UNIVERSITY OF CALGARY

USING MAPPING TOOLS TO IMPROVE THE INTEGRATION OF TRADITIONAL KNOWLEDGE AND SCIENCE IN EIA: THE SITE C CLEAN ENERGY PROJECT CASE STUDY

by

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Abstract

This study examines information provided by traditional knowledge and science studies that were sourced from the Site C Clean Energy Project EIS to develop a more complete understanding of the impacts on watersheds, species of interest and cumulative effects of energy development on Indigenous communities. Impact maps were created and compared, using Geographical Information Systems, to determine what species and watersheds were impacted and cumulative effects maps were made to display the impacts of energy development on the area over time. The maps reveal that traditional knowledge and science have more in common than they differ, and the cumulative effects of energy development have significantly impacted Indigenous people's ability to live their traditional way of life. The study recommends a more collaborative approach between the two knowledge systems to share data and work cooperatively to ensure the impacts on valued environmental components are understood for future development.

Acknowledgements

This report is dedicated to my late Mishomis (grandfather) Alex Niganobe. He was a hunter, trapper, fisherman, and guide in the area around Mississaugi First Nation near Blind River, Ontario. He would tell me about his experiences in the bush, and I was always amazed at his intricate knowledge of animal behaviour, based on the intergenerational teachings of his people as well as, his own keen observations of the animals within their natural environment and their interactions with other species, including man. Although not formally educated, my grandfather drew upon Anishinaabe traditional knowledge systems passed down to him through many generations. In accordance with Anishinaabe scholar, Leanne Betasamosake Simpson, my grandfather "embodied Nishnaabeg intelligence because he was a practitioner of Nishnaabeg intelligence" (Betasamosake Simpson, 2017) . I was fortunate that he took the time to share some of this traditional knowledge with me.

Unlike my grandfather, I took the path of science and found my passion in geology and map making. I pursued this particular research project to gain a more holistic view of the world, to reconnect with my Anishinaabe heritage, and to embrace and find the parallels between the Indigenous ways of knowing and being. It has been a very enlightening journey. I would like to thank my mother Eva Tyszko (nee Niganobe) and my father Johnny for their love and support, encouraging me to get a good education and to find my own path. I would like to sincerely thank Dr. Alan Kennedy for being my supervisor and for his guidance and support throughout my research. I was inspired by his expertise in the field of EIA and his enthusiasm and respect for traditional knowledge. Special thanks to Daniel Grunberg and Cartofact GIS for allowing me to use their system for my project.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

