by Les Dysart (CASIL CEO) during a participatory mapping engagement (April 2023), "Historically there was only a small creek here [1972 map] that was even dry at times that flowed so there wasn't an adequate water system to go to and from these areas, hydro cleared this and then blasted the dryland forcing the water to enter the Rat River system".

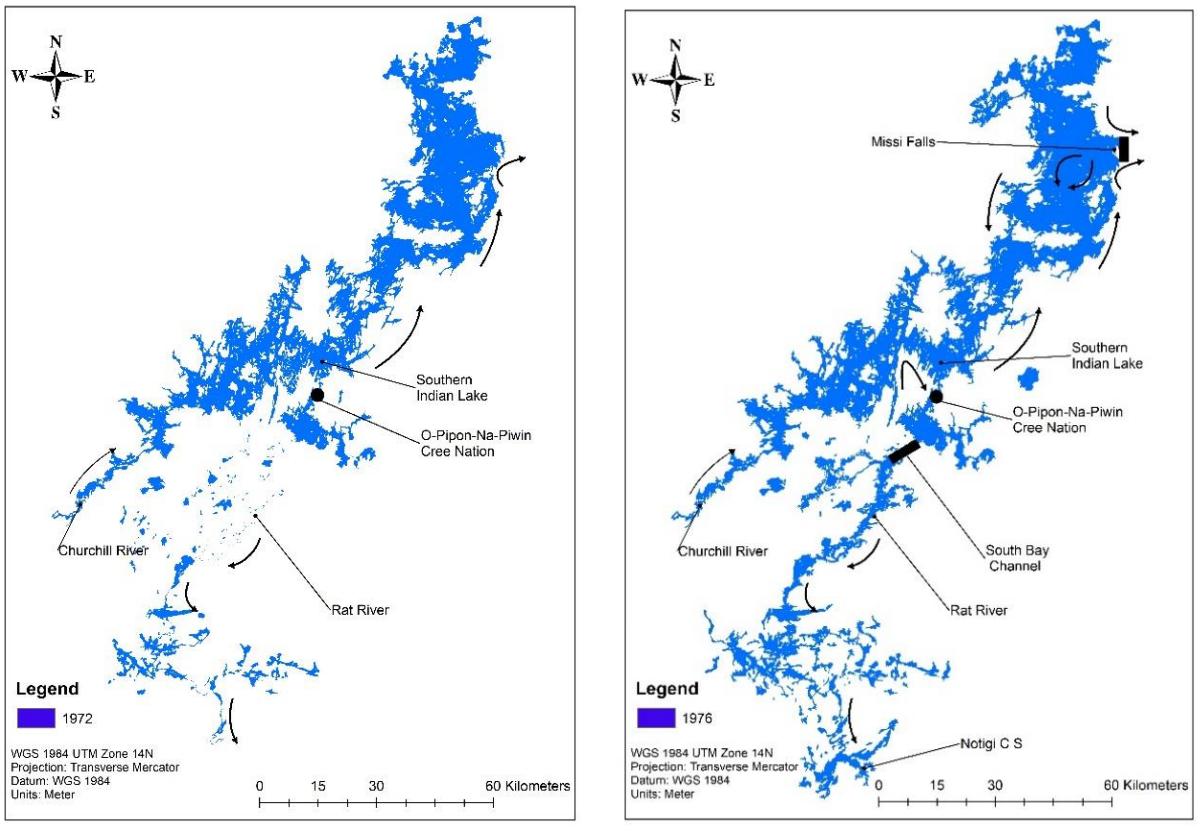
Figure 13: Shows Les Dysart pointing 1972 historical map of Rat River Creek

Source: Gerald Beta. Les Dysart pointed out how Rat River used to be a creek before the hydro

Les Dysart further explained that the river used to be a small creek that was difficult to travel with boats and canoes. After hydro dams came into their territory, the Rat River was artificially widened through the construction of the South Bay channel. Today, any size of boat can travel to and from into Rat River system. R Linklater (2022) further supports that, "Rat River used to be maybe 75 feet wide to Nelson House but today, that river it's the size of Winnipegosis. (Theme: Brief history of how dams and control structures started in OPCN, the timeline at 2:59).

The purpose of CRD was to increase power generation along the Nelson River system, but the process affected a lot of traplines and forcibly relocated an entire community (Dysart & Spence, 2021).

Figure 14: Shows 1972 and 1976 extracted water levels from historical satellite imagery.



1972 Water level 1976 Water level

Source: Gerald Beta

Figure 14, 1972 map shows the approximate normal water levels in Rat River being described as a narrow creek before the CRD and the approximate 1976 abnormal water levels after the completion of the CRD. The maps also show how the river shape has changed and R Linklater, OPCN fisher, trapper and hunter emphasised that,

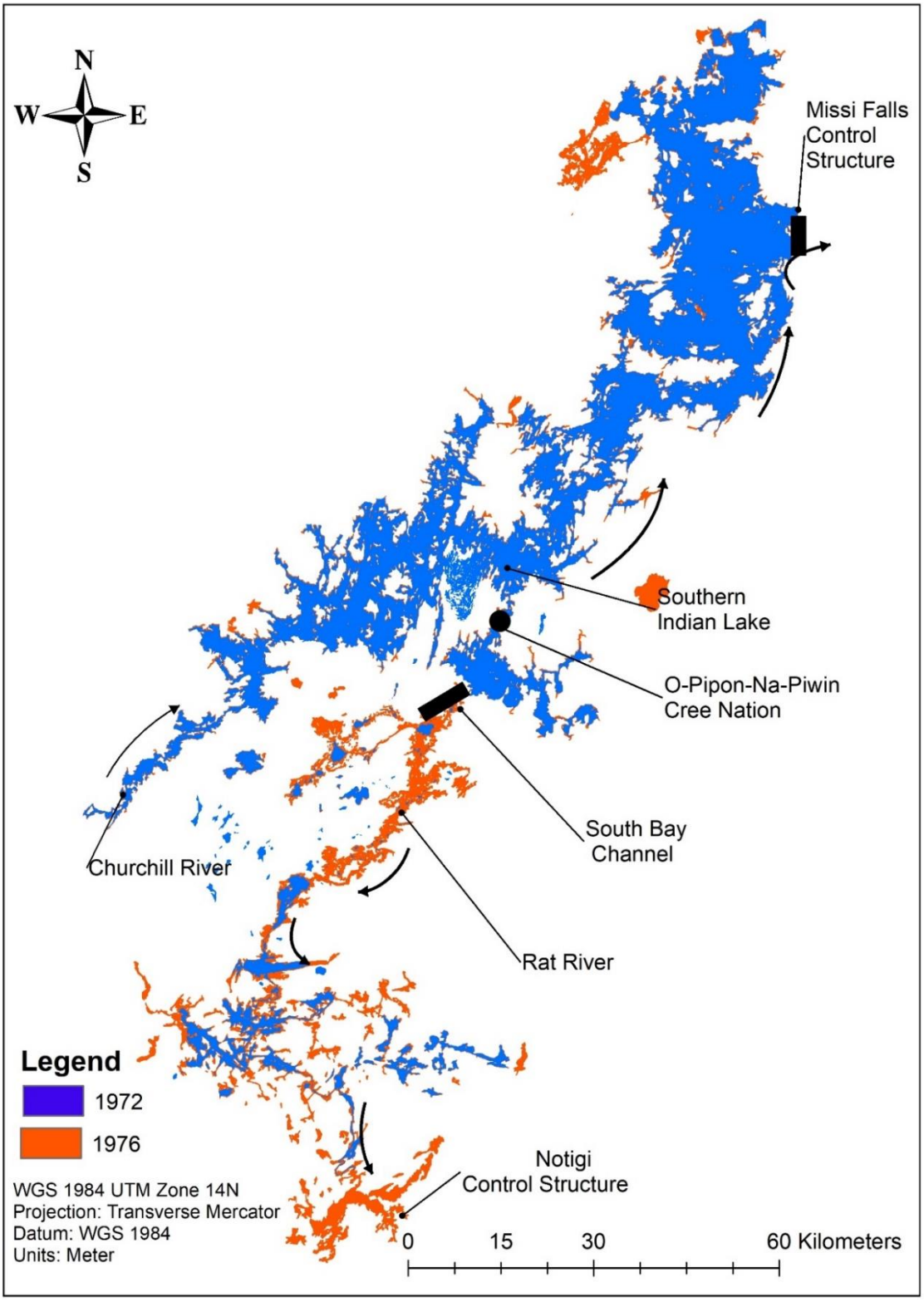
> "It used to be a river maybe 75 feet wide all the way to Nelson House. Today that river it's the size of Winnipegosis same on both sides, it used to be smaller in size. But they [Manitoba Hydro] can't tell how far the water is to the bushes went in. I travelled in these waters for maybe forty-three years, I fished in this water, and I see it my way when I worked in with conservation and Manitoba Hydro for 43 years." Randal Linklater, OPCN Fisher, Trapper and Hunter (Personal Interview, October 2022).

NB: Click and navigate to the theme: ‘Brief history of how hydro dams and control structure started in OPCN’ timeline 3:00, for a full video description.

Figure 15: Show Randal Linklater giving a brief history of how hydro dams and control structures started in OPCN

Source: Gerald Beta. Randal Linklater describes the history of hydro dams that came into OPCN territory

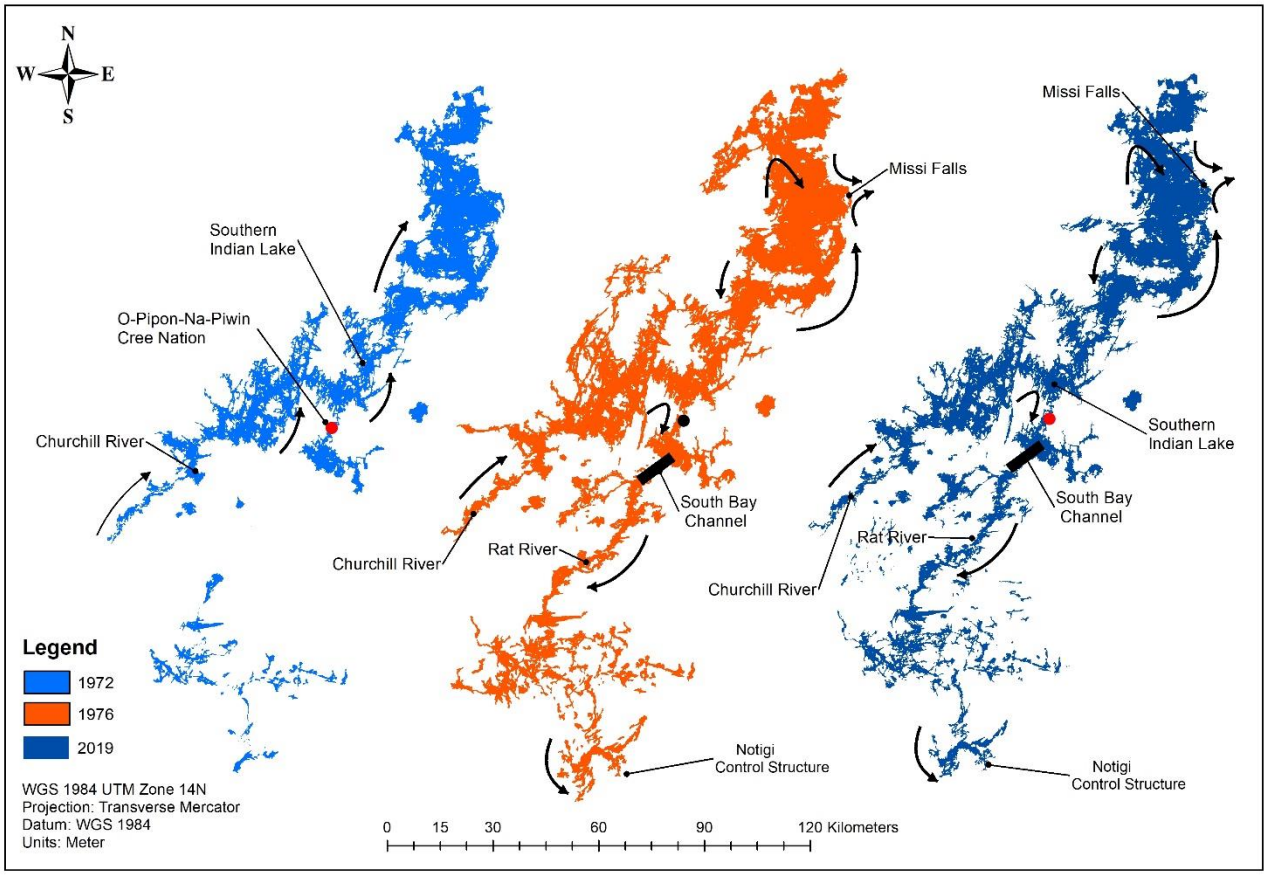
Figure 16: Showing overlay between 1972 pre-CRD and 1976 post-CRD



Source: Gerald Beta

Figure 16 shows an overlayed map between different periods along the Churchill River and Rat River systems. The blue colour on the map represents the water level in 1972 before the construction of the CRD project. The 1972 water level clearly shows that the Rat River system was not huge before hydroelectric dam projects. Using the 1972 satellite images, the same location [Rat River] made it difficult to tell where the river was when I was processing the data. Overlaying the same 1972 satellite imagery data with the 1976 satellite imagery data provided a clear representation of how the landscapes have changed. According to community testimonies, the ecological, economic and cultural devastation of hydroelectric dams was severe, ongoing and heartbreaking (Dysart & Spence, 2021).

Figure 17: Water levels between 1972 pre-CRD, 1976 post-CRD and the 2019 follow-up of CRD

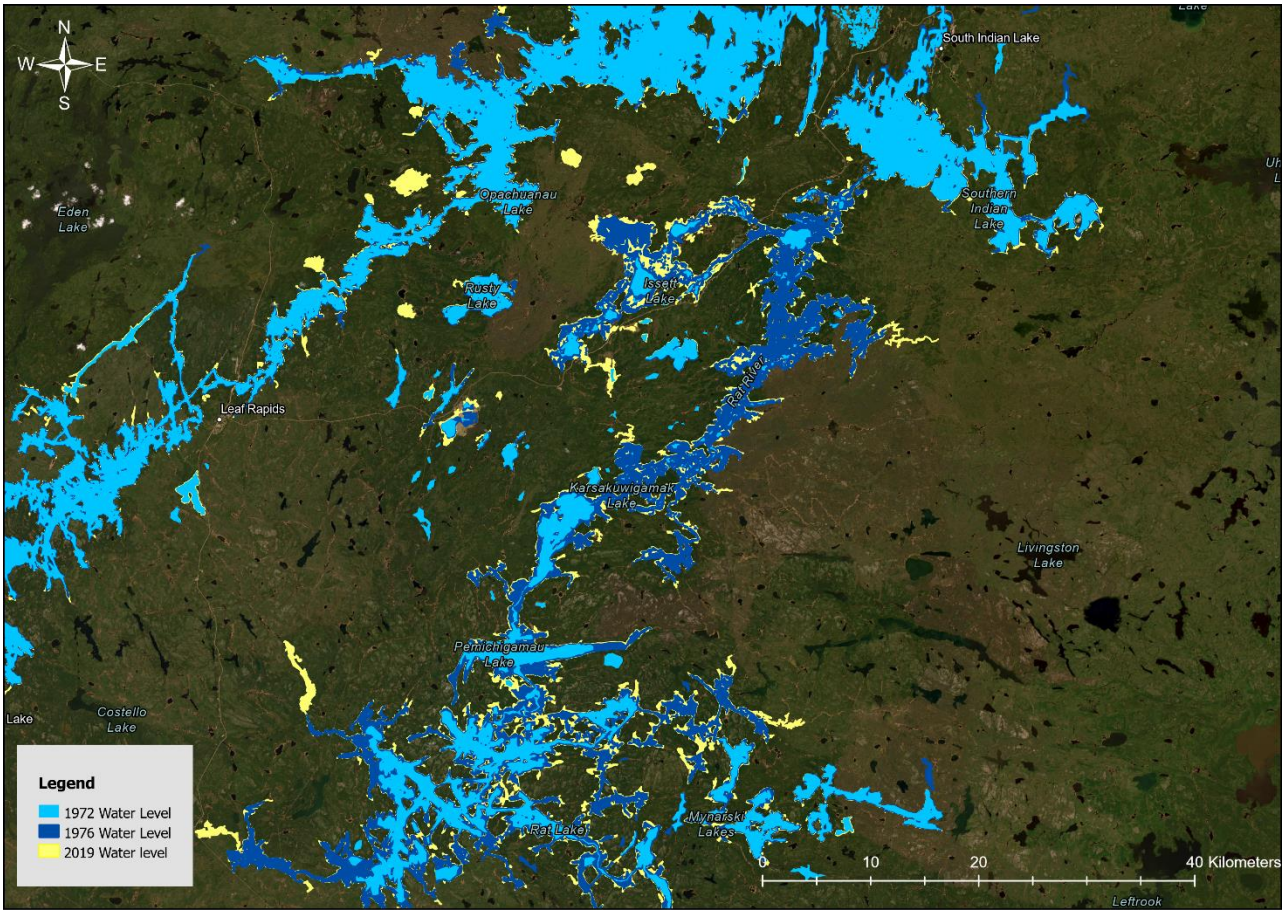


Maps showing three water levels between 1972, 1976 and 2019. Source: Gerald Beta

Figure 17 presents a series of landscape changes due to hydroelectric dam projects in OPCN. The map shows the differences in water levels extracted from the 1972, 1976 and 2019

satellite images provided by USGS. The 1972 light blue colour shows the river shape before Manitoba Hydro blasted the 9km South Bay Diversion channel. The 1976 map is represented in orange colour and the 2019 map is represented in dark blue colour showing the changes in the river shape (length and width). Gallons of water splits into the bush for miles and miles hence erosion keeps going down the river.

Figure 18: Shows a series of flooding events along the CRD



Source: Gerald Beta. Map showing 1972, 1976 and 2019 different flood levels.

Figure 18 shows the transformation of the narrow Rat River into a giant river in subsequent years after Manitoba Hydro diverted 85% of Churchill River water to join the Nelson River system. The flooding was a result of the combination between the Notigi control structure and the Missi Falls control structure. Both the control structures act as water impoundment and the South Bay diversion channel redirects, controls and connects the flow to the Rat River system which feeds the Burntwood River system. Cameroon Moose (2022) explained that when Manitoba Hydro shuts down the Missi Falls CS, water flows back towards the Notigi control structure and

when Notigi CS shuts down, the water goes in the opposite direction. All the fish will be carried along where the river will be flowing. Calvin Baker (2022), the OPCN Fish Plant Operations Manager added by supporting that the gradual changes in water movement are not good for fish, especially white fish.

Figure 19: Shows Calvin Baker describing fish's favourite spawning areas.

> "Whitefish spawn on the shoreline and the changes in water flows do no good with the silt coming in washing and crushing all the eggs".

Theme: 'Fish favourite spawning areas' at 0:25 seconds **(PGIS Source: Gerald Beta)**

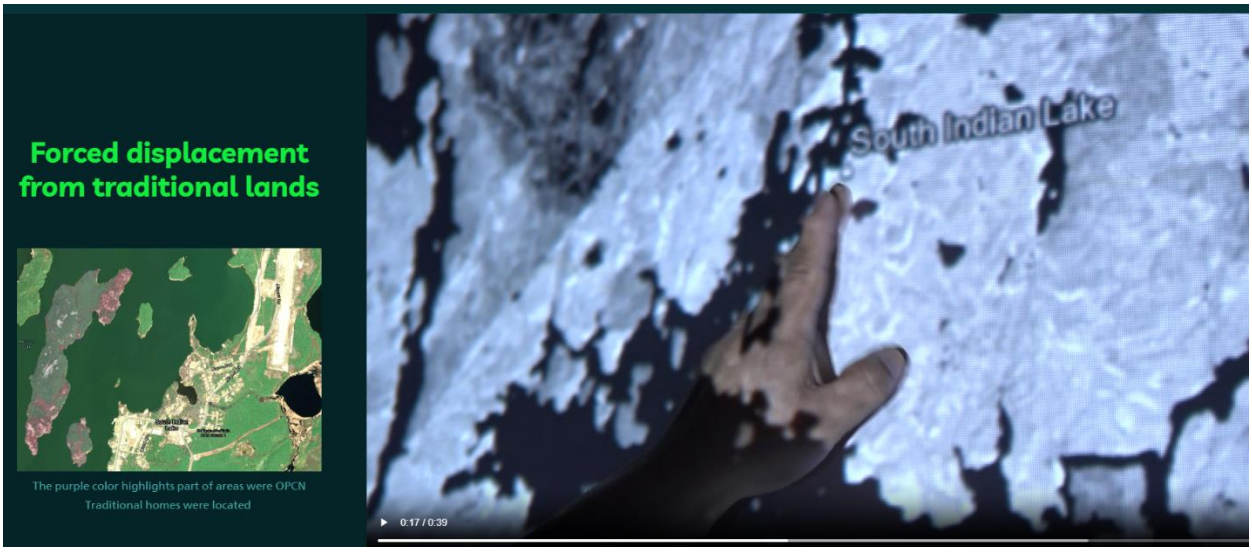
3.7 Participatory Geographic Information System Mapping with and for the OPCN Community

Figure 20: OPCN Traditional Homelands before the flood

Historical map before OPCN was forced to relocate to the other side of the river (PGIS Source: Gerald Beta)

In the 1970s, the majority of the OPCN traditional housing and homes were located on the East side of the river (As shown in Figure 20). After a series of continuously forced displacements due to hydroelectric dam projects, the community housing was moved to the West side of the river (Figure 21).

Figure 21: Resettlement areas across the lake after the flood



Historical map after OPCN was forced to relocate to the other side of the river (PGIS Source: Gerald Beta)

Today, what used to be OPCN's traditional homeland has become an island characterised by a lot of erosion effects from the hydro dam flooding. According to Les Dysart (Personal Interview, October 2023), pointing to Figure 21,

> "The whiter line is where the majority of the community lived and there were few houses for homes on the east shore of the river. Manitoba Hydro forced everybody to move from the east to the west side of our traditional area…." Les Dyasrt (2023 Personal Interview)

NB: Click the quote and navigate to the theme: 'Forced displacement from traditional lands?' for a full video description of how OPCN was forced to relocate from their land

Figure 22: Part of OPCN Traditional homelands and relocation area

The map shows part of OPCN's Traditional homelands and part of the new relocation area across the river (Source: Gerald Beta)

Figure 22 shows part of OPCN Traditional homelands highlighted in purple colour where the community used to be located before hydroelectric dams came into their territory. The previous

traditional homeland's location shows the cumulative effects of erosion along the community riverbanks. The islands are getting smaller because of fluctuating water levels and high currents as explained by Les during the PGIS mapping engagement. The narratives provided by OPCN members, clearly show how hydroelectric projects not only permanently altered the shape and size of the landscapes but also destroyed the environment through flooding and erosion.

> "If things don't change, eventually our traditional homeland will just disappear into the water". Les Dysart (Personal Interview, October 2023).

3.8 The construction of the South Bay Diversion channel along Rat River

During the community interviews, OPCN community members expressed their concerns about how they were never consulted when hydro projects were coming into their territory. They shared their knowledge and experiences on how they were treated for example being forced to burn their homes and cabins. The narratives went beyond how hydro dams changed the landscapes to how the fishing economy was impacted by the dam project.

Figure 23: Shows Randal Linklater describing a brief history of dams in OPCN

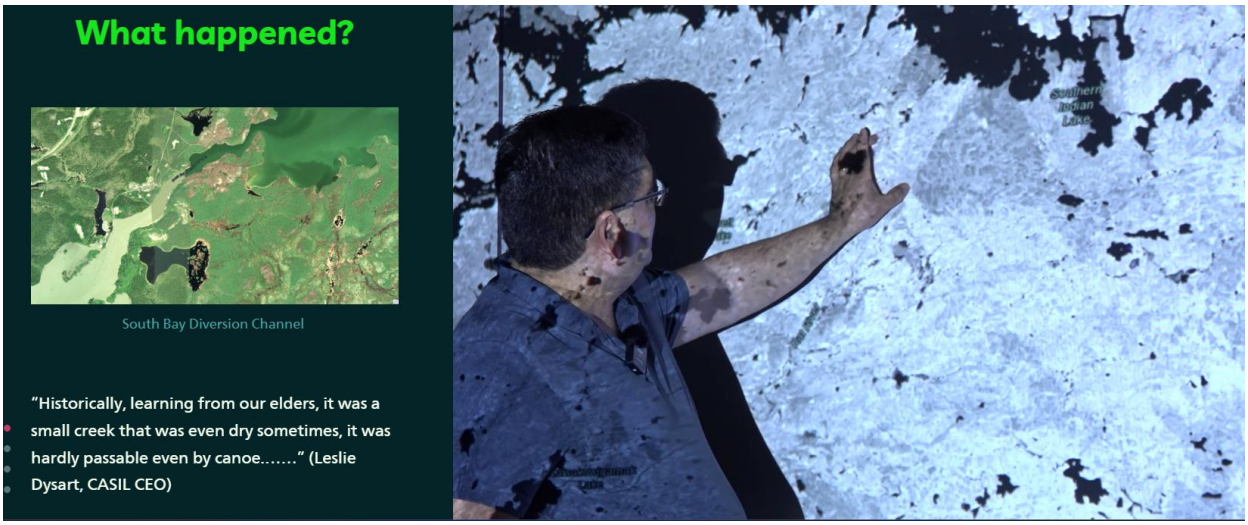
Source: Gerald Beta

> "Well right from the beginning I was tracing the trap line and it was in the 60s when hydro started coming survey down below here [OPCN]. That was my trap line there. My dad's trap line, we were all working there all the time. We didn't know what they were looking

for. They were going to build that channel [South Bay Diversion Channel] to the other side of the town down to the west-northwest side. But we didn't know [there was no consultation], they did a lot of survey [Manitoba Hydro]. And then after 15 years, they decided to blast through that channel 200 feet down on a rock. It affected a lot of trapping on our site because there were three trap lines placed on that side when they started blasting." Randal Linklater, OPCN Fisher, Trapper and Hunter (Personal Interview, October 2022).

NB: Click the quote and navigate to the theme 'Brief history of hydro dams and control structures in OPCN' for a full video description of R Link-later explaining how hydro dams started in OPCN.

Figure 24: How Manitoba Hydro planned and mapped the Churchill River Diversion channel



Les Dysart illustrates how Manitoba Hydro mapped the expected route for the South Bay Diversion.

"Historically, learning from our elders, it was a small creek that was even dry sometimes, it was hardly passable even by canoe, so it wasn't a natural outflow inflow to South Indian Lake. I mean it was, but it wasn't an adequate volume of water [where he is pointing]. Manitoba Hydro had to blast and clear about 8 miles of solid land to create the diversion channel. Forcing the water to flow south and then north into the Nelson River. The area had high landmass, anybody portaging the area would have to drag their canoe

over dry land at times to access the Rat River system……" Les Dysart (PGIS Personal Interview, April 2023).

NB: Click the quote and navigate to the theme 'What happened?' to view the full video description of Les Dysart illustrating how Manitoba Hydro mapped the expected route for South Bay Diversion.

Locally in the community, the Churchill River diversion is referred to as the flood. The engineering projects flooded the ancestral traditional landscapes of OPCN thereby compromising cultural land-based activities that were at the heart of the community. Hydro flooding disconnected people from the land especially youths who were reported to have been resorting to drugs and substance abuse and violent crimes (C. Spence, 2022, W. Wood, 2022, Personal Communication).

Figure 25: The 1976 hydro flooding after the completion of CRD

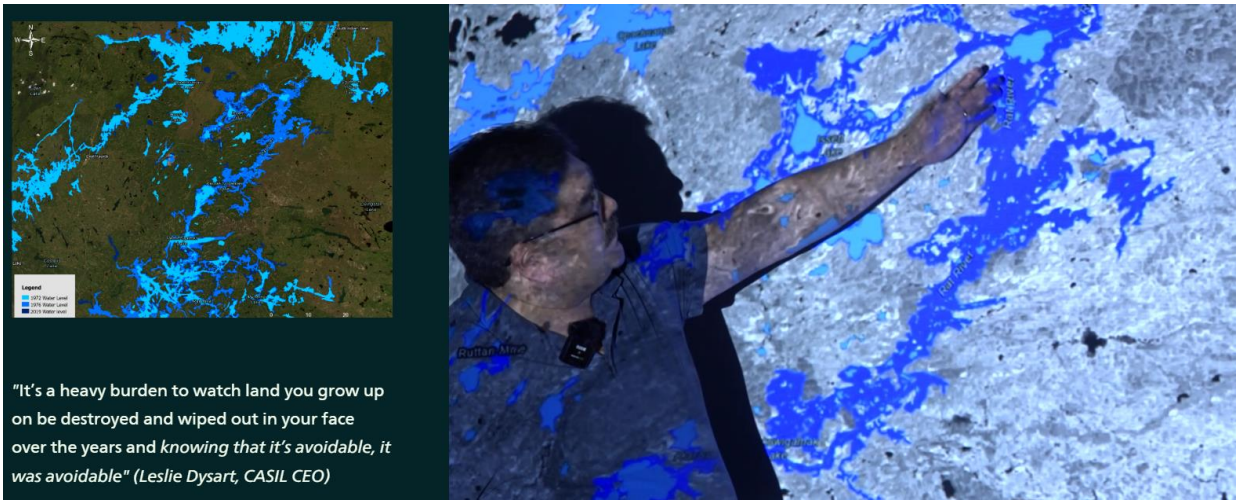
Les Dysart pointing at the flooding that occurred after the construction of the South Bay Diversion, when CRD was in full operation in 1976 (PGIS Personal Interview, April 2023)

Figure 25 shows the area flooded in 1976 by the man-made South Bay Diversion Channel. This was the early stages when the CRD was in full operation forcing water to flow South into Rat River. Les Dysart (2023) pointed to the area flooded by the South Bay Diversion Channel during the PGIS session and he explained how the area used to be dry land which has been flooded. Les added more explanation emphasizing that the flooding of the land was a process, it took about 2 – 3 years to get flooded when Manitoba Hydro started to raise the water levels.

"This is 1976 shortly after the flooding of South Indian Lake, you see a number of the islands don't exist anymore …….The water flows south and all this area is flooded, the older picture was dry land [1972]….." Les Dysart (Personal Interview, 2023)

NB: Click the quote and navigate to the theme; '1976 Flooding' for a full video description of how the South Bay Diversion channel flooded the land.

Figure 26: Les Dysart describing the 1972 and 1976 environmental footprint caused by the South Bay Diversion Channel



"It's quite an experience to watch this over the years and to see visually the desecration of the land, water, and the people. It's a heavy burden to watch the land you grew up on being destroyed and wiped out in your face over the years and knowing that it's avoidable, it was avoidable. You can not change time but do more responsible job and stabilize the water and lake levels. Right now, our lake is a toilet bowl for Manitoba Hydro under the permission of Manitoba to flush out their system, sacrificing our community and the people….. The scars are huge on the land and it's never-ending". (Les Dysart, Personal Interview, 2023).

NB: Click the quote and navigate to the theme; 'Was it avoidable?' for the full PGIS video description of Les Dysart describing the 1972 and 1976 environmental footprint caused by the South Bay Diversion Channel.

3.9 Notable outcomes and implications

3.9.1 Flooding of traditional homelands

The construction of hydro dams and control structures in OPCN was not received well by the community members because there was little to no consultation with the community members. According to Dysart & Spence, (2021), hydro dam structures were constructed without the community's consent and it was against the community's wishes. The Notigi CS and Missi Falls CS are dams that raised the water level of SIL by an average of 3 meters (MacLean, 2019). This led to the flooding of the traditional homelands of the OPCN community. In literature, "The shores are constantly slumping into the lake, filling it with debris and mud, wearing away islands. So islands that used to be there don't exist anymore", Jarvis Brownlie in MacLean, (2019). According to Les Dysart (2023) during the PGIS mapping session, families were forced to burn their cabins and displace them from their traditional grounds because of the planned flooding.

The entire community was displaced and made to re-establish itself on the other side of the SIL River. The previous traditional homelands were very important to the community because today, even after more than 50 years since the flooding occurred, the community visits and conducts cultural events yearly at the remaining sites. "It is a heavy burden to watch the land you grow on being destroyed and wiped off on the face of the earth and knowing it was avoidable" Les Dysart (2023). The flooding of traditional homelands of OPCN disconnected the youth from cultural practices and land-based activities leading to drugs and substance use. The use of PGIS mapping tools in documenting these stories provided detailed information that text and video techniques could not capture because the community members interacted with maps, pinpointing the areas they were referring to for example the location of the flooded traditional home grounds.

3.9.2 No access to updated flood maps

Since the hydro dams started flooding the OPCN territory, community members were concerned that they had never been provided with updated maps of how much water had gone into the bushes. During one of the interviews, Randal Link-later explained that whenever Manitoba Hydro comes for surveys, some of the community members ask for updated maps but they are provided with the same outdated maps that don't tell and show how much land has been flooded.

Lacking access to updated water level maps in the OPCN community is a major risk to Fishers and water travellers because they cannot tell how far they are from the shoreline because of gradual water level changes in the lake. Randal Linklater attended several boat accidents along the SIL where fishers testified that they were not aware of how close they were to the shorelines therefore they either would hit a tree log or a rock in the lake. Updated maps are very important to community members because maps help in making informed conservation decisions and planning for biodiversity protection (Ramirez-Gomez et al., 2013). However, as a solution to outdated maps, the OPCN community works with academic institutions and NGOs to assist them in updating their community maps.

3.9.3 The quality of the satellite data

In this thesis, I used the 1972 USGS satellite imagery data to visualize the OPCN landscapes before the construction of the CRD channel. The quality of the raw data was good for visualizing the Rat River before the construction of the CRD channel. However, the satellite data was not the best for calculating or providing matrixes of how much land was lost due to the construction of the CRD channel because the imagery was not clear (low resolution) and the presence of many small floating islands also affected the matrix calculations.

Figure 27 Showing 1972 satellite image of Rat River before CRD

Photo by Gerald Beta

Figure 27 above shows how the 1972 satellite image of the meandering Rat River made it difficult to calculate the area flooded by the CRD but it was good for visualizing how Rat River was smaller before the CRD.

Figure 28 shows the 1976 Rat River after CRD was constructed

Photo by Gerald Beta

Figure 28 shows the 1976 satellite image of Rat River after the CRD was constructed in the OPCN community. Visualizing the flooding was good however calculating the area flooded by the CRD in such a big river was difficult because 1976 was the early stages of flooding and because of the gradual water level fluctuations, the flooding levels constantly changed. The results of the 1972, 1976 and 2019 flood maps show how the landscape has changed due to the construction of the CRD however, the maps failed to show the extent of land or soil fully saturated by the water because of the forest cover.

Figure 29 Les Dysart demonstrates how the water is oozing from the ground

Photo by Michael Tyas: Wa Ni Ska Tan

Figure 29 above shows Les Dysart demonstrating lateral erosion uphill and how the water table has saturated the topsoil in OPCN land, information that the satellite images could not show on the map.

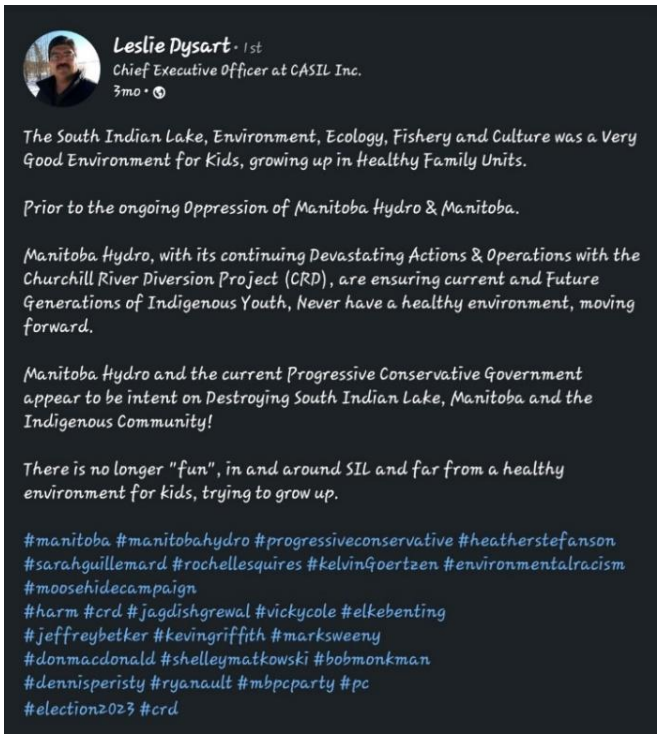
3.9.4 The difference between hydro-impacted water and non-hydro-impacted water

During the PGIS mapping session, Les Dysart highlighted an important aspect of how hydro-dam water and non-hydro-dam water show on Google Earth maps and satellite images. Hydro-dam-impacted water shows a dull brown/green colour on maps and non-hydro-dam water shows dark black on the maps. According to Schmaltz, (2013), clean water is usually black/dark blue because it absorbs light and the sediments reflect light thereby colouring the water. The water looks brown when there is suspended sand or dense mud because the sediments disperse the light. The unpredicted fluctuation of water levels in SIL contributes to soil erosion causing water to become silty, murky, and muddy thereby turning into a brown colour. The effects of hydro dams in OPCN are also felt in other Northern communities like NCN and TCN. The former Councillor of TCN, Robert Spence made a post on LinkedIn that, “The only thing green about it is the water

we can no longer drink after it's been through hundreds of thousands of kilometres of land it's flooded to create reservoirs for its dams to power its turbines."

3.9.5 Animals migrating routes shifted

OPCN community lives, and livelihoods are based on hunting, fishing, and trapping. These practices have sustained the community for decades of years. The PGIS outcomes show that the construction of Missi Falls CS, Notigi CS and South Bay Diversion Channel increased the water levels of SIL, and it flooded the traditional hunting grounds in OPCN. Before hydro dams came into OPCN, the Rat River used to be a small creek that sometimes was difficult to travel with a canoe (Les Dysart 2023). Community members had to portage along the Rat River with small canoes when they travelled to other areas mainly for hunting and fishing. The community's traditional areas surrounded by Rat River were considered migration routes for animals like caribou and moose therefore the traditional area was the favourite hunting spot for many OPCN community members because of the short travelling distance to the area. The 9km South Bay Diversion Channel changed everything, it increased the width and depth of the Rat River which made it difficult for animals to migrate further up north. Currently, the channel is characterized by high water currents and depending on how much water Manitoba Hydro needs, the river flows in either direction because the river doesn't flow naturally. As a solution to shifting animal migration routes, the OPCN hunters travel to areas far from their community. Spending more time travelling further disconnected the youths from land-based activities and it compromised the people's ability to pass down their cultures because it now requires more time travelling and the cost of living increases leading to high crime rates in the community (Brake, 2018).



LinkedIn Post by Les Dysart (2023)

3.10 Discussion

Over the past three years, I had the privilege of hearing the lived experiences of Indigenous communities in Northern Manitoba. The journey was made possible by choosing an appropriate research method for this thesis and establishing long-lasting relationships first before proposing any collaborative work with the OPCN community. The thesis chapter focused on assessing the spatial-temporal changes in the physical environment due to hydroelectric dam projects in OPCN by comprehensively analyzing the ongoing modifications to the land and water bodies. The two-eyed Seeing research method was the best method to document collaboratively the environmental impacts of hydro dams in OPCN. According to Wright et al., (2019), the Two-Eyed Seeing research approach creates a space for Western ways of knowing and Indigenous ways of knowing and doing to come together to best aid understanding and solve problems.