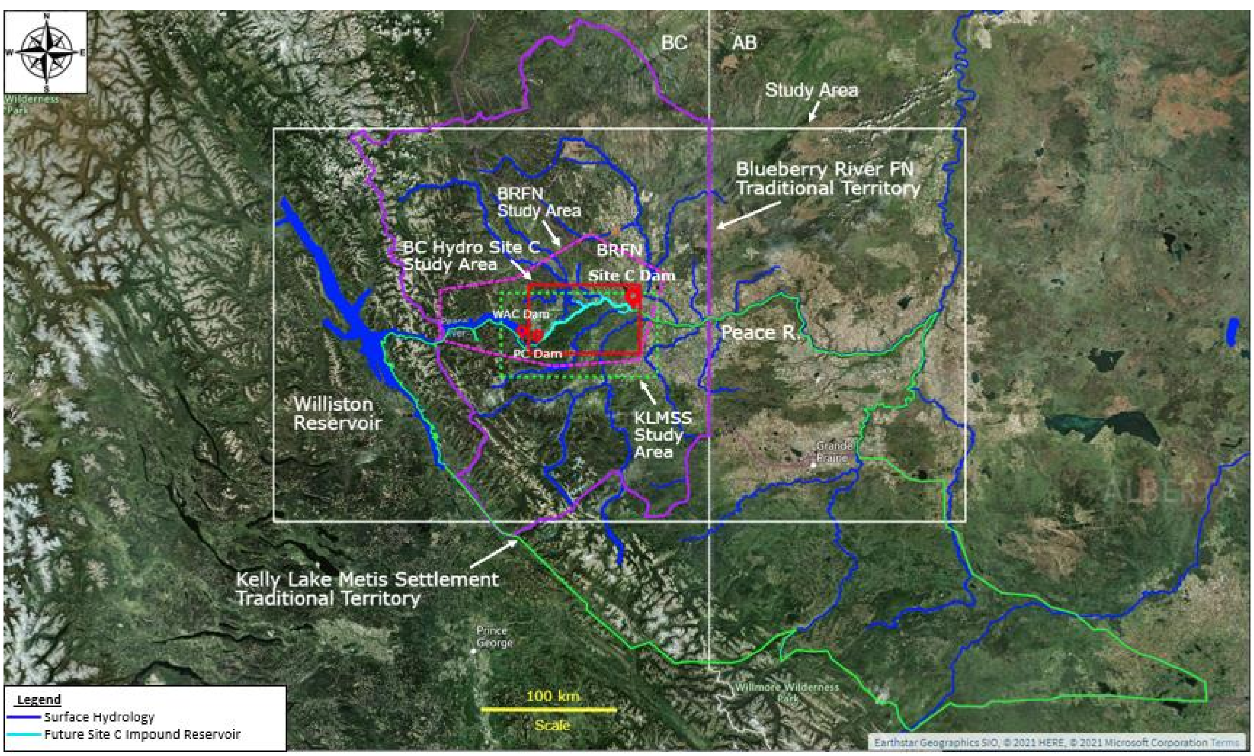
Abbreviation	Meaning
Site C	Site C Clean Energy Project
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
BC	British Columbia
BRFN	Blueberry River First Nation
KLMSS	Kelly Lake Metis Settlement
TLUS	Traditional Land Use Study
CO_2	Carbon Dioxide
GHG	Greenhouse Gas Emissions
TK	Traditional Knowledge
VEC	Valued Environmental Component
IAA	Impact Assessment Act
IK	Indigenous Knowledge
TEK	Traditional Ecological Knowledge
OCAP	Ownership Control Access Possession
GIS	Geographical Information Systems
NGO	Non-Government Organization
PC	Peace Canyon
CEAA	Canadian Environmental Assessment Act
SO_2	Sulphur Dioxide

CEA	Cumulative Effects Assessment
LNG	Liquefied Natural Gas
KCN	Keeyask Cree Nation

Chapter 1. Introduction

The Site C Clean Energy Project (Site C) is the third hydroelectric project to be built on the Peace River near the town of Fort St. John, British Columbia. An Environmental Impact Assessment (EIA), has been conducted to assess the Site C impacts on the environment and social and economic aspects associated with the project. The Site C Clean Energy Environmental Impact Statement (EIS) can be found on the Impact Assessment Agency of Canada website (Government of Canada, 2013). For the purposes of this report, EIS and EIA will be used interchangeably. EIA is a process to identify and evaluate environmental impacts, provide mitigation measures and provide alternatives for the project to help decision makers evaluate whether or not a project should proceed. The study area for this report uses the Site C area as the focal point and includes

Figure 1: Study Area and Project Areas for the Site C Clean Energy Project.



the major tributaries of the Peace River from the town of Peace River to the Williston Reservoir. It covers an area of approximately 142, 000 km^2 (Figure 1).

The Blueberry River First Nation (BRFN) and Kelly Lake Metis Settlement (KLMS) traditional territories cover an area of 61,700 km^2 and 94,200 km^2 respectively. The Site C study area is approximately 4,000 km^2 in size. The study areas and traditional territories for the BRFN and KLMS are shown by the dashed lines and were approximated from the maps in the Traditional Land Use Studies (TLUS) and the polygons were drawn and approximated from topographical features like lakes, rivers, and roads.

The planet has undergone numerous energy transitions over the last several hundred years, and it is continuing today with the move away from fossil fuels to reduce carbon dioxide (CO_2) emissions. Energy transitions are characterized by a move to higher performing fuels that take place over decades and follow a path toward decarbonization; however, when one problem is solved another one is created (Webber, 2021). Global population and energy demand have grown significantly since the end of the second world war, increasing global demand for oil resulting in increased greenhouse gas (GHG) emissions. Expansion of the oil and gas industry solved the demand for energy; however, increased emissions have led to higher global temperatures and governments are looking at developing lower carbon sources of energy. Hydroelectric projects are viewed as a clean source of energy; however, they can have significant environmental impacts on species and ecosystems. Site C has been a controversial project, opposed by many Indigenous groups, environmental groups, communities and stakeholders.