Using the Two-Eyed Seeing research method, the CRD can be evaluated as the main cause behind environmental injustice in OPCN because there was little to no community consultation from the project planners to the community. Following a series of no consultation and forced displacement, the construction of the Notigi Control Structure, South Bay Diversion Channel and Missi Falls control structure increased water levels by more than 3 meters in SIL leading to a backflow of water (Levasseur, 2022). This move wasn't accepted widely by the OPCN community because the hydro dam flooding was accompanied by varying environmental damages such as deteriorated water quality (silty, muddy/murky) (Peter, 2004), increase in mercury toxins, dissemination of fisheries (Read, 2020), flooding of traditional hunting grounds, flooding of land-based foods (mushrooms, berries, and medicine), soil erosion, disappearing of shorelines/lands, increased foreign floating objects (logs, sticks) (CBC, 2018), and flooding grave sites. These cumulative environmental impacts further deteriorated the environmental health of the land, water and people leading to increased heart attacks, diabetes, high blood pressure, cancer, depression, and Alzheimer's. From the findings of this thesis, R Link-later commented that,

> "They [Manitoba Hydro] never gave what people wanted and today every single one of those people [Elders] that spoke what they wanted from hydro, they are gone, we are just following our grand-grandparents footsteps right now". Randal Linklater (Personal Interview, 2023).

The statement provided by Randal Link-later clearly shows that most of the project planners do not meet the needs and expectations of the local communities because project planners are concerned more about making money and local communities are concerned about their livelihoods, culture, and traditions. Most of the Elders who fought Manitoba Hydro succumbed to cancer, heart attacks, diabetes, and kidney failures.

All the environmental impacts of hydro dams such as flooding were documented using GIS and Remote Sensing techniques. GIS and Remote Sensing techniques offered an opportunity for non-community members to visually understand how hydro dams devastated the community's landscapes. According to Williamson et al., (2023), indigenous practices, knowledge and perspectives have sharply been in focus by environmental researchers and governing practitioners towards providing precise solutions to environmental issues. The PGIS techniques provided me with a unique perspective that enabled community members to fully engage and interact with the maps while sharing their experiences on the land and water. This thesis used both historical satellite imagery maps and contemporary maps in documenting the environmental impacts of hydro dams in OPCN because maps enable community members to historically track year-by-year how hydro dams flooded their territory.

For example, I used the 1972 map before the hydro dam flooding during a PGIS session and the community members quickly remembered how the community were made to burn their cabins for little compensation by Manitoba Hydro. I then used the 1976 map after the hydro dam flooding and community members were amazed visualizing how the community land had been lost due to erosion effects caused by fluctuating water levels. The findings of the thesis chapter show that since the flooding started in the 70s, Manitoba Hydro rarely provides OPCN community members with updated flood maps that show how much traditional land has been flooded. PGIS mapping with the OPCN community provided an opportunity for community members to highlight, interact, engage and interpret the meaning of the maps by highlighting their areas of interest. One of the main intents of the project was to empower Indigenous communities to tell their own stories, concerns and issues surrounding their environment, well-being, culture, and traditions using maps.

However, the quality of the 1972 satellite images was good for the visualisation of the landscapes before the CRD channel but the resolution was low because they were the first satellite

images to be produced or collected by USGS therefore they were not clear enough for processing to produce matrixes of how the Rat River had changed. The missing GIS gaps that the satellite images could not show were complimented by OPCN community visits I did in October and November 2022. OPCN community members confirmed that there was so much more water in the bushes, the soil was saturated, and the shorelines constantly changed. The land was becoming unusable because of the scares that Manitoba Hydro was leaving on the OPCN land. Patches of land in the community that used to provide quality medicines are either underwater or saturated with water.

Chapter 4

To understand the implications of these spatial-temporal changes on community livelihoods

And

To present and share these community experiences using ArcGIS Storymaps, a web-based tool that allows users to combine text, audio, videos, and maps to present information.

4.0 Introduction

> "When you force people to abandon their ways of knowing, their ways of seeing the world, you literally destroy their spirit and once that spirit is destroyed it is very, very difficult to embrace anything- academically or through sports or through arts or through anything – because that person is never complete. But to create a complete picture of a person, their spirit, their physical being, their emotions and their intellectual being… all have to be intact and work in a very harmonious way". Elder Albert, Mi'kmaw Nation (Bartlett et al., 2012).

Globally hydro dams have been built for purposes of flood protection, irrigation, tourism, and electricity generation; however, hydro dams have caused widespread environmental and health impacts on local communities that surround such ecosystems. The environmental impacts range from flooding (Moran et al., 2018), soil erosion, water pollution, the destruction of wildlife habitats (De Launey, 2018) and the decimation of local fisheries leading to poverty, human rights abuses and health declines (Anderson, 2017). Most of the hydro dams were built with little to no local community consultation or involvement resulting in forced displacement yet these communities rely on the impacted ecosystems for survival (Stone, 2016). The OPCN community also has been experiencing environmental health problems related to hydroelectricity dam projects for more than 50 years now. The community has been negotiating with governments and corporations on how the proposed and established hydro dam projects should conserve the environment and preserve the health of the people.

To better understand and share the community stories, I set out to understand how the land and the water have changed through community-based participatory research. I interviewed Elders, Fishers, Knowledge Keepers, Trappers, and Medicine pickers using "convenience sampling" (also known as Haphazard Sampling, which is a non-probability sampling that targets a population readily available or accessible within a geographical proximity at a given time who meet certain criteria to participate in the study (Etikan, 2016). I also visited the OPCN community to video and audio document community stories on their traditional lands. I used qualitative research methods such as interviews, observations and field surveys for data collection purposes and ArcGIS Storymaps for reporting the findings. The outcomes of environmental health concerns were associated with poor water quality, mercury-intoxicated fish, consumption of polluted medicines, dispossession from the land and loss of connection to cultural practices. However, the OPCN

community remained resilient to their cultural traditions such as fishing, hunting, and medicine picking by travelling far away from their traditional lands to continue their practices. All the community knowledge was presented in an ArcGIS Storymap to help non-community members visualize and learn how hydro dams devastated the OPCN community.

In response to environmental issues voiced by the hydro-impacted OPCN community, this thesis chapter aims to document community experience and perspectives on the environmental health implications of hydro dams due to permanent landscape changes in the OPCN community. The landscape changes were a result of the construction of hydro dams, weirs, and diversion channels such as the Notigi CS, Missi Falls CS and South Bay Diversion Channel to increase electricity generation in the Keeyask hydro dam. This chapter demonstrates the environmental health impacts of hydro projects in the OPCN community, and it shows how the community remained resilient to its cultural activities despite experiencing land dispossession.

4.1 General objective

To understand the implications of these spatial-temporal changes on community livelihoods.

4.1.1 Specific objectives

1. To document the community experience and perspectives on how the environmental health impacts of hydro dams impacted the OPCN community livelihood.
2. To explore collective solutions to curb the environmental health impacts of hydro dams in the OPCN community.

4.2 Research Methods

To fully understand the multi-faceted devasting effects of hydroelectric dams on the communities' environmental health and well-being in OPCN, I used a combination of the Two-Eyed Seeing research approach and Community-based research methodology to wholistically understand the interconnectedness between the spatiotemporal changes of the landscape and the environmental health impacts of hydro dams in the community. The research approaches enabled the thesis goals to remain locally relevant to the community because of their ability to tailor the specific needs, preferences, and cultural contexts of the community. The community-based research approach enabled me to collaboratively work with OPCN community members who

possess knowledge of the underlying causes of fishery collapses, environmental dispossession, and the deterioration of water quality. The Two-eyed Seeing research approach provided an opportunity to fully embrace Western ways of knowing and Indigenous ways of knowing (Bartlett et al., 2012). The combination of the concepts allowed me to fully understand how the physical changes in the landscape have affected the health and well-being of OPCN community members.

The thesis chapter used qualitative interviews to document the environmental health impacts of hydro dams in the OPCN community. Patton & Cochran, (2007), explain qualitative interviews as everyday conversion although they are focused on needs. Qualitative interviews are a two-way communication that enables the researcher and the participant to have a conversation regarding the subject matter (Murairwa, 2010). The advantages of qualitative interviews are they provide a guard against confusing items and the interviewer could clarify confusing items thereby obtaining relevant responses (Babbie, 1992). Interviews were flexible and controllable, they produced a high response rate, provided me with precise answers, and were appropriate for storytellers like Community Leaders, Knowledge Keepers, Fishers, Trappers, Hunters and Medicine Pickers (Denzin & Lincoln, 2007). However, interviews were expensive and time-consuming because I travelled 1094km from Winnipeg to Thompson and then to the OPCN community.

With permission from the actively participating OPCN participants, I audio and video recorded the interviews using Zoom mics, Sony Video camera and Unmanned Aerial Vehicle (drones) for documentation purposes. I also used recorded videos for location-based digital story-mapping purposes using ArcGIS Storymaps. The aim of the story mapping was for knowledge-sharing purposes with non-community members such as project planners, decision-makers, governments, and NGOs. The storytelling maps outcomes embedded participants' knowledge by generating dynamic visualizations of historical maps and video interpretations of the environmental health impacts of hydro dams in OPCN. In-person interviews created a safe space for communities to co-lead the conversations by considering their cultural norms, traditions, and values. The questions I asked were open-ended questions, that allowed the participants to feel comfortable addressing environmental health issues they need project planners (Manitoba Hydro), governments, institutions, non-community members and other communities to hear, learn and reflect.

A total of 10 interviews, 9 interviews were conducted on the 2nd and 3rd of October 2022 with fishers, trappers, hunters, medicine pickers, and knowledge keepers from OPCN. Of the 9 interviews, 6 interviews were conducted in OPCN community participants' homes, 2 interviews along the impacted SIL water and I interviewed at the SIL Fish Plant. The interviews that I did on the OPCN traditional lands and waters enabled me to collect geo-pinpointed locations of the exact hydro dam devasted areas. This process of geo-pinpointing locations in OPCN also acted as my ground-truthing activity where I had to verify the flooding extent and environmental degradation that I had observed on my map results. The concept of conducting interviews on the impacted lands and waters was adopted from Pratt, (2018) who explained the power of locations.

> "If you hold (a meeting) in the health department building, there's a particular set of behaviours and languages that are associated with that building, and people who dominate those behaviours and languages will dominate the meeting." (Pratt, 2018) The University of Melbourne.

The power of locations was very important during the interviews because it completely placed communities at the centre of the research about, and for, them.

In addition to the 9 interviews in OPCN traditional lands, 1 participant was interviewed on the 23rd of April 2023, in Winnipeg Manitoba, Canada. During the Winnipeg interview session, I used PGIS mapping tools such as Google Earth Pro and ArcGIS Pro to insert lines, points, and polygons for documentation purposes. The PGIS session equipped me with knowledge and understanding of the historical information surrounding the 1972 pre-hydro dams, 1976 post-hydro dams and the 2019 hydro dam's follow-up. The PGIS mapping also helped me with deep knowledge of how the changes in landscape affected the environmental health and well-being of the OPCN community.

I used the convenience sampling design method to choose whom to interview because according to Murwira (2021), the sampling design depends on the convenience and availability of individuals with the knowledge required for the project. The sampling design was also the best because it was moose hunting season in the community so most of the Hunters, Trappers and Fishers were busy performing their cultural activities on the land and water preparing for the winter season. All interviews were video, and audio recorded. The knowledge was used to create a

collection of community-led story maps for knowledge-sharing purposes with non-community members.

The intent of doing interviews was to better understand how the permanent changes in landscapes influenced the environmental health and well-being problems in the OPCN community. The other aim of the interviews was to embed the hydro dam impact stories on digital maps to help educate non-community members living in the South of Manitoba because they might not have a chance to visit the OPCN community. Sharing the stories also helped to raise awareness among hydro customers who might not understand the devastating impacts of their source of energy. Following the interviews, all recorded stories were uploaded in themes on ArcGIS Storymaps, to let the stories speak for themselves (Kingdon, 2022). No translations were made to the interview transcripts because according to the United Nations (2016), "Saving Indigenous languages is crucial to ensure the protection of the cultural identity and dignity of Indigenous people and safeguard their traditional heritage." (Chang-Castillo, 2019).

> "Data and directives are good, but stories can go a long way in creating more empathy and understanding." Vinita Ambwani in That public servant, (2021).

With the OPCN participants' approval, I embedded ArcGIS Storymaps links with direct quotations whenever possible to intensify community voices in words and videos. I also acknowledged previous quotes from previous work done in the community and social media posts like Linked In. QR Code for accessing the ArcGIS Storymap.

4.3 Environmental impacts of hydro dams

4.3.1 The impacts of hydro dams on the OPCN economy

Hydro dam projects along SIL destroyed the OPCN community's well-established and thriving fishing economy because of the Missi Falls CS and Notigi CS that blocked fish corridors along the lake. According to Thomas Spence, an Elder and fisherman from OPCN, the Missi Falls CS and Notigi CS affected fish movements such as sturgeon, pike and whitefish (Craft & Blakley, 2022). In an interview with OPCN Fish Plant Manager Calvin Baker (2022, Personal Interview), he shared his experiences,

> "I started working at the fish plant when I was young. And then 30 years later, here I am waiting for fish and not getting any, sad. We used to get 300 to 400 tubs a day and I got 2 tubs of fish in my plant [Figure 1]. That's not feasible, it's not economical. It's better just to shut down. I don't think there's too much life in this plant. And yet it was the fish that made this community years and years ago until hydro came over and destroyed everything. What do you call that? Genocide? Economic genocide?" Calvin Baker, OPCN Fish Plant Manager (Personal Interview, October 2022).

NB: Click the quote and navigate to the theme "Impacts on fish quality" for a full video explanation.

Figure 30: O-Pipon-Na-Piwin Cree Nation Fish Plant

Photo by Gerald Beta (2022), Part of South Indian Lake and OPCN small fish plant with empty tubs out outside the storage room.

Calvin continued emphasizing,

> "We used to do a million pounds of whitefish, now I don't think I'll have 10,000 pounds, I don't think so and it's crazy, It drives me nuts!" Calvin Baker (Personal Interview, October 2022).

In literature, hydro dams plunged the OPCN community into extreme poverty because the community used to be the third largest white fish commercial industry in North America (Levasseur, 2022). The community had a 98% employment rate mainly from fishing and only three people were on social assistance before hydro dams came into the OPCN territory (Hilder Dysart, OPCN Elder and Educator). Now, 95% of OPCN community people rely on social assistance (Brake, 2018; Randal Linklater, 2022, Personal Interview). Historically, OPCN residents "have never lived on welfare." Van Ginkel, (1967, 8).

> "You know, if they would have done what they promised to do and operate under the 1973 license, we probably could have lived in some kind of harmony," Les Dysart (CEO of CASIL) in Read, (2020); Les Dysart (Personal interview, April 2023)).

Manitoba Development Authority studies prior to Churchill River Diversion articulated that the OPCN community earned ten times more than other First Nations communities. With an average household income of $5000 in 1960 compared to other Northern First Nations with a household income of $500. According to a 1976 report commissioned by Hydro, approximately 5% achieved a level of income of more than $ 10,000 per year (Van Ginkel, 1967, 2). Today (Levasseur, 2022), the fishing industry has become obsolete and many residents are living in abject poverty and poor health depending upon provincial and company assistance. OPCN Fish Plant manager concluded by saying,

> "So that's the greatest impact. Fishermen are losing out millions of dollars due to the flood. Even the spin-off from that, like employment insurance, which they benefit all through the year from fishing, all that, most of it is gone." Calvin Baker, OPCN Fish Plant Manager (Personal Interview, October 2022).

NB: Click and navigate to the theme “Hydro dams’ impact on the fish industry” for a full video description.

Calvin has recognized these cumulative environmental impacts for more than 30 years since he started working at the OPCN fish plant. Calvin further noted that fishers are losing millions of dollars due to reduced fish quality and quantity. “It takes a serious toll on the well-being of the community because fishing is now hard, and the industry can’t sustain itself hence people are no longer as active as they used to be.” Calvin Baker.

Table 1: The impacts of augmented flow on South Indian Lake fish catches

BIG FLOW YEAR*	COMMERCIAL CATCHES
1980	1981 catches were the lowest from 1975 to 1986
1986	1987 catches were the lowest until 2007
1997	1998 catches were the lowest from 1993 to 2002
2000	2001 catches were much lower than in 2000
2005	2006 catches were the lowest for more than 10 previous years
2006	2007 catches were the lowest for more than 15 previous years
2008	2009 catches were the lowest for more than 30 years
2009	2010 catches were the lowest since 1941
2011	???

Source: A slide from a presentation on the effect of augmented flow on South Indian Lake fish catches provided by Drew Bodaly in Read, (2020).

A scientist named Drew Bodaly produced a report in 2013 showing results of tracked commercial whitefish declines in OPCN from 1980 up to 2011 in SIL. The findings of the report show large drops of whitefish catch in SIL tend to occur after every year peak flows out of Missi

Falls CS and the estimated pick flows were greater than 30, 000 cubic feet per second (Bodaly, 2013). Due to reduced fish populations in the SIL,

> "Everything is deteriorating, my conveyor, I can't seven fix that because I'm looking for a $ 6,000 motor." Calvin Baker (Personal Interview, October 2022).

The fish plant sustained itself before hydro dams and fed many families in the OPCN community. Today, the fish plant is supported by the bank,

> "Yeah, without that money, we wouldn't be here. It would just be all the equipment going to waste. I got a million-dollar setup up north and it's just sitting there rotting. No fish. Without any funding, a lot of people made a lot of money. Gone are the days, when some guys had five or six boat motors. Now, they're all just rotting away." Calvin Baker (Personal Interview, October 2022).

Figure 31: Shows a list of registered fishers in OPCN

Photo by Gerald Beta. List of fisher's billboards inside SIL Fish Plant

Hydro dams destroyed the third-largest whitefish industry in SIL and 95% of OPCN members depend on welfare and handouts from different organizations. Hoffman, (2004) articulated that the main economic pursuits were fishing and trapping, with 80-125 licensed fishers

and 80-150 licensed trappers. Southern Indian Lake's fishery used to hire 175 fishers and produced millions of pounds of fish per year (Solilak, 2018). However, employment was down to 40 fishers or fewer and yields produced were less than 10 per cent per catch. In late 2023, there were 10 registered fishers in OPCN, three being women and seven men (Calvin Baker, 2022).

4.3.2 Hydro dams Impact on Fish

As a fishing community, the entire OPCN community was shuffled and effectively wrecked due to planned flooding (Kulchyski, 2012). The Missi Falls CS and Notigi CS have no fish passages, so they seriously affect migratory fish populations such as pike, sturgeon, and jackfish from movement upstream and downstream in SIL. Fishers in OPCN harvest fish from interconnected rivers and lakes (Craft & Blakley, 2022) therefore Hydro dams, weirs, control structures and diversion channels threaten fish migratory routes. Calvin Baker commented that,

> "We did a test on whitefish to determine the age of the whitefish and now we are finding whitefish like this big… that's a small and they are about 27 years old and they should be this big…. a 27 years old"

NB: Click the quote and navigate to the theme "Impacts on fish size" for a full video description.

Figure 32: Shows Calvin Baker revealing the fish size

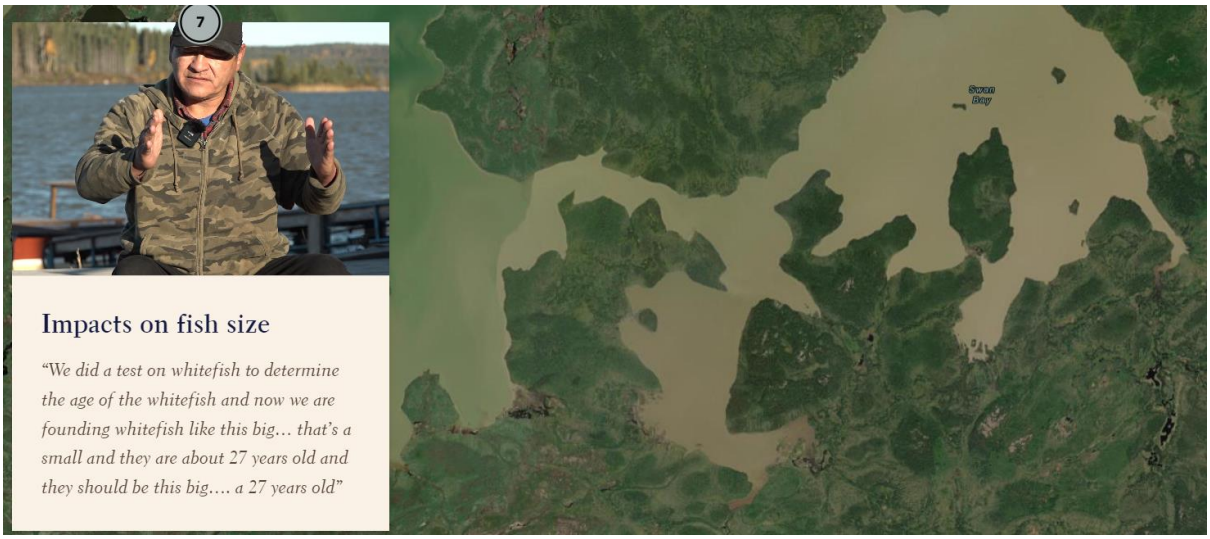


Photo by Gerald Beta. Calvin Baker describes the findings for whitefish sizes in SIL

> “Because fishing is hard nowadays, it’s going to be a very sad story. The youth are not like me. I grew up in the camps fishing with my dad when I was young. All my family have families all over the lake fishing. But fishing is now hard”.

Wilber Wood supported the statement made by Calvin,

> “Fishing is dead. We made large money but now you will get a loan, it will take you 5 years or more to pay but before you will get a loan for a motor and you pay in a month”

Calvin further asked me a question,

> “If you going to have a kid/s, are you going to send them out to fail?”

For him, the answer was a “No, not me”. This clearly shows that the fish populations in SIL have declined due to hydro dams therefore youths in the community are already disconnected from the land and cultural activities such as fishing because the SIL can’t sustain fishing activities. However, despite the declining fishing activities for cultural purposes and the fishing business in the community, Calvin Baker ended by saying,

> “I won’t cross my heritage and my livelihood. I just want to keep going, keep fishing. I’m not gonna bow down to Hydro and that’s a fact. I never will!” Calvin Baker, OPCN Fish Plant Manager, (Personal Interview, October 2022).

4.3.3 Impacts of Hydro dams on Wildlife

Figure 33: Beaver house being washed away

Photo by Gerald Beta in SIL October 2022

Figure 33 shows a beaver house being washed away in SIL and this was during a boat ride/tour in SIL with OPCN Fisher and Trapper Cameroon Moose and Darcy Michelle. Cameroon Moose shared knowledge that the flooding of beaver houses and other animal habitats is a result of gradual changes in water levels especially when Manitoba Hydro releases or store water in SIL. During a PGIS session with Les Dysart (April 2023), he further explained deeper concerning this beaver house,

> "This is a clear example of a beaver house-made. This one might be alive but maybe not because the feed pile hasn't been eaten so there's a good chance this beaver was frozen out either when the water went down or when it was too high. Over the summer, beavers build houses, and, in the fall, they make their feed piles but hydro raise water in the fall time before freezing up. And they could have drowned this beaver out. During freeze-up, he was killed so he didn't have a chance to eat his feed pile." CASIL CEO, Les Dysart (Personal Interview, April 2023)

NB: Click the quote and navigate to the theme "Habitat destroyed: Beaver Dam" for a full video description.

4.3.4 Impacts of Hydro dams on accessing traditional foods

Since time immemorial, many First Nations have been self-sufficient primarily from foraging (moose, caribou, deer, muskrat) and harvesting (mushrooms and berries). According to Power (2008, 93), land-based foods that sustain communities are considered vital for identity, health and survival yet hydro dams devastated wild foods and affected human health. The obliteration of the environment caused by the flooding disrupted thoroughly traditional hunting grounds and patterns (Robson, 1993, 115). In other words, all land-based activities that supported a functioning economy and community were effectively destroyed thereby deepening dependency on government welfare. Before the hydro dam flood,

> "A long time ago, people were very active because it was everybody's chore and job just to survive. So, they were very active at all times." Elder Christine Spence, OPCN. (Personal Interview, October 2022).

Hydroelectric dams threatened the OPCN community's access to traditional foods due to flooding that reduced the population density of animal and plant species (Power, 2008). Hydro dam's impacts changed animal migratory patterns and destroyed animal habitats and well-known functioning Elders' calendars, which were used for timing (hunting, and trapping) and planning were affected.

> "For a long time, we had lots of everything but now it's all disappearing. The ducks are now very hard to catch. It's now hard to catch something now, ducks, beavers, muskrats, and rabbits. Everything is disappearing". Bruce Tait, OPCN Elder, Fisher and Trapper (Personal Interview, October 2022).

The disappearing of wildlife and losing access to traditional lands meant the community had to find alternative foods to sustain their livelihoods and cultural activities. Some OPCN community members travel outside of the community to look for traditional foods and as a remote community, most of the community members had no choice but to rely on welfare, donations, and other sources of food.

4.3.5 Soil erosion

According to Hoffman (2004), a trip at South Indian Lake to Missi Falls reveals a constantly eroding shoreline with visible sediments and roots, trees suspended at all angles, roots

vainly trying to hold onto soil washing steadily into the lake and waters so degraded. The spatial temporal changes in land use irreparably damaged the OPCN community to the extent that accessing shorelines using boats became difficult with dead logs floating. Depending on which control structure is realizing water, the water current will be so high and dangerous for travelling in the lake. The land is being lost every day due to erosion and high water currents.

> "There is all this erosion that has been happening, you don't know where the shoreline is? And it could be 100, 200 or 300 fits away. That's where the shores used to be……" Randal Linklater (Personal Interview, October 2022)

NB: Click the link and navigate to the theme: "Soil erosion" for a full video description.

Figure 34: Eroding shoreline with exposed tree roots and trees suspended at all angles.

Photo by Gerald Beta. Randal Linklater explains soil erosion in SIL, October 2022

Figure 34 shows a constantly eroding shoreline with exposed tree roots and trees suspended at all angles. This photo illustrates how the land is being lost due to constant soil erosion and the effects of fluctuating water levels in the SIL. The progression of soil erosion in OPCN has been an ongoing process for more than 50 years whenever the Missi Falls CS and Notigi CS are opened by Manitoba Hydro.

Figure 35: Impacts of gradual water level changes

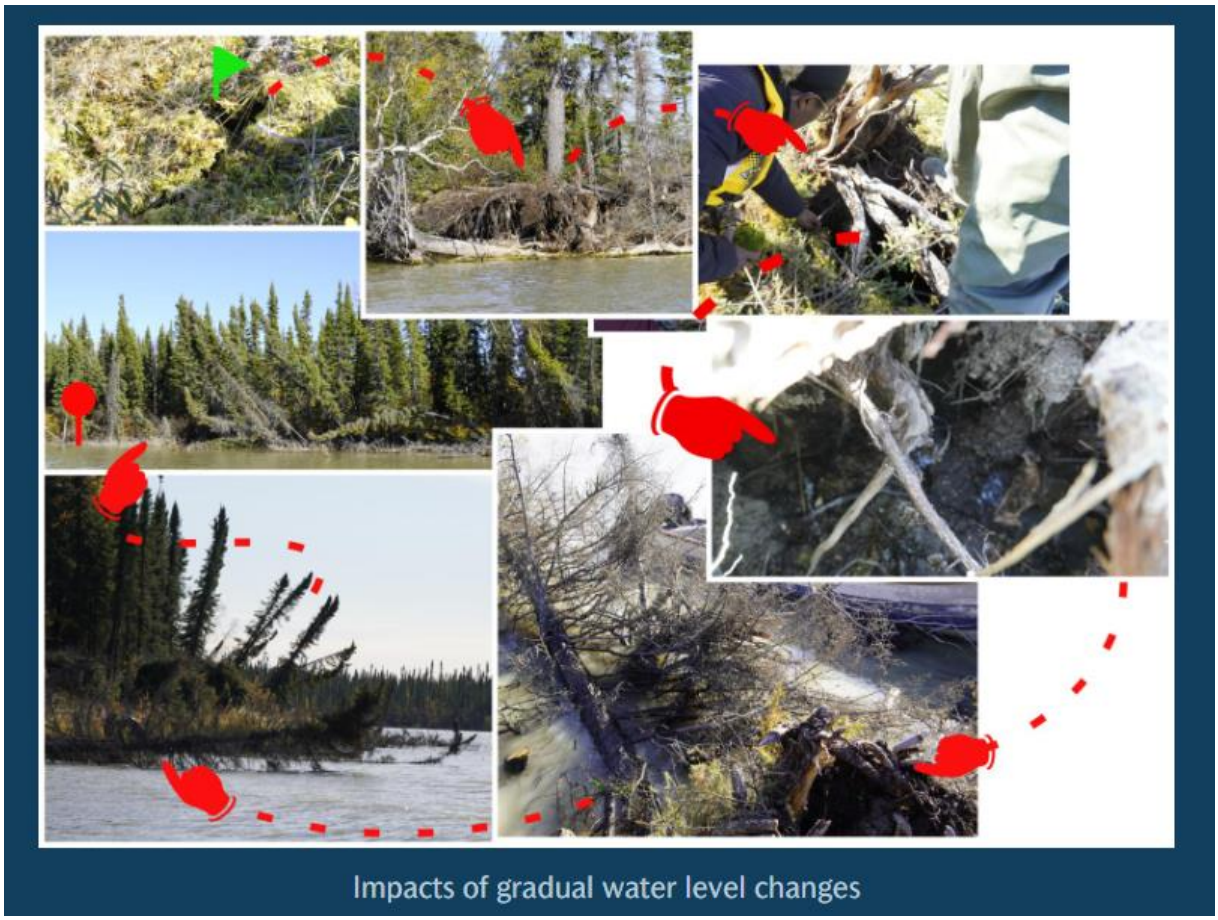


Photo gallery by Gerald Beta. The impacts of gradual water level changes due to hydro dams along SIL.

> "Like this, the water is already under here and when it's high, the water goes under and the trees fall like this. No matter how the tree is big, it falls….We use to park our boat here….."
> Cameroon Moose, (Personal Interview, October 2022)

NB: Click the quote and navigate to the theme: "Impacts of gradual water level changes" for a full audio description of the process.

4.4 Environmental health impacts of hydro dams

4.4.1 Impacts of consuming mercury-contaminated fish

More than 90 per cent of anticipated Canadian Hydroelectric projects are expected to increase substantial concentrations of the neurotoxins methylmercury in food webs (Leah, 2016). In Manitoba First Nations, communities are heavily concerned about how their land-based food

chain has been compromised by hydro dams. Hydro-flooding contributed to the biomagnification and accumulation of heavy toxins (mercury) across all hydro-impacted First Nations lands and waters. Methylmercury is a neurotoxin that bioaccumulates in food webs and negatively impacts individuals who rely on local ecosystems for food. According to Zheng et al., (2019), mercury exposure can produce teratogenic, neurotoxic effects and reproductive toxicity in fish which harms cells, tissues, proteins, genes, survival, growth and behaviour of fish. Indigenous communities rely on local fishes that carry a substantial amount of these toxins' elements.

> "Eating fish is a lot different now. You know, like before we had good fish. Now we hardly eat fish because the taste is different, the quality of fish is now watery." OPCN Elder Wilber Wood, (Personal Interview, October 2022).

Consumption of mercury-intoxicated fish causes serious health problems associated with brain problems, Alzheimer's, autism, depression, high blood pressure, increased heart attacks and anxiety (Bastos et al., 2006; Fillion et al., 2006; Guallar et al., 2002; Halbach, 1990; Yoshizawa et al., 2002). "The human and ecological impacts associated with increased methylmercury exposures from flooding for hydroelectric projects have only been understood retrospectively after the damage is done," said Elsie Sunderland (Calder et al., 2016). In the same manner, (Robson, 1993, 115), mercury intoxication become a way of life. In the OPCN community experiences after the hydro dam flooding,

> "All kinds of sickness came to our town right after the flood." Randal Linklater, OPCN Fisher, Trapper and Medicine Picker (Personal Interview, September 2022).

4.4.2 Impacts of poor water quality on community health and well-being.

During the interviews, Elders, Trappers, and Fishers shared knowledge that water quality started to deteriorate around the 1970s, early stages of hydro dam projects. The artificial concrete-filled South Bay diversional channel along Rat River contributed to increased sediment load in the rivers. This physically and bio-chemically affected the turbidity of water because the river could not absorb the deposited amounts of clay introduced into the river system. Land-based activities conducted in 2019 by an indigenous-led organization Kis Kin Ha Ma Ki Win (Learning Science through the land) produced a community report that stipulated that (Tahsin, 2021) the turbidity levels in most First Nation sampled were above the Maximum Acceptable Concentration (MAC).

It was not surprising that OPCN was among the mentioned Cree Nations with turbidity levels above the MAC due to frequent flooding. According to Tahsin (2021), they could easily detect the impaired water quality with their naked eye. These scientific observations were further supported by community members who had to say before the CRD, they could see fish underwater because the nipi (water) was crystal clean.

> "The lake used to be crystal clear water. We had clear water and nice beaches but now, all over trees falling in the water" Wilbur Wood, OPCN Fisher, Trapper (Personal Interview, September 2022).

Figure 36: Water quality sampled in three communities.

Source: Tahsina Tanjina (2021): Water quality sampled in three communities: Brokenhead Ojibway Nation (left), Sagkeeng FN (middle) and OPCN (right) (used with permission).

Canadian water quality guidelines (CCME, 1999) make it clear that low values of dissolved oxygen threaten aquatic life (plants). After OPCN camp results were analyzed, Tahsin (2021) articulated that dissolved oxygen levels in OPCN and other communities were found to be below the expected value, hence they pose a risk to aquatic life. Communities were concerned about testing their waters because they could easily visualize a gradual change in their plant species, medicines, and deteriorating waters. The water in the SIL is no longer safe for the community members and aquatic species to depend on because it's unhealthy.

> "We used to drink direct from the river but now we can't, we now depend on trucks that deliver water in holding tanks." Wilber Wood, OPCN Fisher, (Personal Interview, October 2022).

Table 2: Results of the water samples

Community	Physio-Chemical Parameters Biological Parameters											
Parameter	pH	Turbidity	Chlorine	Fluoride	Ammonia	Nitrate	Nitrite	Copper	Arsenic	Dissolved Oxygen	Total Coliform	Fecal Coliform
O-Pipon-Na-Piwin Cree Nation												
Sagkeeng FN												`````
``												

Key:

Good	Fair	Marginal	Poor

Source: Tahsin Tanjina (2021): Camp water sample results (used with permission)

According to Health Canada (2019) guidelines, green colour (good) means the sample is under MAC, yellow colour (fair) means the sample is equal or just above the MAC, hence needs regular monitoring, orange colour (marginal) means the sample tests is above the MAC, hence needs preventative action and regular monitoring and red colour (poor) means the sample results are above the MAC, hence needs immediate preventative action and regular monitoring. Community members had to say,

> "Today, people are dying. People never died before from cancer in this community [OPCN] till after the flood and lots of diabetes from this flood. I'm one of them, I had it probably in my 30s. 32 years I had my diabetes." OPCN Fisher, (Personal Interview, October 2022).

> "…… nobody is healthy because of the water. Everything has changed…..not like the old days when everyone was healthy, now everybody is dying from cancer, diabetes…." Cameroon Moose, (Personal Interview, October 2022).

Many community members shared similar sentiments regarding the environmental health conditions in their community. They testified that they used to drink water directly from the river by just scooping and drinking without worrying about any disease. Especially when they were camping, they never worried about travelling with bottled water because the water was clean and

healthy. After hydro dam projects deteriorated the water quality, the community now travels with many bottled drinks of water.

4.4.3 Environmental health impacts of consuming mercury-contaminated traditional foods

Hydro flooding in South Indian Lake not only affected the pristine life of the waters, it eventually impacted traditional lands used for hunting (Dysart & Spence, 2021), gathering, trapping and fishing (Buckland & O'Gorman, 2017), which was the back-borne economic activities, socio-cultural and spiritual activities of the community. Food insecurity became an urgent public health issue in OPCN because the CRD heavily degraded the environment and polluted traditional food systems which led to high rates of diet-related diseases. Before hydro dams, people were generally active and,

> "In those days, we have never seen pills of different prescription medication. Nowadays, especially the elderly, they've got such a large bubble pack with all sorts of pills that they have to take. But in the olden days, no there was nothing, nothing of that sort we knew."
> OPCN Elder Christine Spence, (Personal Interview, October 2022).

Figure 37: Elders Christine Spence describes the health impacts of hydro dams

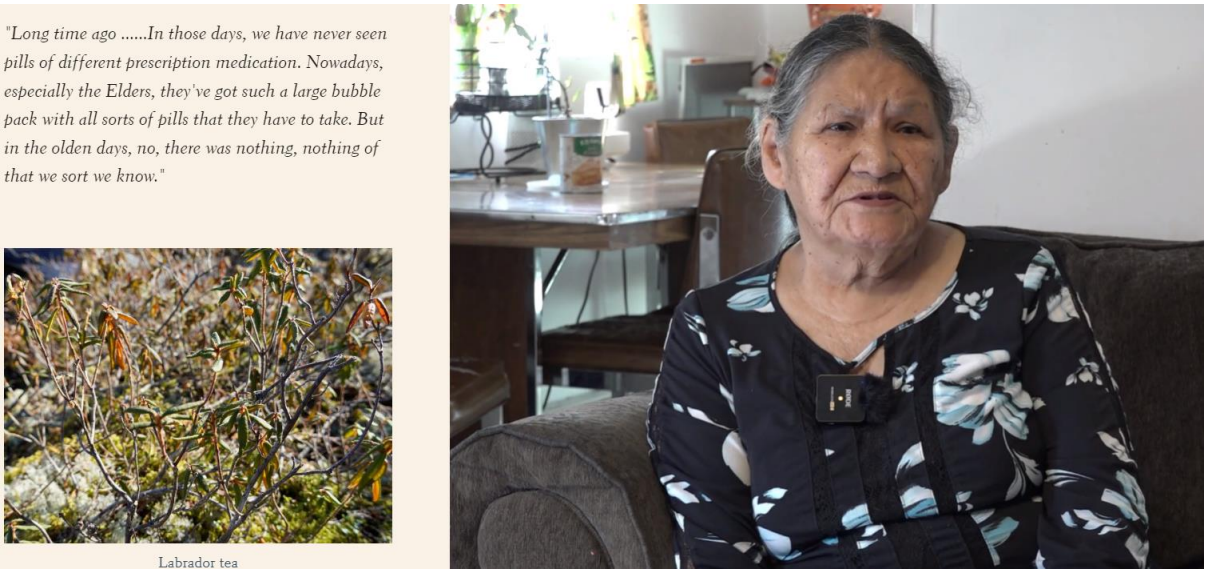


Photo by Gerald Beta. Elders Christine Spence describes the health impacts of hydro dams

However, to date, the OPCN community members have not yet fully recovered from environmental health problems because the cumulative CRD impacts are still ongoing. According

to Power (2008), public health failed to address these problems because they are operating with concepts that do not take full account of traditional food practices. Public Utilities Board., (2014) added that OPCN gradually increased reliance on poor quality store-bought food and a lack of physical activities caused lingering ailments and health disparities such as diabetes. Elder C Spence continued by articulating that,

> "People were well and healthy. They weren't sick like nowadays, you know, there's a lot of sicknesses we've noticed like diabetes, high blood pressure, abdominal cancer, kidney loss, kidney diseases. These are the 4 types of illnesses we see nowadays [2022]. And we lose a lot of our people through this with kidney failures and diabetes, amputating legs, and arms. These are the things that we notice. They are taking lives and damaging to the lives of our people." Elder Christine Spence, OPCN (Personal Interview, October 2022).

In another interview with an OPCN Elder, she shared her personal information supporting Elder Christine Spence,

> "I have seen great impact. Three of my children are now diabetic and the other two have kidney disease. We rarely see any type of sickness or illness because we all always like travelling. Basically, we were very active people then, not like now." OPCN Elder, Personal Interview, October 2022).