The environmental impacts from the W.A.C. Bennett Dam affected the traditional way of life for other Indigenous communities like the McLeod Lake Indian Band, Dene Tha, Doig River, Halfway River, West Moberly, Prophet River, Horse Lake, Duncan and Saulteau First Nations. Many Indigenous people still live off the land and have generations of experience out in the field and sustainability is part of their cultural tradition. Indigenous people understand the impacts man can have on the environment through traditional and experiential knowledge. Governments and industry are starting to recognize the importance and scientific value of traditional knowledge (TK) and its usefulness for project design, baseline data collection, identification of valued environmental components (VEC), identification of temporal and spatial boundaries, potential mitigation measures, and monitoring (Government of Canada, 2020).

The Impacts Assessment Act (IAA) requires that traditional knowledge or Indigenous knowledge (IK) be included along with science in the assessment (Government of Canada, 2020). There are many different definitions for traditional knowledge and Indigenous knowledge, which can also be tribal specific, and traditional ecological knowledge (TEK) is another term that is used quite frequently in scholarly discourse. For the purposes of this study, the term traditional knowledge will be used to include Indigenous knowledge and TEK and other knowledge that may have originated outside the community but has been incorporated in their knowledge system and traditional way of life. Traditional knowledge takes a holistic approach and can provide understandings of the biophysical environment and includes economic, health, social, and cultural issues as well as, insights into traditional laws and governance and sharing of resources (Government of Canada, 2020). In line with OCAP (2010), the principles of ethical research with First Nations communicates are ownership, control, access and possession (First Nations Information and Governance Centre, 2021). Therefore, traditional knowledge is to be respected, and cultural and spiritual information should remain confidential and only released at the discretion of the Knowledge Keepers and/or the communities.

This capstone project will be a review of the impact of regulation on the Peace River and its tributaries and the impacts on VECs such as mammals, fish, waterfowl, and vegetation that depend on the rivers and lakes in the study area. The study will also review the impacts of cumulative effects of other energy developments in the study area. The information used in the study was from the BC Hydro's Site C Project EIS. The Environmental Background (Volume 2, Section 11) of the EIS and other commissioned studies were used to source science information on the hydrology of the Peace River and the impact of regulation. The project relied heavily on the Traditional Land Use Studies (TLUS) of the Kelly Lake Metis Settlement Society (KLMSS) and the BRFN were used for traditional knowledge associated with regional ecosystems. Cartofact GIS was used to map rivers and lakes and species that were impacted by hydroelectric projects on the Peace River and other energy development projects in the area.

1.1 Research Analysis and Sustainable Development Goals

This research project provides a holistic analysis of energy, environment and traditional knowledge sustainability. Site C is currently under construction on the Peace River in northeast British Columbia. Previous construction of the W.A.C. Bennett Dam and impoundment of the Williston Reservoir in 1968 had significant environmental impacts (KS Davison and Associates, 2012). This project changed the seasonal flow and geomorphology of the Peace River as well as, delaying ice formation to the town of Peace River (Peters, 2001). Fluctuation in water levels and subsequent environmental changes impacted species that Indigenous groups rely upon. Development of oil and gas and the expansion of industrial, agriculture, and urban development have also exacerbated the problem for local communities. Incorporating traditional knowledge is not only a regulatory requirement but also an opportunity to develop a more collaborative approach with governments and proponents to share knowledge regarding energy projects and sustainability.

The UN Sustainable Development Goals addressed in this study include: #7 Affordable and Clean Energy, #14 Life Below Water, and #15 Life on Land (Nations, United, n.d.). The Site C Project will provide clean energy into the electrical grid; however, project cost has increased dramatically and there are still environmental concerns from non-government organizations (NGO), communities, stakeholders, and Indigenous groups. The impoundment of the Site C reservoir will impact habitats from the Peace Canyon (PC) Dam to the Site C Dam. Similar impacts that occurred due to the impoundment of the Williston Reservoir and Dinosaur Reservoir are expected at Site C. Species that are important to Indigenous communities will be impacted by this project. Additionally, development of the Montney gas play, coal mining, forestry, farming, and other industrial activities are impacting ecosystems and the species that inhabit them, making it difficult for Indigenous peoples to live a traditional way of life, which is part of their treaty rights and recognized by section 35 of the Constitution of Canada (Littlebear, 2009).

1.2 Project Scope

1.2.1 Research Problem

Indigenous systems for managing the environment are an integral part of each Indigenous communities' social integrity and cultural identity and are most often based on community members lived experiential knowledge gained over Millenia and orally passed down through generations (Mazzocchi, 2006). Traditional knowledge emphasizes the symbiotic relationship of humans with animals and nature and offers local knowledge based on the co-evolution with the environment and an intimate understanding of the capacity of ecosystems (Mazzocchi, 2006). There are practical applications for strategy and decision-making regarding water management, agriculture and animal husbandry, biological classification, hunting and fishing, forest fire management, and energy and natural resource development. Traditional knowledge is empirical, subjective and qualitative, whereas science is analytical, reductionist, and quantitative. The biggest difference between traditional knowledge and science is that science isolates individual components of the study in controlled and simplified experiments, separating them from the complexities of the natural world. Traditional knowledge does not view the world based on linear conceptions of cause and effect but as constantly forming multidimensional cycles where all elements are part of a complex web of entangled interactions (Mazzocchi, 2006). It can be very difficult to compare these knowledge systems and it is important not to try to analyse and validate one system with the criteria of the other, potentially distorting the system in the process (Mazzocchi, 2006).

The energy sustainability challenge will be to determine an approach to improve the understanding of both knowledge systems by identifying areas where complementary data exists and where they differ on environmental impacts. Through this study, I also noted an opportunity for Indigenous communities to control how their knowledge and expertise is represented and disseminated. Indigenous communities must protect their harvesting areas and at the same time reveal where these areas are in EIA submissions to protect these areas from development. The dilemma for Indigenous communities is map or be mapped.

Geographical Information Systems (GIS) have become a relatively inexpensive tool for mapping and allow the user to store large amounts of data on layers stored within the GIS. The systems require some software knowledge but are generally user friendly. It is important that traditional knowledge is properly represented and recognized in EIA, and it is imperative that some areas of traditional knowledge remain confidential to protect and respect what is considered spiritual and sacred to each specific Indigenous communities' way of life. GIS also provide the opportunity for communities to collect traditional knowledge that might be lost due to passing generations of community Elders and/or Traditional Knowledge Keepers.

Water resources are becoming a precious commodity and it is important for Indigenous communities to ensure a safe and abundant supply of water for their own use, but also to sustain the ecosystems and wildlife that are important to their communities. Understanding the changes in ecosystems and monitoring changes in surface hydrology and impacts of VEC species can be mapped in GIS. Information can be stored and communities can manage the collection and presentation of the data. They can also download shape files from governments and industry for comparative or future work. Comprehensive mapping projects can be undertaken in GIS, and the data can be compared and modified to include additional information for TLUS and inclusion in impact assessments.

1.2.2 Need for the Study

Proponents preparing and EIA under the Impact Assessment Act (IAA) are expected to engage with affected Indigenous communities and begin environmental and socio-economic assessments before filing an application or project descriptions to government agencies (Government of Canada, 2020). The Canadian Environmental Assessment Act (CEAA) and the

Impact Assessment Act (IAA) require input from Indigenous groups as part of the consultation and regulatory process (Government of Canada, 2020). The regulatory process has made proponents more aware and conscientious regarding treaty rights as well as, the *duty to consult* and accommodate with Indigenous peoples. This was part of the agreement between Indigenous leaders and the crown when the treaties were originally signed.