All kinds of diseases have been noticed and reported in the community such as diabetes, kidney diseases, kidney failure, cancer and amputation of legs and arms. All the identified diseases are associated with environmental health changes, this leads to the consumption of mercury-intoxicated fish, animals, medicines, and water. The spatial-temporal changes in landscapes heavily impacted the environmental health and well-being of the OPCN community because all land-based activities that kept the community active, healthy, and connected to the land were devastated because of the hydro flood. Traditional activities like fishing, hunting, trapping, and harvesting wild fruits are no longer sustainable in keeping the community healthy because the activities now require more time for travelling to good areas. These traditional activities kept the community healthy; they encouraged knowledge transfer from Elders and Knowledge Keepers to the younger generation.

4.5 Collective solutions to curb environmental impacts of hydro dams in OPCN

4.5.1 Community-led strength-based Approaches to Access Traditional Foods and Medicines

Despite being a fishing and hunting community, OPCN community strength-based alternatives to access healthy traditional foods involve travelling to areas outside the community that are not affected by hydro dams. For example, OPCN members go for fishing, berry picking and medicines picking in inland lake areas that are not affected by erosion (Craft & Blakley, 2022). Sometimes,

> "……there is one area that I pick one medicine which is still on good site because it on a hire rock so they are not underwater….." Elder Christine Spence (Personal Interview, October 2022).

Figure 38: Shows Labrador tea plant

Photo by Gerald Beta. Medicine: Labrador tea plant

> "Some people had to go out of the community if they want good food. You know to an inland lake when they want good fish. There have to go there. Some people don't even fish

and eat fish around here. They don't like them and I'm pretty sure there's a lot of mercury on our fish in this lake". OPCN Elder Wilbur Wood, (Personal Interview, October 2022)

However, because of the high current water flows everywhere along the SIL,

> ".....not too many people go to do the trapline and go fishing camps and even hunting because the lake is no longer safe to travel. There are a lot of high currents all over and it's unsafe to travel so people like the trappers and fishers don't travel as much because they don't know which areas are safe to travel on and it's a continuous thing, you don't know when it's safe for travelling ....." Christine Spence (Personal Interview 2022).

Most of the medicine areas in the OPCN community have been flooded and eroded since hydro came into the territory. However, harvesting traditional foods like berries in the late summer and early fall is an important cultural practice for the OPCN community because it promotes social interactions and provides an opportunity for practising a healthy lifestyle (Craft & Blakley, 2022).

4.5.2 Fish Spawning Program

Despite all the efforts made by the community to conserve their land and water resources using Indigenous ways of knowing and doing techniques, Manitoba Hydro tried to provide solutions to restore the whitefish and pickerel population in the SIL through fish spawning. Calvin Baker participated in the program, and he explained that,

> "I did that [fish spawning] for a few years. We call it pickerel spawning where we go out into the other end of the lake where there is pickerel, and we fertilize the pickerel eggs and then they spawn……." Calvin Baker, OPCN Fish Plant Manager (Personal Interview, October 2022).

However, the solution proposed by Manitoba Hydro to restore fish populations in SIL received critique,

> "According to me why you would release a fish into a body of water which can't sustain them?" Calvin Baker, OPCN Fish Plant Manager (Personal Interview, October 2022).

NB: Click the quote and navigate to the theme "Proposed solutions to restore fish in the lake" for a full video description of Calvin Baker explaining the fish spawning program and how it is not working.

The solutions seemed not to be working well for SIL resource users because of the poor water conditions (silty, muddy) and because of the gradual water level changes in the river. During COVID-19, the OPCN community was fully locked down for 3 months because of community safety measures and no visitors were allowed in the community. All land-based activities like hunting, camping, fishing and trapping were on hold for all OPCN community residents because of COVID-19 restrictions. After 3 months of the community being locked down, movement restrictions were loosened and only families were allowed to go fishing and trapping. All land-based cultural activities like fishing were partially opened for approximately 8 months for a few selected OPCN member groups and all activities were fully opened after 1 year. Despite the OPCN community being locked down, Calvin Baker articulated that fish populations remained very low after 1 year of partial fishing. This shows that the fish spawning solution did not work well for SIL.

4.5.3 Manitoba Hydro Debris or Shoreline Base Cutting Program

The environmental impacts of hydro dams in OPCN such as soil erosion, flooding and water pollution have been ongoing continuously for 50-plus years when hydro came into the community. Manitoba Hydro proposed alternatives to control and reduce soil erosion and dead organic matter (trees) along the SIL by employing OPCN youths to clean up the shorelines. The program is well known in the OPCN as the debris program or shoreline base cutting where OPCN youths are employed to cut down the green organics (spruce trees) around the community before they enter the lake due to continuous high-water effects along the SIL. When the pile of fresh trees dries, they then burn them.

Figure 39: Shows piles of green organic spruce trees

Photo by Gerlad Beta. Freshly cut spruce trees along the SIL

In literature, the main purpose of preserving trees along rivers or lakes is for erosion control (Rood et al., 2015), bank stabilization (Gurnell et al., 2019), nutrient cycling (Sedell & Froggatt, 2017), carbon sequestration and water quality improvements (UNECE). However, the process of cutting down trees is being used as a mitigation strategy to prevent trees from falling into the lake.

Figure 40: The debris program/ baseline cutting in OPCN

Photo by Gerald Beta. Les Dysart explains why the debris program is increasing soil erosion and dead organics along the SIL (April 2023).

> "This spreads up the erosion within a relatively small number of years. All these organic materials will enter the lake. All these mature spruce trees will end up in the lake because the high-water effects continuously pull the landmass down along with the tree system……" CASIL CEO, Les Dysart (Personal Interview, April 2023).

NB: Click and navigate to the theme "The problems of Manitoba Hydro debris cutting program" for a full video explanation of how the debris cutting program is not working.

4.6 Notable outcomes and Implications of environmental health impacts of hydro dams in OPCN

4.6.1 Implications of high-water flow currents in SIL

The construction of Missi Falls CS and Notigi CS increased the SIL water levels leading to the flooding of traditional homelands of the OPCN community. The South Bay Diversion Channel is a 9km concrete-filled channel with increased high water flow currents in SIL leading to cumulative soil erosion and boat accidents along the river. During an Interview, an Elder who is a Fisher and Trapper remembered that,

> "There have been boat accidents here. I was the first responder for such incidents. These boats I have seen hit a lot of sticks and they [Fishers] fell off the boat. That's it! They're gone. Even at night, I hit a few sticks myself. But I managed to survive one of them. I floated up with my shoulders and my partner came around and picked me up." Randal Linklater, OPCN Fisher and Trapper (Personal Interviews, October 2022).

As a Fisher and Trapper, Elder Randal Link-later spent most of his entire lifetime travelling in the South Indian Lake. He continued to share knowledge that,

> "One time I went moose hunting. In coming up the channel, I hit a stump on the water. I just went flying into the middle of the boat and my motor bounced off, never seen it again. But I had a spare motor. If I had fallen off the boat, I would have never been found or seen again, hitting that log. Nobody would have known what happened." Randal Link-later, (Personal Interview, October 2022).

Figure 41: A boat motor used during fishing/ travelling in water.

Photo by Gerald Beta, in South Indian Lake, October 2022

The increased water currents in SIL had negative implications for travelling along the community lake because of the increasing rates of boat accidents. OPCN is a fishing community, and frequent travelling along the lake was considered a major activity for revenue generation through fishing.

However, fishers were forced to travel outside their community's traditional lands in search of good and quality fish. In addition to high water currents, the community has no road access to other parts of the community therefore travelling along the high water currents will be the only option to visit other parts of the community. According to Kulchyski, (2012), what used to be the highway for hunters is now dangerous to travel because of the unpredictable retreating water and partially unfrozen patches of ice. The unpredictability nature of the SIL water currents causes OPCN community members to rarely go camping because travelling along the water is risky. For example, Randal Link-later was concerned that he spent 5 years without visiting their family camps and was wondering if the camps still existed or if they were underwater.

4.6.2 Implications of hydro dam's impacts on OPCN youth

Youths in the OPCN community are not interested in land-based activities because fishing is no longer profitable, and they are unwilling to travel long distances away from their community for hunting. The implications for disconnection from cultural land-based activities led to high rates of alcohol use, drug and substance abuse, violence, suicides, and high crime rates such as home and cabin breakouts. Rather than going out to try fishing, they prefer to depend on EI rather than survive on fishing because SIL is unhealthy and it's now very hard to be in the fishing business compared to life before hydro dams (Brake, 2018; Levasseur, 2021). During the interview with an OPCN Commercial Fisher, one youth came and shared knowledge that,

> "There's no discipline anymore. These guys had it and they have respect [referring to the Commercial Fishermen Wilbur Wood]. And that's what I have, that's what I was taught. A lot of little kids around here drink and smoke with 12, 14, and 15-year-olds. A lot of them not a little of them a lot of them burn houses and they burn trucks, boats just because they can't, there's no discipline done." OPCN Youth, Personal communication (October 2022).

Similarly, Elder Cristine Spence highlighted the same breakout situation in their cabins and houses. Many of the youths are no longer interested in many of the cultural activities like fishing, hunting, and trapping because performing all these activities requires more time than before and travelling outside the community's traditional lands. Before hydro dams, land-based activities kept everyone busy and healthier. At a younger age, some of the OPCN youths were reported to have tested for diabetes due to living in unhealthy environments. Calvin Baker argued that it's now hard to fish because there used to be fish in the lake and it's not as profitable as it used to be. Les Dysart supported these arguments by mentioning that the "youths have been disconnected from the land and it is very sad to see the youths losing their traditional values and being diagnosed with diseases at a younger age".

4.6.3 Implications of environmental health impacts on health services within the community

Before hydro dams came into the OPCN territory, it was reported by OPCN community members that everyone was healthy and active. The environment provided more than enough to support a healthy community for example the water was crystal clear, and fishing was profitable

and healthy. Indigenous communities rely on their traditional water sources as they have been doing since time immemorial (Goldhar et al., 2013; Wilson et al., 2019). After hydro dams came into the OPCN territory, hydro dams devastated the land and polluted the water, Fisheries were devasted and it affected people's health. Most of the community people, for example, Elders and Adult youths, have been diagnosed with diabetes, cancer, kidney problems and lung problems due to their dependency on contaminated traditional foods.

According to Harper & Harris, (2008), it is easier for Indigenous people to consume chemical risk food than giving up their culture and religion. The natural environment provides Indigenous people with sources of medicine to treat ailments such as colds, respiratory diseases, head ach and wounds (Neufeld, 2017). During the interviews, community members highlighted that before hydro dams, they were not used to seeing bundles of prescription drugs being used in the community, especially with elders. The increased rates of people diagnosed with diabetes, cancer and kidney problems increased the demand for health services within the community after drastic environmental changes brought by hydro dams (Pepper-Mackena, 2018). Therefore, as a remote community in Manitoba, OPCN lacks access to major healthcare services and most of the time, community members had to drive to bigger cities like Winnipeg to access health services. Elder Christine Spence highlighted that the delay in accessing health care services would lead to the amputation of body parts such as legs. Randal Link-later further added that many of the Elders who fought Manitoba Hydro died from cancer and even after 50 years when hydro dams came into the territory, Elders are still dying from cancer. The community people are spending more time taking care of the Elders rather than spending time camping with Elders. Camping is crucial in Indigenous communities because that's when land-based skills are taught and transferred to youths by the Elders. With the outbreak of the COVID-19 pandemic, the OPCN community lost many Elders who had compromised health systems.

The OPCN community used to drink water directly from the river. The community members never relied on or carried bottled water when they were travelling for camping, fishing, and hunting. Instead, they used to scope and drink directly from the river because the water was clean and healthy. Since hydro dams flooded the OPCN community, today the community people depend on delivery trucks that often deliver water burrels or tanks in the community for a 'charge'. The SIL water was reported to have become unusable by the community members because of

mercury contamination from decomposing flooded sand and organics. The water is murky and silty and it's even failing to sustain fish populations leading to increased health problems in the community. In Indigenous ways of knowing and doing in Canada, water and the land are sacred, medicinal and a living entity (Wilson et al., 2019). The OPCN community's concerns about poor water quality were crucial because the water is affecting the health of the people, fish, wildlife, birds, and medicines which is linked to high rates of cancer, diabetes and kidney failures in the community (Elder Christine Spence, Elder Randal Linklater, Fisherman Cameroon Moose) OPCN members, Personal interviews, October (2022).

4.7 Discussion and Thoughts

The construction of Hydro dam structures like the Missi Falls Control Structure, Notigi Control Structure and South Bay Diversion channel to increase electricity generation along Nelson River permanently reconfigured the Manitoba Northern Indigenous community's landscapes and livelihoods. Hydro dams in the OPCN community were associated with massive environmental degradation such as water pollution (Dysart & Spence, 2021), destruction of wildlife habitats (MacLean, 2019), flooding and soil erosion (Read, 2020). The environmental impacts and the permanent changes of landscapes due to hydro dams in OPCN further compromised the environmental health of the community people. After hydro dams came into the OPCN territory, the community people reported all kinds of diseases such as cancer, diabetes, kidney failures and amputation of human body parts.

For more than 50 years since hydro dams came into the OPCN community, the findings show that the current generation of the OPCN community elders had firsthand lived experience of how the community health was impacted by hydro. Before hydro dams, the community people were very active and healthy, they enjoyed spending time in their cabins surviving on land-based traditional foods and animals. All the Elders indicated that they used to drink directly from the river and they never travelled with bottled water because the lake was crystal clear and clean. The food and medicine were abundant and healthy (Craft & Blakley, 2022). After hydro dams flooded the traditional lands such as hunting grounds, medicine areas and patches of berries in the community, all kinds of diseases such as cancer and diabetes came into the community.

Most of the grand grandparents of the current Elders' generation died from cancer, kidney failures and diabetes because of the consumption of contaminated traditional foods, medicines, water, wildlife, and fish with methylmercury. The current generation of Elders inherited environmental health problems from their grandparents therefore they are continuing from where the grandparents left off, fighting Manitoba Hydro for environmental justice. Hydro dam's impacts deteriorated the fish quality from Grade A to what fishers call cutter, the lowest fish quality on the market because of poor water conditions in the SIL (Calvin Baker, OPCN). Before hydro dams, the community never lived with sacks of different Western-prescribed drugs because the environment supported a healthy lifestyle for everyone in the community. With hydro flooding, the community people were forced to travel long distances away from their traditional areas in search of good quality medicines, traditional foods, animals, and fishing areas. Some of the Elderly populations in the OPCN community now depend on processed unhealthy stored foods, they cannot travel long distances for harvesting, hunting, and fishing because of high water flow currents in the SIL, for fishing mercury-intoxicated fish. All activities that kept the community healthy and active were affected by hydro dam projects leading to indigenous culture, language, community, economy, people, and children being destroyed (Les Dysart, 2023). During my community visits, OPCN was still adjusting to the COVID-19 pandemic and the community members highlighted the increase in demand for health services because most of the community people (Elders) who are fighting cancer, diabetes, TB, and kidney failures were infected by the virus.

Despite the collaborative work being conducted during COVID-19, some of the OPCN community members were fighting the after-effects of COVID-19 infections so I had to maintain social distancing and wearing a mask when I was conducting interviews with OPCN Elders. Interviews worked very well for the thesis chapter because every participant had a unique experience/ story to share on how they experienced the environmental health impacts of hydro dams. I hope using Storymaps to share the findings and knowledge acquired from the project will help raise awareness of the environmental health impacts of hydro dams. I hope non-community members, project planners and decision-makers will learn, reflect, and acknowledge the importance of community consultation and involvement before implementing projects.

Chapter 5: Thesis Discussion

5.1 Introduction

This thesis chapter reviews the project findings and reflections on the outcomes by clearly showing how changes in the landscapes led to increased environmental health problems in OPCN. Environmental health impacts of hydro dams are not particularly confined to one community or country, but the impacts are experienced and felt whenever hydro dams are built globally. The environmental health impacts of hydro dams are experienced by local communities whose lives and livelihoods depend on the fragile ecosystems surrounding the dams. In reality, most of the proposed hydro dam projects are associated with little to no consultation of local communities, little to no compensation, forced displacement, environmental degradation, water pollution, destruction of wildlife habitat and dissemination of fisheries. Referring to what OPCN has currently experiencing for the past 50-plus years living with hydro dam projects, they have reported environmental health problems such as kidney failures, heart attacks, diabetes, cancer, and amputations. Diseases which they never knew before hydro dams came into their territory. As highlighted in previous chapters, hydro dams disproportionally disconnected local communities from their land, water, and traditional livelihoods. This chapter will also discuss methods used to conduct the project, project outcomes and findings, lessons learned, brief COVID-19 implications about environmental health impacts of hydro dams and lastly provide recommendations for future work.

5.2 Project setting

For the past two and half years after joining the Wa Ni Ska Tan Alliance of hydro-impacted communities, the project emerged as a need raised by northern Manitoba hydro-impacted communities. Many Northern Manitoba communities such as Tataskweyak Cree Nation, Kinosao Sipi Cree Nation, Misipawistik Cree Nation, and Nisichawayasihk Cree Nation, are experiencing environmental health impacts of hydro dams. For this project, I choose to focus more on the OPCN community because of the long-lasting relationships that I managed to establish during the entire two and half years of working as a student researcher with Wa Ni Ska Tan Alliance of hydro-impacted communities.

The past two and half years of acknowledging previous literature on hydro dams, conducting community visits, interviews and attending conferences provided me with great insights into how local communities are being negatively impacted by hydro dams. While this thesis has only focused on the environmental health impacts of hydro dams, I believe the documentation of the findings will add more knowledge and contribute to further research in other communities living with hydro dams in their territories. Likewise, I have aimed to contribute another perspective – collaborating with indigenous communities to document their stories using a combination of historical maps, Participatory GIS mapping and digital location-based storytelling techniques. I hope these techniques I used will help policymakers, project planners and governments to critically evaluate how hydro dams cumulatively impact local communities.

To fully understand the stories associated with the environmental health impacts of hydro dams, the project had to start by understanding how the rivers used to flow before the construction of hydro dams and diversion channels. This process was made possible by compiling and analysing 1972 historical satellite images provided by USGS. The findings I attained from the historical maps were analysed using Indigenous community ways of knowing and doing techniques. The research method I used provided detailed information on how the OPCN community was negatively devasted by hydro dams on a landscape basis as described in Chapters 3 and 4. During interviews and informal discussions I did with OPCN, the community members shared knowledge that they have experienced for example they mentioned that they were forced to be displaced from their traditional homelands before the flooding and they were forced to burn their cabins with little to no compensation. These experiences shared by the community members who participated in interviews and participatory GIS mapping sessions were distressing because most of the participants were toddlers and youths during the phase of hydro dam planning and construction. They had first-hand experience with how hydro dam projects came into their territory. Some of my participants shared testimonies recalling how they saw their family cabins being burnt down.

Next, I aimed to investigate how the environmental health impacts of hydro dams were associated with the spatial-temporal changes in landscapes. The first step I did was to acknowledge the environmental health impacts of hydro dams that have been documented by academic institutions, individual researchers, governments, and non-governmental organisations such as diabetes, kidney failures, cancer, skin diseases etc. Then I did community visits and I interviewed

OPCN Elders, Hunters, Trappers, and Knowledge Keepers. The community members who participated in this project through interviews, and formal and informal discussions for example Les Dysart, Elder Christine Spence, and Elder Juliet Spence, shared their experiences on how the community people were becoming less healthy because of the consumption of mercury-intoxicated fish, mercury-polluted water, mercury-contaminated medicine, and disconnection from the traditional or cultural way of living through forced resettlement. The investigation findings added more evidence of what has been documented by other researchers mentioned in Chapter 2. These experiences provided evidence that hydro dams' negative impacts outweigh the benefits prescribed by hydro dam peddlers. It was interesting to know that some of the participants whom I interviewed were youth when hydro dams were being planned and built. All the participants I interviewed inherited the cumulative environmental health impacts of hydro dams from their Elders.