Their lands and way of life are affected by major energy projects and this is not only a concern for Indigenous communities but for local stakeholders and non-Indigenous communities alike. In 2016, BC Hydro's Deputy CEO Chris O'Reilly acknowledged the adverse impacts of the W.A.C. Bennett Dam on the environment and Indigenous communities and that BC Hydro would not repeat past mistakes (Cox, 2016). When the Williston Reservoir was impounded by the W.A.C. Bennett Dam, the local Indigenous communities were not informed that impoundment was even occurring (Cox, 2016). Therefore, in this case, consultation did not occur which is the responsibility of the federal and provincial governments. The province of BC is also legally obligated to accommodate and consult with First Nations on land and resource decision that may impact their interests (Government of British Columbia, n.d.a). Sharing of resources is something that was promised to First Nations; however, the Kwadacha First Nation, located on the Finley River northeast of the Williston Reservoir, still relies on diesel for electricity generation due to lack of hydro power (Cox, 2016).

Impoundment of the Williston Reservoir had significant environmental impacts. Improper clearing of the reservoir area resulted in an abundance of debris and log jams making it difficult for animals to cross; and it also resulted in increased methylmercury production by microorganisms in sediment which subsequently contaminated fish populations in the reservoir

(Cox, 2016). Migration routes were cut-off, trails and gathering sites were destroyed, and traditional ceremonial sites and burial grounds now lie under water (Cox, 2016). Disrespect and disregard for Indigenous grave sites is a problem in Canada and many people were shocked at the recent discovery of unmarked graves on the sites of former residential schools. The oral history of residential school survivors has provided knowledge of potential sites of unmarked graves for future ground-penetrating radar surveys and Indigenous people fear many more grave sites will be found (Sawyer, 2021). According to the BRFN TLUS, burial sites would have been located along the banks of the Peace River where the Beaver people were located, however the exact location off these burial sites is unknown (Bouchard & Kennedy, 2011). GIS provides a platform to capture and store this information. GIS are also useful for temporal mapping. Air photos or satellite images that are georeferenced can be imported into GIS. This allows the user to identify changes in geomorphology, land use and potential ground disturbances, like unmarked graves.

It is important that governments and proponents understand the impacts their decisions will have on Indigenous communities, and it is equally important that Indigenous people effectively communicate their concerns to industry and government. Mapping impacts to watersheds, species of concerns, and especially cumulative effects, are an effective way of accomplishing this goal. The IAA allows for Indigenous led assessments and this is an opportunity for Indigenous groups to present their knowledge in a way that exerts their rights for meaningful consultation. There is a misunderstanding amongst the general public that Indigenous communities are against energy projects due to the historic conflicts with governments and industry, which is not the case. Objections by Indigenous groups to energy projects are often related to their treaty rights not being recognized and/or an improper consultation process. The *duty to consult* is the responsibility of both levels of government and it is imperative that governments fulfill their fiduciary duty to Indigenous communities to avoid lengthy delays in project approval. In 2018, the Federal Court of appeal overturned Kinder Morgan's approval of the Trans Mountain Pipeline Expansion Project by the National Energy Board resulting in costly delays (Bryden, 2018).

1.2.3 Objectives of the Study

The objective of the study is to provide GIS mapping tools to improve the integration of traditional knowledge and science into EIA. Understanding the environmental consequences of energy development and other industrial projects is critical for sustainable development to occur. Hydroelectric projects in northeast British Columbia (BC) have impacted water quality and quantity, altering seasonal discharge levels, changed sediment distribution, and changed some ecosystems completely. Altering habitats will impact species that Indigenous people rely on and it is important to understand how and what are causing these changes to occur. Indigenous groups are forced to live with these changes or travel further to sustain themselves which has a cost.

The traditional way of life has provided Indigenous people with a unique understanding of the interconnectedness of all things and intimate knowledge of the natural world. However, since the knowledge is passed down orally and there is no formal documentation, it is problematic for the scientist because there is a lack of understanding of the methodology behind it. Mapping in GIS will allow Indigenous groups to convey their knowledge and concerns in a manner familiar to industry and governments. Improving the integration of information from the two knowledge systems may fill in the knowledge gaps and improve the integration into EIA. Introducing new mapping techniques for cumulative effects may improve the understanding of how numerous projects over time are impacting the environment and Indigenous communities.

1.2.4 Project Approach

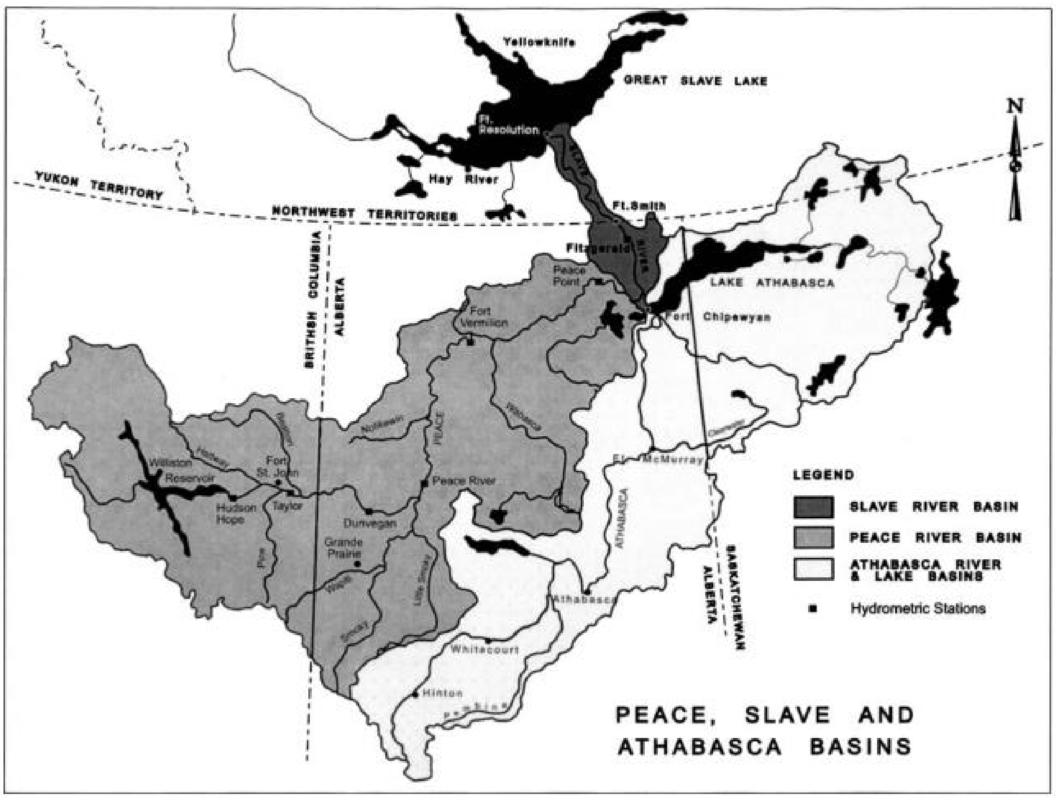
This project will take a qualitative approach to identify how science and traditional knowledge are complementary and where they differ using the Site C EIS as a case study. Much of the knowledge presented in Traditional Land Use Studies (TLUS) in the Site C EIS focuses on impacts of the W.A.C Bennett Dam. This study will focus on all TLUS information that pertains to changes in water levels and impacts on VEC species. This information will include traditional knowledge of impact on hunting, fishing and gathering of traditional foods and medicines before and after the construction of the W.A.C. Bennett Dam. Some studies have made direct reference to changes in water levels while others focused on impacts to the VECs. The VECs selected for the project are: the surface hydrology, and the species that are of interest to local Indigenous communities.

VECs are aspects of the human or physical environment that are deemed to be important and require investigation, review, and analysis in the EIA (Noble, 2014). VEC indicator species can be a species or group of species that can reveal a qualitative or quantitative estimation of environmental impacts to allow decision makers to estimate environmental change (Noble, 2014). Population or functions of species may alter due to environmental change. The study will map science and traditional knowledge of VECs with information provided by BC Hydro, TLUS and other scientific studies.

1.3 Background

The Peace River is a 1,923-kilometer river that is part of the Mackenzie River drainage system and its the principal tributary (Leonard, 2018). Figure 2 shows the Peace, Slave and Athabasca basins. The Dane-Zaa word for the Peace River is unchaga which translates to ‘big river” (Leonard, 2018). The Peace River Basin drains an area approximate 233,000 square kilometers

Figure 2: Peace, Slave and Athabasca Basins.