As a non-Indigenous person in Canada, I cannot speak on behalf of Indigenous people but the most powerful narratives I aimed to share in this thesis were the environmental health impacts of hydro dam projects in OPCN community voices embedded in location-based storytelling maps. The literature documenting such impacts is more text-based information without visual representations hence this thesis aimed to bring the graphical visual aspects of the information being communicated by OPCN people. I hope the visual insights I have shared will help non-community members understand how hydro projects are impacting local communities in Manitoba. I also hope that project planners will value and consider community voices when planning projects especially projects that are related to communities' lives and livelihoods.

When I was an undergraduate student in Zimbabwe, I participated in a university project that focused on the environmental implications of the construction of the Tugwi Mukosi hydro dam. We used interviews and community visits as our research methods. The narratives and findings we got from the local communities were similar to the findings I got here in Manitoba despite the differences in the global positioning of the two countries. For example, in Zimbabwe, the socio-environmental impacts were associated with environmental degradation, impaired water quality, forced resettlement, and little to no consultation and compensation. These hydro dam impacts also led to environmental health problems like cancer, malaria, diabetes, and kidney failures. It was interesting to me that regardless of the country, whether developed or developing, project planners are not concerned about the long-term effects of their projects. To them,

development is money and to the communities, development is learning and sharing new techniques for safeguarding and preserving the natural environment.

5.3 Participatory GIS mapping (PGIS)

Reflecting on the PGIS sessions I did with Les Dysart, there is a wise practice I can share information on the lesson that I have learned.

5.3.1 Lesson 1: The importance of active listening

According to Cuncic, (2022), active listening is a communication technique that involves fully focusing on and understanding the verbal and non-verbal cues of another person speaking. During the PGIS session, I learned the importance of active listening such as listening to understand rather than to respond. The skill helped me to be fully engaged with the conversation we were having with my participants, and it helped me to avoid missing out on important information/ details. The skill helped me to hover around the Google Earth Map software, placing points and polygons while my participants were sharing their knowledge of the land. Without actively listening and following the places that I was being directed to identify on a map, I would not have managed to document all the important details that were being shared. The process promoted narrative sovereignty meaning the PGIS session gave the community members the ability to share knowledge that was important to them.

5.3.2 Lesson 2: Transitioning from paper-based PGIS mapping to digital PGIS mapping

It was my first time designing and implementing a digital PGIS mapping session for this thesis. The whole process of documenting community knowledge using digital tools like Google Earth Map software, Geo Tracker mobile application, ArcGIS Storymaps and ArcGIS Pro software interchangeably was new to me. I have used all these software individually for 3 plus years for different projects but using them interchangeably at the same time during interviews and field surveys was new to me. From this experience, I learnt the importance of re-practising the tools/software before engaging in any activity. I also learned that an interview session might not go as planned and the intended tools might not work as planned hence being resistant to change and new ideas can cause you to miss important information and opportunities.

5.4 Nelson House Cree Nation Trip Reflection

NCN is a Manitoba Northern community located along the CRD route. I had the privilege to visit the community to document the environmental impacts of hydro dam projects. We visited one of the camping cabins in NCN and we had community members accompanying us who were amazed by the changes in water levels.

> "The water level dropped with four (4)Fit since we left the campsite. We never camped during the COVID-19 pandemic for a period of three years (2019 – 2022), because we were not allowed to be on water by the Community Council. We are shocked to see our boat no longer floating on water as the water levels were very high. We do not even know how we are going to drag our boats back in the water, except when Manitoba Hydro released the water which they are holding in Wuskwatim Lake" NCN community member, Eddy (2022, 07).

Figure 42: Shows changes in water levels in NCN

Photo Courtesy of Gerald Beta: Changes in water levels in NCN

Figure 43: Shows how water levels in NCN decreased

Photo courtesy of Gerald Beta: The boat was in the water for the past 3 years during the COVID-19 pandemic.

The above pictures provided evidence that not only OPCN is experiencing environmental impacts of hydro dam projects but also other communities who share the same river tributaries.

More so, I had an informal discussion with NCN members, and they mentioned how the community people were becoming less healthy because of hydro dams and some of the stories were from lived experiences. The implications of hydro dams disconnected the youths from land-based learning and cultural activities leading to high crime rates, drugs and substance use in NCN.

5.5 A brief overview of COVID-19

On the 30th of January 2020, WHO declared the COVID-19 disease outbreak as a worldwide emergency that needs international attention (Gunner et al., 2020); WHO). As the disease rapidly spreads, in March 2020 it was declared a pandemic emphasizing the gravity of the situation. Health experts could not understand the virus and with time, COVID-19 was declared an endemic by WHO, as it consistently spreads and mutates, killing millions of people (Melimopoulos, 2022; Molina, 2022).

People felt trapped indoors with COVID-19 disease (Mcmaster, 2020) because COVID-19 was associated with widespread panic, political opportunism, economic disruption, discrimination (Gunner et al., 2020), xenophobia and discussions around public health versus the economy, Susan Smith in Mcmaster, (2020). Like the recent 2023 Birds flu (H5N1) in Equatorial Guinea (Apex News Live, 10 Feb 2023), COVID-19 symptoms were associated with fever, coughing, fatigue, headache, sore throat, diarrhoea, congestion/runny nose, chills and shortness of breath (Nazario, 2019).

5.6 Reflection on the implications of COVID-19 in this thesis

When COVID-19 took hold in 2020, it was my first year doing my master's program and I was heavily affected by COVID-19 movement restrictions. I could not connect and establish a relationship with OPCN community members because the community was also in total lockdown. I tried online connections but the community experienced unstable network connectivity, so it was difficult for me to get started with my thesis. When movement restrictions were loosened, in October 2022 I attended a youth camp in Mile 20 and made connections with OPCN leadership. I then visited the OPCN community and conducted in-person interviews and field surveys. At some point, because of my program timeline, I cancelled all planned interviews because I had no hope that COVID-19 would come to an end.

My interview questions were more focused on the environmental health impacts of hydro dams and the OPCN Elders were happy to share their experience. When COVID-19 infections were reported in the community, Elders testified that they were at more risk of losing life because they were already fighting cancer, diabetes, and kidney failures. Reflecting on the cumulative health impacts of hydro dams, COVID-19 worsened the situation because the OPCN community lost some of the elders in the community. When I did interviews, some of the elders were still battling the aftereffects of COVID-19.

5.7 Recommendation for future work

It was exciting to write this thesis, travel to different Indigenous communities, collaborate with different Indigenous communities, and analyse maps using Indigenous ways of knowing and Western science. However, from the spatial-temporal changes in the landscape and the environmental health findings of this thesis,

5.7.1 Recommendation 1

Background – The permanent reconfiguration of landscapes due to hydro dam projects affects many Northern Indigenous communities. In this thesis, I focused more on the OPCN community which is one of the Northern Indigenous communities being negatively impacted by hydro dams. Along the CRD channel, many Indigenous communities that are located along the Churchill River Basin and Nelson River Basin are also being environmentally affected by hydro dams. For example, Nelson House and Split Lake have also reported environmental health impacts of hydro dams.

Recommendation – I recommend that future work should also document hydro dam stories of different Northern Indigenous communities, especially communities located along the CRD (Churchill River Basin and Nelson River Basin) network using PGIS mapping techniques. The work can be conducted using Chief Kerry's Moose guidebook for setting community mapping.

5.7.2 Recommendation 2

Background – GIS and Remote sensing approaches have constantly been improved to bridge the gap between oral traditions and scientific methods of documenting community stories. In this thesis, I used video cameras and drones to capture videos of different aspects of the research such as hydro dam control structures, diversion channels, environmental degradation (soil erosion, flooding, deforestation, habitat destruction), collapsing cabins etc. However, the processed videos of this thesis were still, meaning end users of the videos could not zoom in and out, and navigate either way in the videos. Therefore, it affected the interactiveness between the videos and the end-user.

Recommendation – I recommend that future work complement still videos by adopting 360-degree Imagery Technology when documenting community stories using videos and pictures. The 360^0 technology promotes engaging and interactive visuals that are very powerful in documenting

and sharing community stories. This technique can use either Virtual Reality (VT) equipment or 360^0 cameras like GoPro 11.

5.57.3 Recommendation 3

Background – Environmental health impacts of hydro dams in the OPCN community such as cancer, diabetes and kidney failures due to environmental devastation of the land and water have been ongoing for more than 50 years since hydro dams came into the territory. The community has been suffering from environmental health problems which normally compromise the respiratory system of the elders in the community. Recently, with the COVID-19 pandemic, the mortality rates of elders in the community have been higher than other population groups. From the brief results of this thesis on the impacts of COVID-19 in the community, some of the elders I interviewed were recovering from the long-term effects of COVID-19.

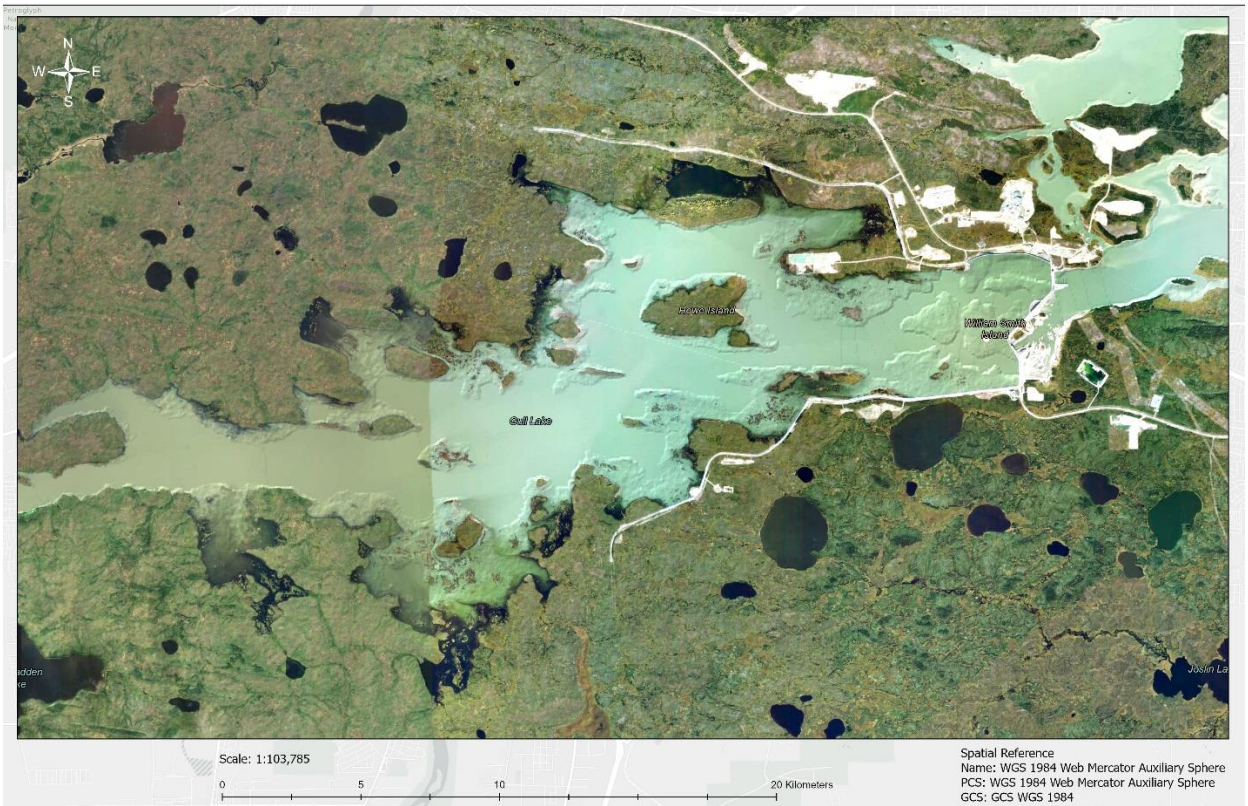
Recommendation – I recommend that future work examine how the cumulative health impacts of hydro dams worsened the impacts of the COVID-19 pandemic in the OPCN community. The work can be accomplished by interviewing community members about their experiences with the COVID-19 pandemic.

5.7.4 Recommendation 4

Background – GIS and Remote sensing techniques such as 3D mapping have been widely used for flood mapping and planning globally. In this thesis, I used 2D techniques to identify the extra water caused by the CRD channel in OPCN. However, I did not use 3D mapping techniques to visualise how the water level in SIL has increased because I did not manage to secure the digital elevation model (DEM) for SIL before the hydro flood, that is before 1972. Instead, I managed to partially use 3D techniques to visualize islands flooded by hydro dam floods in TCN as shown in Figure 59 below.

Recommendation – I recommend future work using 3D Mapping technology to visualize the pre-hydro events and the post-hydro events. 3D mapping techniques can be accomplished using DEM and some cartographic skills to show the differences in water levels before flooding and after the flooding.

Figure 44 Islands flooded by the construction of Keeyask Hydro Dam in TCN



Source Gerald Beta

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Appendix 1

6.1 GIS and Remote Sensing Procedures

This section of the thesis will go through step by step showing how GIS and Remote Sensing techniques were incorporated into this project. The steps will allow anyone interested to follow through with all the steps used to produce the outputs of the maps. I used an authorized ArcGIS Pro version 3 and ArcGIS Desktop version 2.8 software for data analysis, visualization, and reporting. ArcGIS Online and ArcGIS Storymaps were also used to tell comprehensive community stories and experiences digitally and interactively. The approach enabled community members to recall land-based activities and cultural practices that were conducted before hydro dams devasted the land. Satellite imagery data for August 1972, July 1976 and July 2019 were acquired from the USGS website and the digital elevation of 2006-2011 was acquired from the Copernicus[10] website. Copernicus is an Earth observation programme of the European Union Space programme. All the data processing phases are outlined and described in the coming sections.

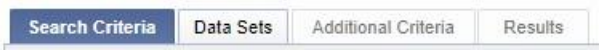
6.1.1 Step-by-step guide to downloading satellite images.

6.1.2 Step 1: Creating a USGS account

To download the USGS Earth Resources Observation and Science (EROS) Landsat Satellite data, the first step I did was to access the USGS Earth Explorer website here: http://earthexplorer.usgs.gov/. I registered an account through the registration buttons shown on the web page. Without registering, I could not download satellite data.

6.1.3 Step 2: Finding and sub-selecting area of interest.

The first step after registering a USGS account, I navigate to the Search Criteria



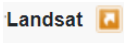
and enter the name/area of interest in the Geocoder tab. Then I selected the search engine to locate the area I needed. Then I selected the

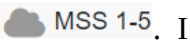
[10] https://scihub.copernicus.eu/dhus/#/home

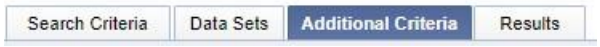
address/place to get coordinates. I navigated to the Date Range 

and entered the desired day, month, and year from the desired end date  .

6.1.4 Step 3: Selecting Data Set(s).

I selected the Data Set tab and a list of different data sets appeared. Then I choose Landsat satellite data 

such as Landsat MSS 1-5 (1972 -1987) 

. I selected the Additional Criteria 

to filter my data or to specify the Path and Row of an area of interest. Then I selected the Results tab. It started searching for available datasets.

6.1.5 Step 4: Image Download.

I selected the download icon  to start downloading. Before downloading, it was necessary and helpful to check my data footprint  . This showed me an overview of the area I was going to download data from. Also, checked the metadata  to have detailed information about the data. There were four different types of downloads, these were Natural colour Images, Thermal Images, Images with Geographic Reference, and Level 1 Products.

6.2 USGS interface summary

The detailed processes and procedures can be accessed on the USGS webpage[11] or the GIS Resources website[12]

[11] USGS| How to Search and Download Satellite Imagery, https://www.usgs.gov/media/videos/usgs-eros-how-search-and-download-satellite-imagery
[12]GIS Resources, https://gisresources.com/download-landsat-satellite-data/

Figure 45: USGS interface below

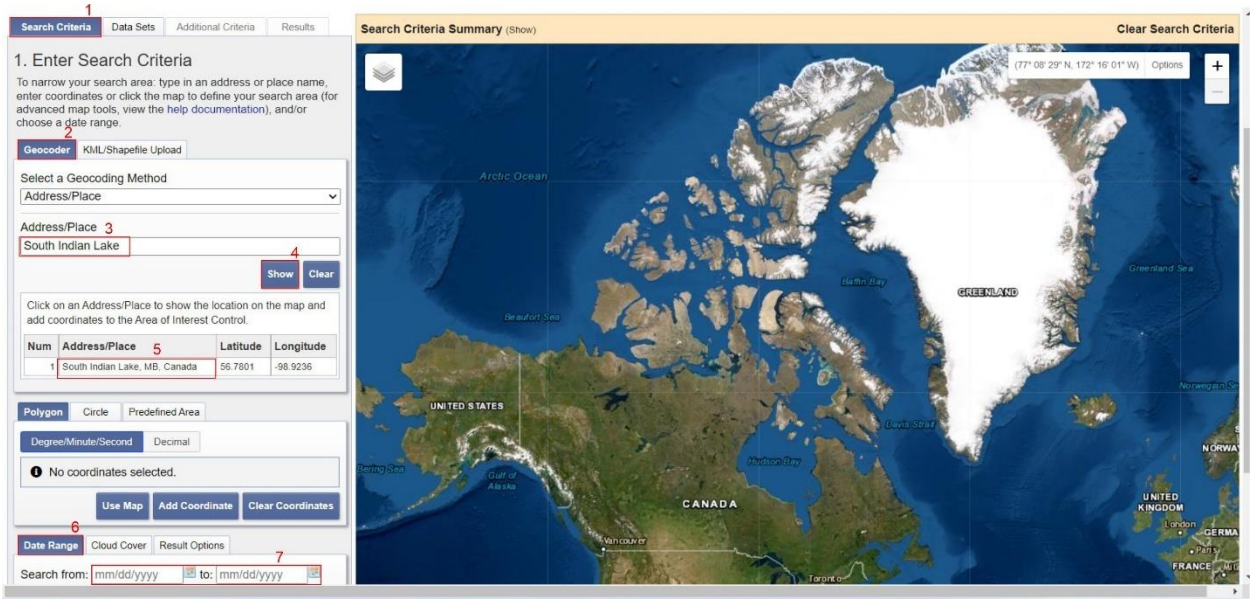
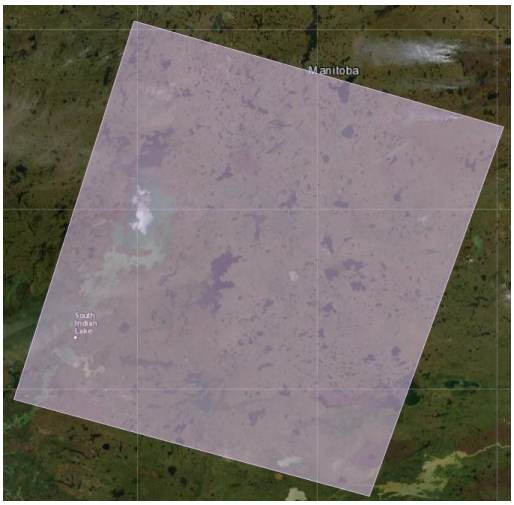
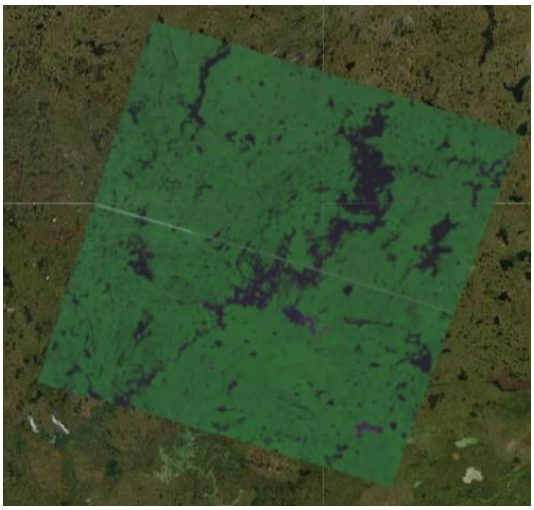


Figure 46: Shows Footprint and Overlay screenshot below

Footprint



Overlay



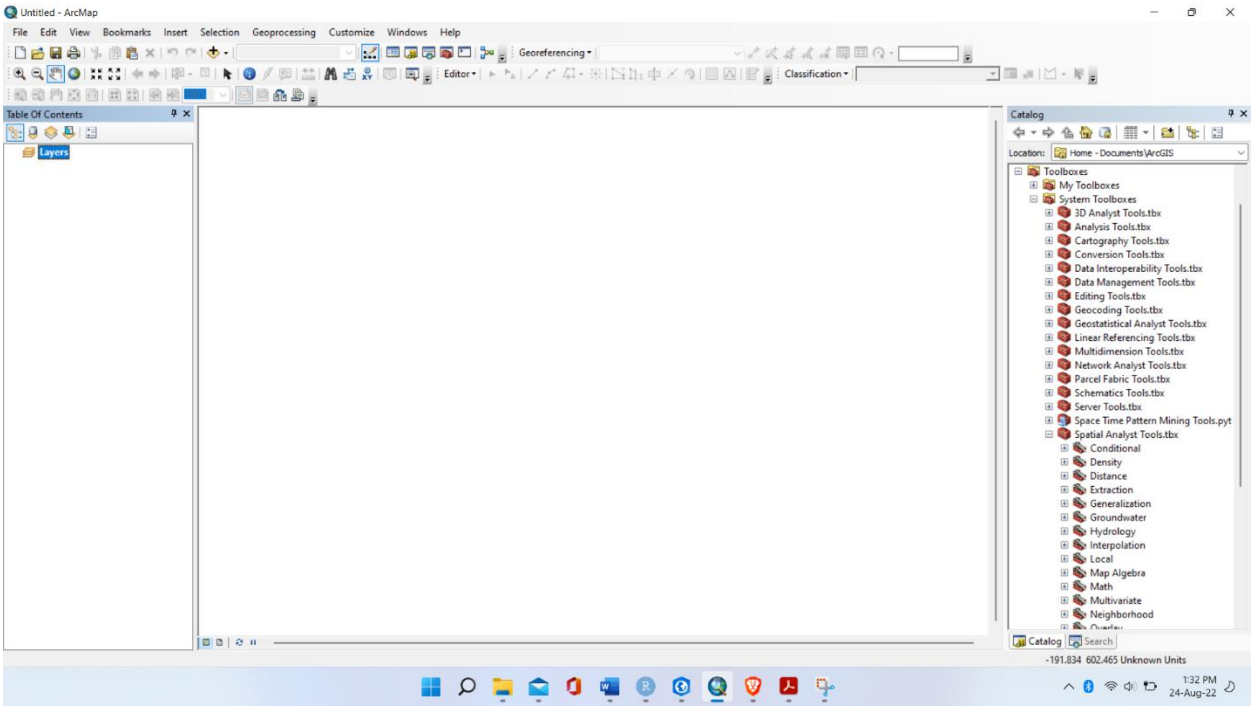
6.3 Data analysis procedures

I analyzed the Satellite imagery datasets using ArcGIS Desktop 10.8.2 and ArcGIS Pro version 3.1

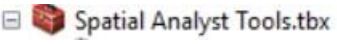
6.3.1 Step 1: Opening ArcGIS Desktop Software

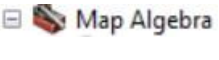
I opened ArcGIS Software  ArcMap 10.8.2, located the downloaded satellite datasets (8 – 9) and Added  Band number 5, the Near-Infrared band. Then Band 5 was visible in the Data View window  . On the satellite image, the water was represented in black and the landscape in grey. I used the Identifier tool  to view the pixel values of the water. Pixel values are widely known as blocks of numbers containing information that represents the smallest individual element of an image (Winter, 2022). I selected different spots to identify the highest pixel reflected by water.

Figure 47: ArcGIS 2.8 Interface



Step 2: Spatial Analyst tool

Then I opened the toolbox  to view the Spatial Analyst tools 

. I opened the tool and navigated to the Map Algebra tool 

. Then I opened the tool to view the Raster Calculator 

. On the Raster calculator (Fig 4 example), I added

a Band 5 satellite image followed by the less than sign  . Then I wrote the highest pixel value recorded using the Identifier tool  . I saved the Output raster in my desired folder.

Figure 48: ArcGIS 2.8.2 Spatial Analyst tools

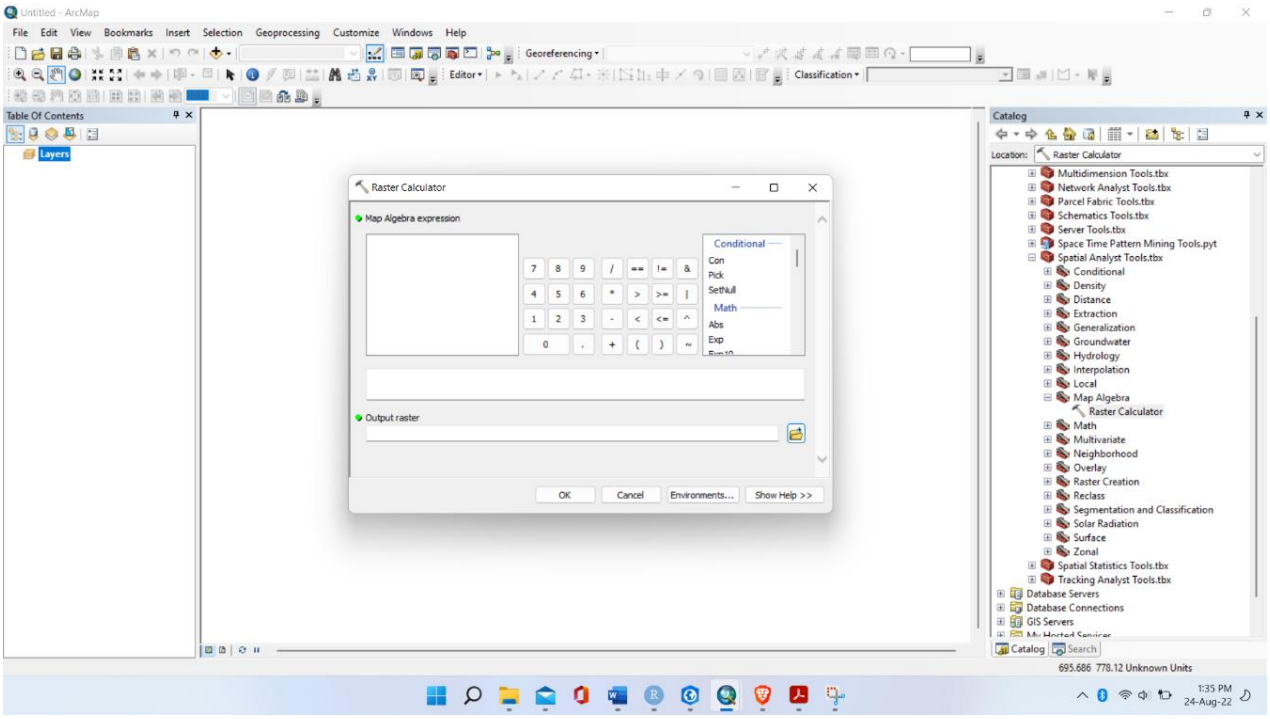
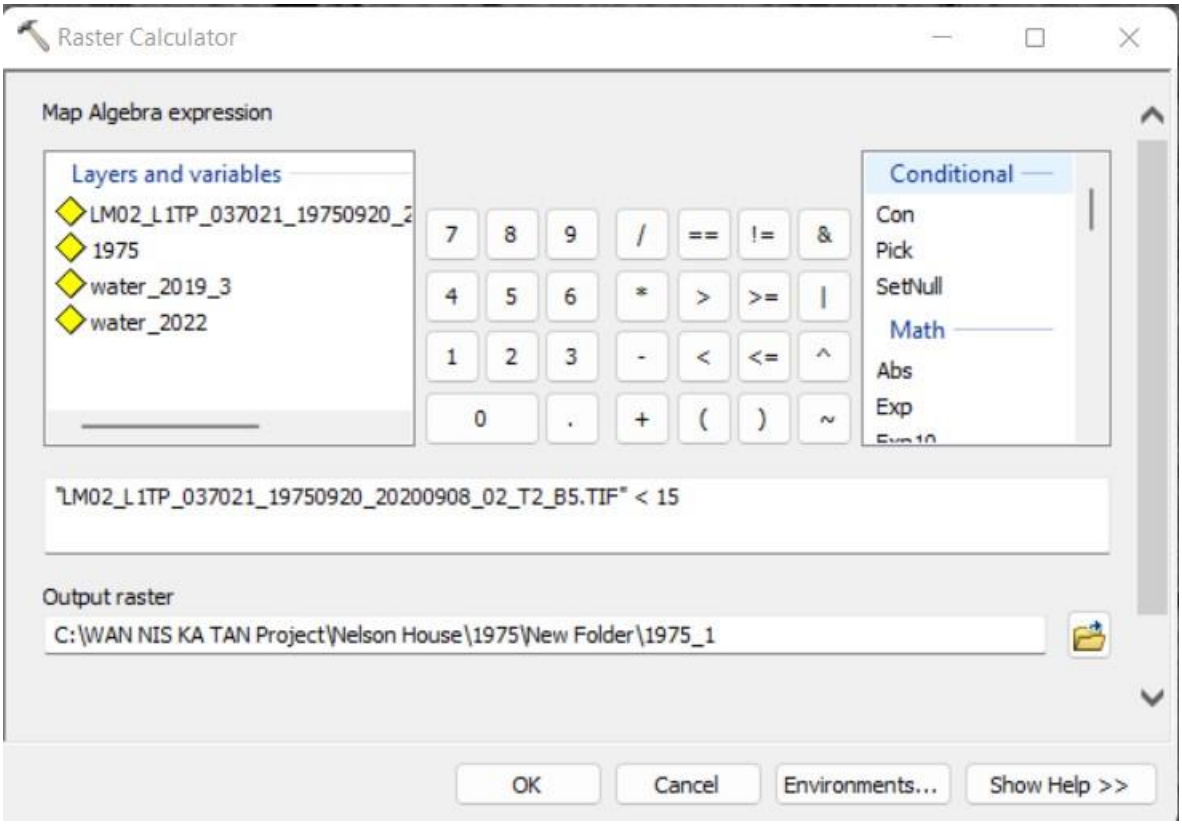


Figure 49: Raster Calculator

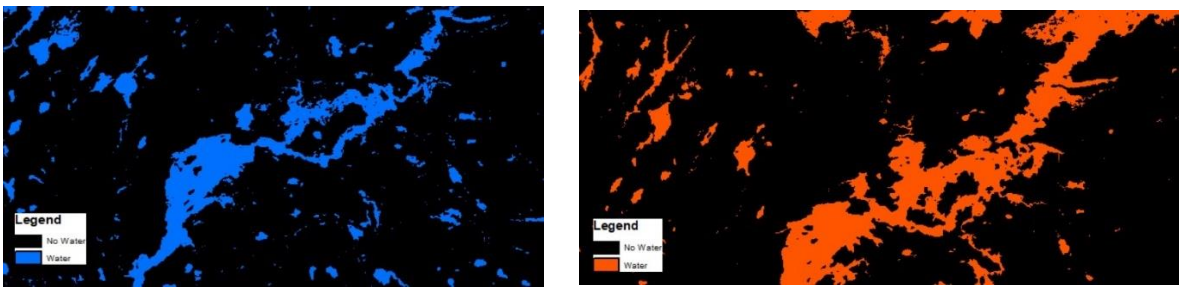


Source: Gerald, ArcGIS Screenshot. An example of the Raster Calculator interface

6.3.2 Step 3: Visualizing water levels: Method 1

The Raster Calculator results opened after the process was complete as shown in Fig 49. The value representing no water was 0 and the value representing water bodies was 1. I repeated the same process using a different year, for example, the June 2019 satellite image data to identify the water level that was recorded in 2019.

Figure 50: Water Levels for Year A and Year B



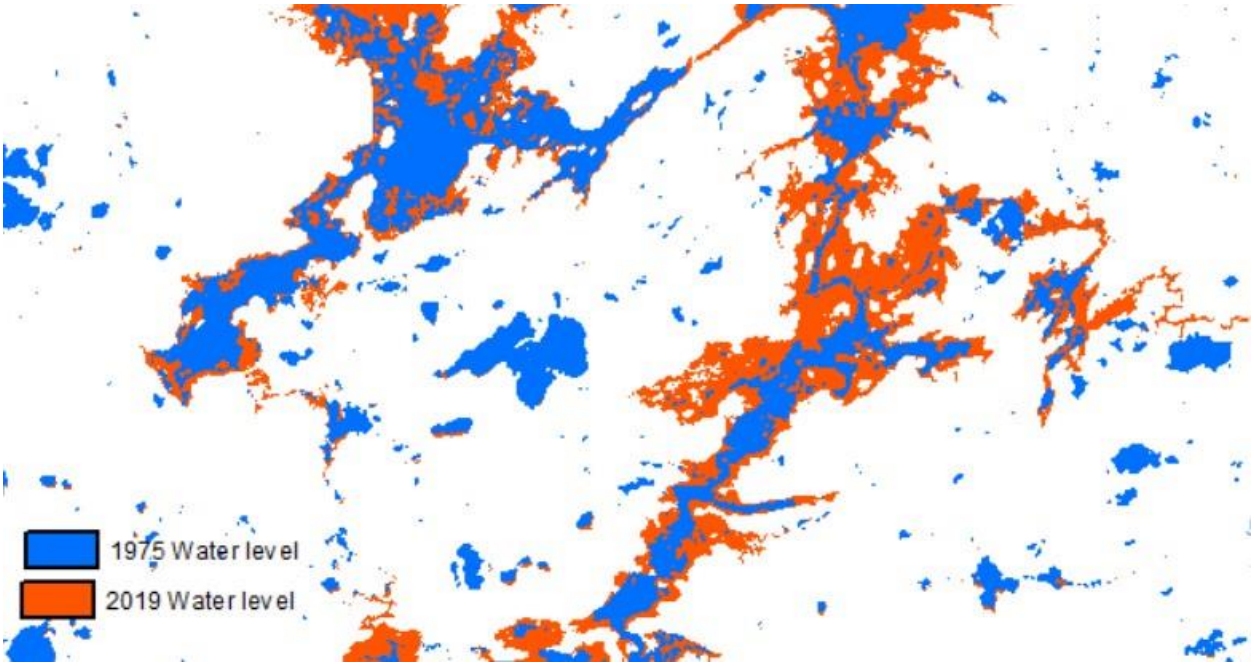
Year A: 1975 Year B: 2019

6.6.3 Step 4: Overlaying 1975 and 2019 results

To determine the differences in water levels between two different years, I overlayed Year A and Year B on the same map in the Data View. I changed the 0 values of both results to Hallow 

in the Symbol Selector properties and it allowed me to see the differences in water levels between different years.

Figure 51: Map showing overlayed map results of Year A and Year B: Map showing overlayed map results of Year A and Year B

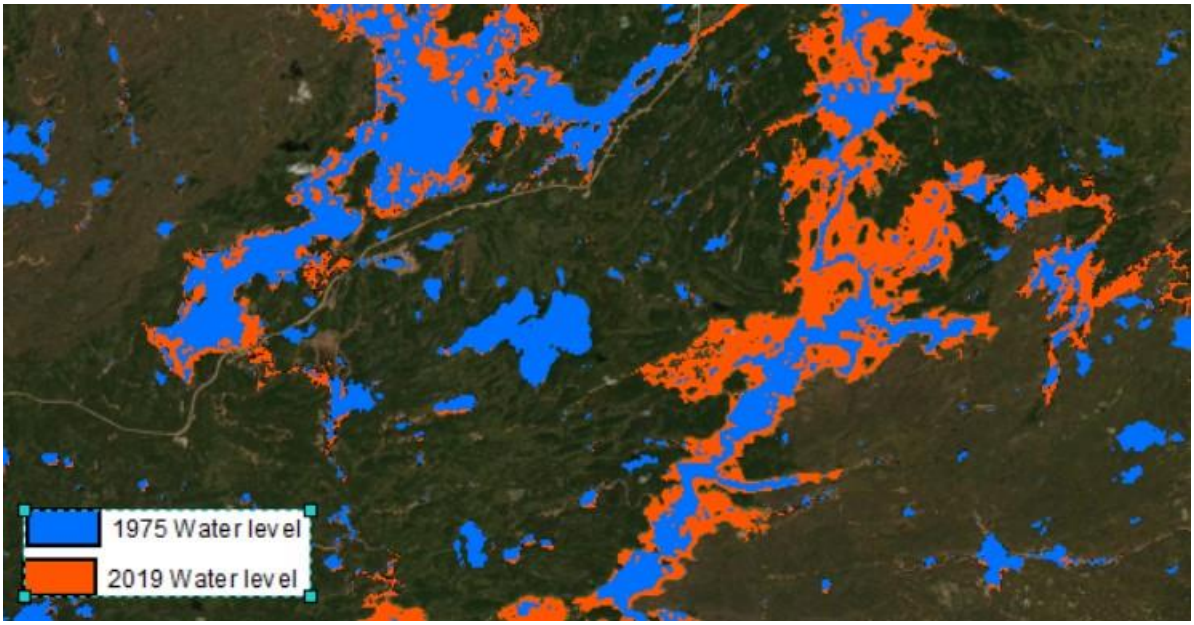


Source: Gerald Beta

Also, I added the  Base-map 

to visualize results in real-life scenarios. In this example, I used Imagery with labels  .

Figure 52: Map shows overlayed map results of Year A and Year B with base-map



Source: Gerald Beta

6.6.4 Step 5: Layout View window

After steps 1 – 5, I opened the Layout View and added the Legend Legend... , North Arrow , Title and Scalebar . This Step finalizes the map results and metadata that act as guides to other End Users such as planners, policymakers, community members etc.

6.7 Visualizing water levels: Method 2

The second method I used to identify the approximate flooded areas in the thesis was unsupervised image classification. I used ArcGIS Pro version 3 to perform the unsupervised image classification technique to extract approximate areas flooded due to hydroelectric dam projects. For the unsupervised classification method, I used 2 classes namely water and land/soil. The reason for using 2 classes was that 1 class represented the flooded water level and the 2nd class represented the land/soil. This process was easy and fast compared to the density-slicing technique I explained above. I used two different techniques to produce the same results to increase the accuracy and reliability of my results. Detailed steps for method 2 will not be provided in this thesis but step-by-step guidelines can be accessed at https://www.youtube.com/watch?v=zkNWjme-BOs.

6.8 Understanding the Historical Landscape

When planning flood mapping, I made sure to first understand the local context of the area where the work is being conducted. The history of the community, the environment, and the history of flooding were taken into consideration and it helped me to choose and apply the best GIS and Remote Sensing techniques for the study. Understanding the environment helped me to understand the shape of the watershed and the tributary patterns. I used PGIS to allow the community members to take the lead and explain what the changes on the maps mean. This process enabled the community members to share their experiences on hydroelectric projects that affected the community. Integrating both PGIS skills and satellite imagery maps with and for the community provided me with in-depth knowledge of how the community is experiencing hydro impacts. All community stories shared during the interviews and PGIS sessions are well presented in a digital story map collection that can be accessed at https://arcg.is/15rSPb.

6.9 Accessing Digital Elevation Data

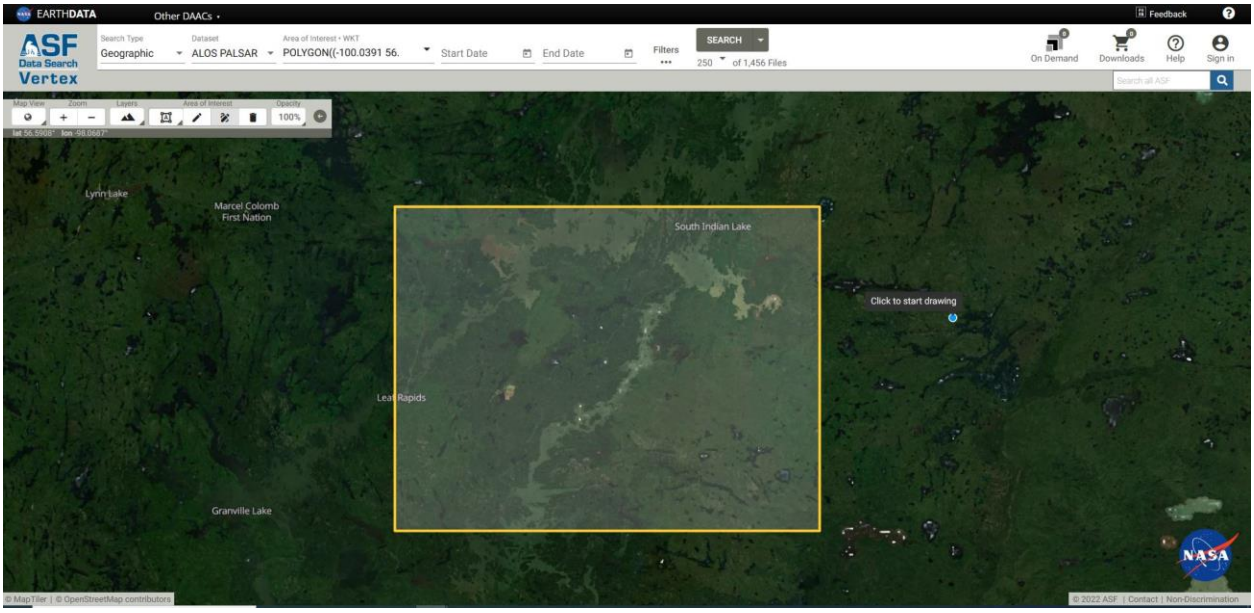
I acquired the Digital Elevation Model (DEM) dataset from NASA EARTHDATA Earth Data[13]. The dataset was an Advanced Land Observing Satellite Phased Array Type L-band Synthetic Aperture Radar Mission 2006 – 2011 (ALOS PALSAR) Dataset ALOS PALSAR . I used this dataset because it is radiometrically terrain correlated, both geometrically and radiometrically (U.S. Geological Survey (USGS)). The other reason I used this dataset was that it helps to determine the river drainage pattern, watershed, river flow direction and stream order.

6.10 The procedure required to access Earth Data

I visited the Earth Data website at https://scihub.copernicus.eu/dhus/#/home. Then I registered a free account with Earth Data Sign in. Then I navigated to the Area of Interest tab Area of Interest • WKT to delineate/mark the area needed for this thesis.

[13]NASA Earth Data, https://search.asf.alaska.edu

Figure 53: Screen capture interface for NASA Earth Data



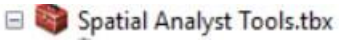
Source: Gerald, NASA Earth Data Screenshot

I selected the Dataset button Dataset ALOS PALSAR and chose the ALOS PALSAR. I Filtered Filters ••• the data to the 2006 - 2011 date range and selected the search button Search Type Geographic Search. The results produced different data scenes of the area to allow me to view scene details before downloading the data as shown in Fig 53. Then I selected the Download button to start downloading the DEM.

Figure 54: Showing Earth DATA scene detailed information.

Source: Gerald Beta, Earth Data Screenshot

6.11 Watershed delineation using DEM

All GIS and Remote Sensing tasks I did were accomplished using ArcGIS 10.8.2 Desktop/Enterprise and ArcGIS Pro 3.8, a product of Esri technology[14]. The thesis used Spatial Analysts tools 

, Hydrology function to delineate OPCN to TCN drainage systems, watershed, direction of flow, tributary patterns, and stream hierarchy/order (Horton, 1945; Strahler, 1952). These techniques are also provided by Esri[15] and further used by other studies such as Gupta & Yadav, (2014) and Saha & Agrawal, (2020) to delineate flow direction and stream order.

6.12 O-Pipon-Na-Piwin Cree Nation to Tataskweyak Cree Nation drainage system delineation

The SIL river system is drained by the Churchill River which lies North of Nelson and Saskatchewan River basins. Its source (headwaters) flows across Saskatchewan in an easterly direction. SIL runs through Manitoba in a north-easterly direction and it is approximately 160km parallel to Nelson River (Environment, Climate and Parks, Manitoba Hydro).

The Burntwood River and Nelson River join and drain into the west end of Split Lake. The Grass River connects with the Nelson River before it joins the lake then the Nelson River proceeds out from the east end of Split Lake.

[14]Esri overview: https://www.esri.com/en-us/arcgis/about-arcgis/overview
[15] Esri Pro hydrology: https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/an-overview-of-the-hydrology-tools.htm

6.13 Steps to process DEM to delineate watershed, flow direction, tributaries, and stream order.

The SIL to Split Lake major drainage system was generated using a dataset collected from NASA Earth Data ALOS PALSAR (2006 – 2011)[16] as mentioned above. I used ArcGIS 10.8.2 to complete all the processes needed for the thesis. ArcGIS 10.8.2 provided Spatial Analyst[17] tools with a sub-toolbox or function called Hydrology toolbox which further provides 12 processes that were utilized to produce a full watershed. The 12 processes are 1) Basin 2) Fill 3) Flow Accumulation 4) Flow direction, 5) Flow distance 6) Flow length 7) Sink 8) Snap Pour point 9) Stream link 10) Stream order 11) Stream to feature and 12) Watershed. According to Gupta & Yadav (2014), the majority of these functions are interdependent because they rely on each other's outputs. I used only six (6) tools of this function to delineate SIL to Spilt Lake watershed DEM output. The techniques are widely known and used by hydrologists even though the processes are time-consuming (Zhan & Huang, 2004). The description of the tools I used was adapted from the Esri website[18]

[16] Data Source – NASA Earth Data (https://search.asf.alaska.edu/#/), Dataset – ALOS PALSAR, Year – 2006 -2011.
[17] Software – ArcGIS 10.8, Spatial Analyst Tools, Hydrology
[18] Esri Pro Website: https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/an-overview-of-the-hydrology-tools.htm

Table 1: Hydrology tools used to delineate watersheds.

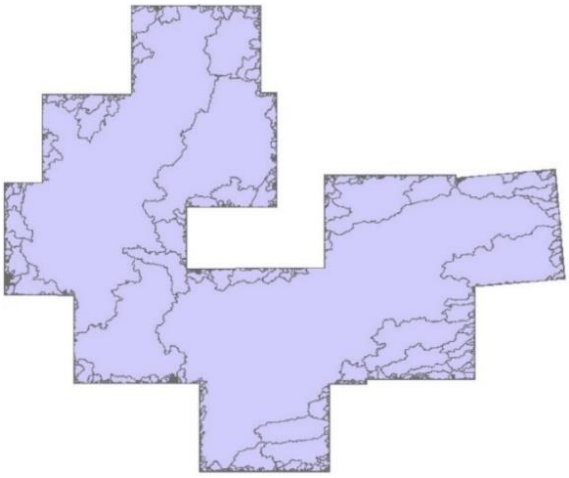
#	Tool	Description	URL
1	Fill	Used to reduce inaccuracy in data	https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/fill.htm
2	Flow Direction	Generates a flow direction from each cell to the steepest downslope neighbor/s	https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/flow-direction.htm
3	Flow Accumulation	Produces a raster accumulated flow into each cell. The higher the value the higher the accumulation thus the potential water stream	https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/flow-accumulation.htm
4	Stream link	The instrument assigns unique values of a raster linear network amongst junctures/intersections	https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/stream-link.htm
5	Stream order	This tool assigns a numeric order to streams based on river branches	https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/stream-order.htm
6	Stream to feature	This tool converts raster stream data to vector (features) data representing the stream.	https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/stream-to-feature.htm

Source: Tools in the Hydrology toolset, ESRI (Esri Documentation)

6.14 Un-processed SIL to Split Lake DEM results

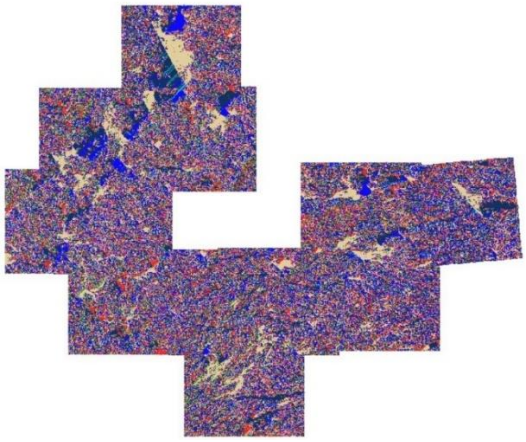
Figure 55: Un-processed SIL to Split Lake outputs

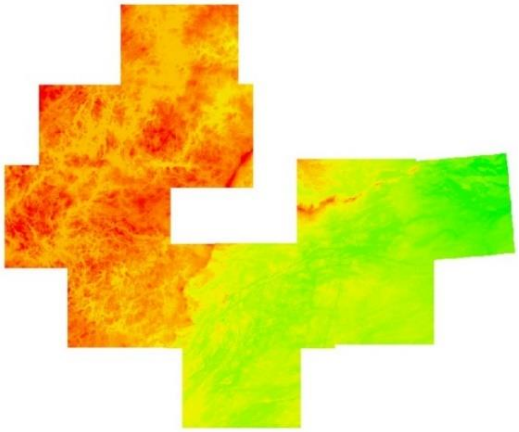
Basin **Watershed**



Flow Direction

DEM





6.15 Insight into how the Churchill and Nelson River Basin flows

As a newcomer in Canada, to assess the spatial-temporal changes of the landscape in OPCN, I had to understand how the rivers are connected, how the rivers flow and the whole drainage system. This was made possible by downloading the 2006-2011 DEMs from the Earth Data website as highlighted in the methods section. I processed the DEM using the hydrology tools to produce the watershed, drainage basin, direction of river flow and stream order from OPCN up to the TCN community.

Figure 56: Shows the Churchill River Basin and Nelson River Basin.

Source: Gerald Beta

Figure 56 shows the 1.609km long Churchill River system flowing from Northwestern Saskatchewan to Southeast, East and Northeast of Northern Saskatchewan and Manitoba emptying at the Hudson Bay at Churchill, Manitoba (Marsh, 2021). It is also known as *Missinipi*, a Cree word meaning great waters or big water. Some of the interconnected big lakes along the "Churchill River are Southern Indian Lake (2.247km2), Peter Pond Lake (778km2), Churchill Lake (559km2), Granville Lake (490km2) and Lac IIe-ea-la-Crosse (391km2) where the river the river takes in its main tributary, the Beaver River (491km)" (Marsh, 2021).

Appendix 2

Community Letters

To whom it may concern

Dear Sir/Madam

RE: REQUEST FOR PERMISSION TO DO RESEARCH IN THE O-PIPON-NA-PIWIN CREE NATION

My name is Gerald Beta, I am currently a student at the University of Manitoba, and I am writing this letter concerning a research project I am hoping to carry out in collaboration with your community. The project is outlined below but I am sending this letter to ask permission to visit your community from the 23rd of September up to the 6th of October 2022 to carry out some research. I learned about health and environmental impacts in O-Pipon-Na-Piwin Cree Nation through working with Wa Ni Ska Tan and I hope to learn more and build more relations with the community. This research aims to assess the health and environmental impacts of hydro dams and COVID-19, in large part by highlighting community experiences. My plan, with the permission of participants, is to conduct video-recorded interviews, surveys and boat rides along the shorelines and waters surrounding the community. I will be calling, texting, and emailing local Elders and Knowledge Keepers about their interest in being interviewed. The results will be organized and captured on a digital map thereby creating a story map for community use. The results of the research will be used to raise awareness on the part of decision-makers and the public about the importance of health and the environment when planning projects that affect the community, land, and waterways.

Since this is an in-person event organized during COVID-19, I will be travelling with Wa Ni Ska Tan workmates: Michael Tyas (Videographer), Bobbie Mang'eli (Communications and Student Researcher) and Ramona Neckoway (Professor, UCN). We will ensure to follow all COVID-19 protocols including rapid self-testing before and while visiting the community.

Looking forward to hearing from you.

Yours sincerely

Gerald Beta

Project title: Health and environmental impacts of hydro dams in OPCN and TCN.

Research Statement

The collaborative research seeks to document and promote a strength-based approach to the health and environmental impacts of hydro dams and COVID-19 in the O-Pipon-Na-Piwin Cree Nation. Hydro impacts emerged early 1970s with Churchill River diversion as the major contributor to flooding. The CRD project led by Manitoba Hydro has increased Southern Indian Lake water levels by approximately 10 metres. They constructed the Missi Falls control structure and the Notigi control structure to control the natural river flow of Churchill River through a 9km channel (South Bay diversion channel) into Rat-Burntwood River and Nelson River. The CRD diversion flooded the Southern Indian Lake community. This resulted in the forced displacement of the whole community. TCN was also subsequently affected by Wuskwatim and Keeyask. The CRD project further impacted TCN which is situated along the downstream of Nelson River. Hydro impacts are broadly explained in literature which can be inaccessible to everyone. The impacts are not explained at a landscape level so geographic Information Systems become an opportunity to describe and see the impacts of hydro dams at a landscape level.

GIS represents a spatial system that creates, manages, presents, and maps all types of digital data. It is a process that connects layers of data to a map. This allows me to integrate location data (where things are) with all types of other descriptive information (stories related to the locations). GIS will play a key role in my proposed work. It allows me to map the long-term impacts of hydro on the environment and community, by highlighting community experiences and stories.

The Goals/objectives of the research are: -

1. To document community experiences and perspectives on the spatial-temporal changes in the environment due to hydroelectric dam projects in O-Pipon-Na-Piwin Cree Nation.
2. To understand the community experience and perspectives on these spatial-temporal changes in Indigenous livelihood.
3. To present and share community experiences on the environmental health impacts of hydro dams using digital tools.

Who I am.

My name is Gerald Beta. I was born and raised in Zimbabwe. I have been in Canada for 1 year 9 months, and I am a student at the University of Manitoba. As a student researcher, I have worked with Indigenous communities in my country, and I am improving my qualitative research skills through community engagement here in Canada.

Methods and materials

- Interviews: - I hope to interview Elders, community knowledge keepers, community leaders, fishermen, and hunters from the 23rd of September 2022 up to the end of the month. With permission to record, interviews will be conducted on the impacted lands and waters.
- Surveys- I hope to visit the impacted lands, lakes, and waters. This process will be facilitated by community members/residents.
- Photos and video recordings: - I hope to take pictures and use video to document impacted lands and waters that will be used in a digital map.

Results

A copy of all these data will be made available to OPCN. I will also provide the transcripts of any interviews to the corresponding participant for feedback and their use. The findings from interviews and surveys will be presented on a map and will also be publicly available on the Wa Ni Ska Tan website for knowledge sharing and raising awareness. The results will be presented in the form of paper maps, digital maps, pictures, and videos. This acknowledges the importance of Storytelling as a way of knowledge transfer and cultural revitalisation. This will allow people to learn about the actual area being referred to/ impacted.

Outcomes

- Provide maps showing flooded areas of 1972 before CRD, 1976 during CRD and 2019 following CRD
- Produce storytelling maps that highlight community voices and places of interest that have been affected by hydro dams

Benefits to the community

- Story maps are a useful tool for knowledge transfer and cultural preservation. This project will be useful for the documentation and sharing of local stories, experiences, and knowledge.
- The project will help communities raise awareness and visibility of hydro impacts on the governments, industry, and the public.

Guidance from community

- To learn and work closely with the community members
- Guidance on who to contact and communicate with.

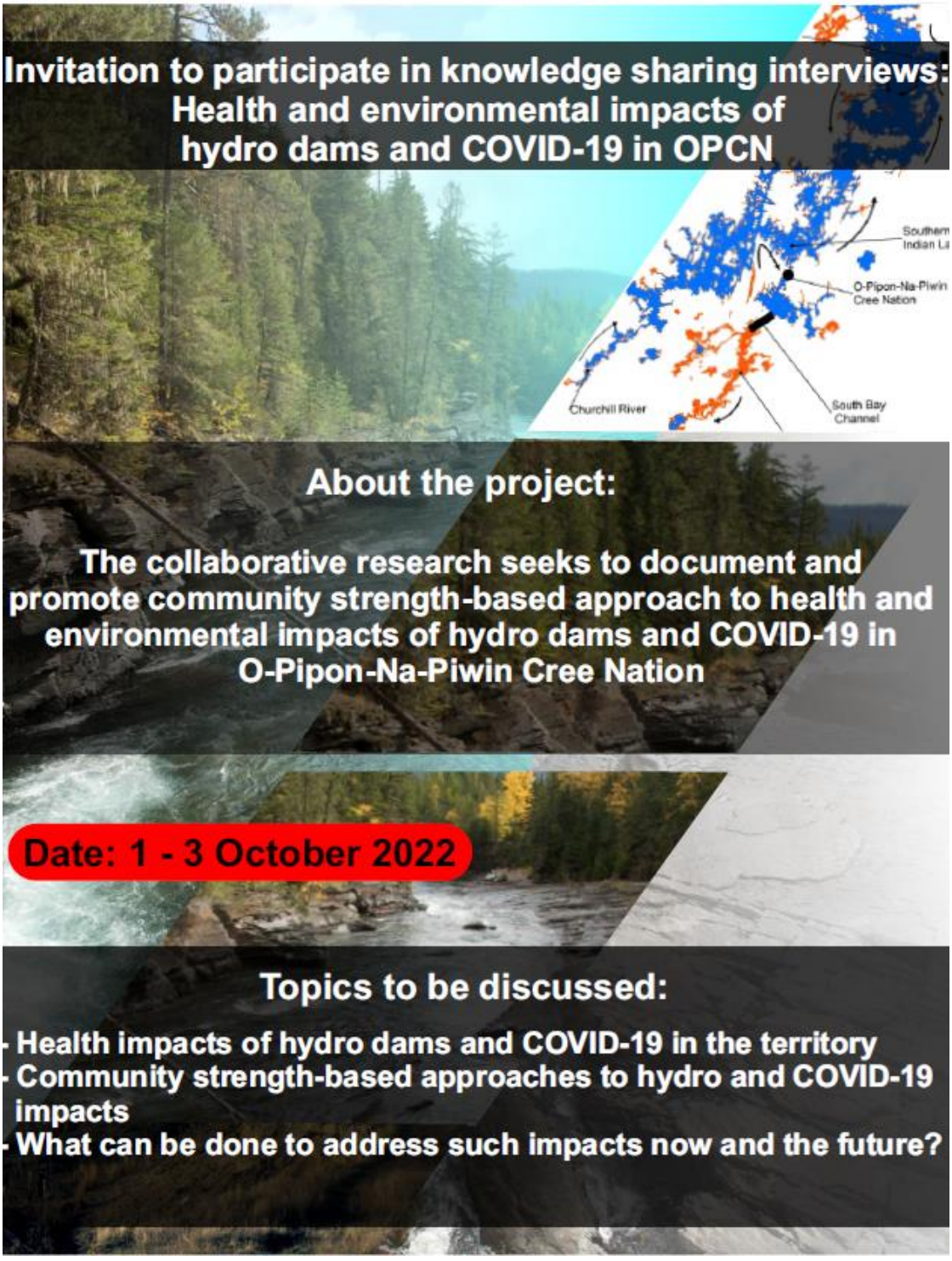
Interview Questions

1. Can you please explain the changes you have noticed after hydro dams?

- On the environment
- On human health
- At the family level and community level

2. What do you understand by health and well-being in Cree understanding?
3. What kind of health impacts has the community experienced since hydro came into the territory?
4. How might these impacts change in the future?
5. What can be done to address such impacts now and into the future?

Appendix 3


Invitation to participate in knowledge sharing interviews:
Health and environmental impacts of
hydro dams and COVID-19 in OPCN
Southern
Indian La
O-Pipon-Na-Piwin
Cree Nation
Churchill River
South Bay
Channel
About the project:
The collaborative research seeks to document and promote community strength-based approach to health and environmental impacts of hydro dams and COVID-19 in O-Pipon-Na-Piwin Cree Nation
Date: 1 - 3 October 2022
Topics to be discussed:
- Health impacts of hydro dams and COVID-19 in the territory
- Community strength-based approaches to hydro and COVID-19 impacts
- What can be done to address such impacts now and the future?