Note: (Prowse et al., 2006).

and has a discharge of 3,800 cubic meters per second (BC Adventure, n.d.). The Peace River extends from the Rocky Mountain Trench in northeast British Columbia to the Peace-Athabasca Delta and Slave Rivers in northeast Alberta. Formerly, the Peace River was formed at the juncture of the Parsnip and Finlay Rivers in the Rocky Mountain Trench. The W.A.C Bennett Dam was constructed in 1968 and it was the first of three hydroelectric projects to be constructed on the Peace River west of the town of Hudson Hope, BC. Major tributaries downstream of the W.A.C. Bennett Dam include the Halfway, Pine, Beatton, Smoky and Wabasca Rivers. Currently the Peace River begins at the PC Dam, flows east to the town of Peace River, turns north to the town of Fort Vermillion, and then east and north to the Peace-Athabasca Delta.

Hydroelectric projects are being built to supply our ever-increasing demand for electricity. Flooding behind the W.A.C. Bennett Dam and changes in the flow regime downstream of the dam had environmental impacts that affected Indigenous communities. BC Hydro owns and operates the W.A.C. Bennett Dam, the PC Dam and the Site C Project. The W.A.C. Bennett Dam is a 183-meter-high earthfill dam that inundated the Peace, Parsnip and Findlay Rivers and impounds the Williston Reservoir which covers an area of 1,773 km^2 (BC Hydro, 2013). The dam is constructed at a natural outlet in the northern part of the Rocky Mountain Trench (BC Hydro, 2013a). The generating station has an installed capacity of 2,730 MW from 10 generating units (BC Hydro, 2013a). The total maximum discharge of the facility is over 11,000 m^3/s, approximately 2,000 m^3/s is used for generation and the remainder is used for the spillway (BC Hydro, 2013a). In 1976, the PC Dam was constructed 23 kilometers downstream of the W.A.C. Bennett Dam just southwest of the town of Hudson Hope (BC Hydro, 2013a). The PC Dam is a 61-meter-high run-of-the-river dam that impounds Dinosaur Reservoir. The Dinosaur Reservoir has an active storage of 0.1% of the storage capacity of Williston Lake (BC Hydro, 2013a). The PC Dam has an installed capacity or 694 MW from 4 generating units (BC Hydro, 2013a). Site C construction began in 2015 and has an expected completion date of 2025. The Site C Dam will have a generating capacity of up to 1,100 megawatts (MW) and 5,100 gigawatt hours (GWh) of energy each year and will be operated as a run-of-river project (BC Hydro, 2013a).

1.3.1 Site "C" Clean Energy Project Submissions

BC Hydro submitted the Project Description Report for Site C on May 11, 2011, to the federal Minister of Environment and the Executive Director of the Environmental Assessment Office of British Columbia and they agreed to a Cooperative Environmental Assessment and entered into the agreement on February 8, 2012 (BC Hydro, 2013a). The Site C EIS was conducted pursuant to the Canadian Environmental Impact Assessment Act, 2012 and the B.C. Environmental Assessment Act (BC Hydro, 2013a). The EIS was carried out in accordance with the Agreement to Conduct a Cooperative Environmental Assessment, including the establishment of a Joint Review Panel of Site C, which was amended in August of the same year (BC Hydro, 2013a). The federal Minister of Environment and the Executive Director of the Environmental Assessment Office of British Columbia issued Environmental Impact Statement Guidelines for the Site C project on September 5, 2012 (BC Hydro, 2013a). The Site C EIS was submitted in early 2013 and was given approval in October 2014 (Site C Clean Energy Project, 2017).

Chapter 2. Traditional Knowledge and Science Knowledge Systems

2.1 Traditional Knowledge System

It has been acknowledged on a global level, within the United Nation Declaration on the Rights of Indigenous peoples (2007) and other scholarly works, that most Indigenous cultures have retained an intimate understanding of the natural world, the relationship between animals and humans, and the healing power of plants, while adjusting to natural rhythms of the planet and caring for the land (Knudtson, 1997). Scientists and researchers are sometimes reluctant to consider Indigenous scientific knowledge because there is a lack of understanding of its methodology. Indigenous people utilize axiology, epistemology, logic and process, in their understanding of the natural world (Cajete, 2015). Traditional knowledge is culturally embedded, has significant ethical and moral context, and understands the interconnectedness of culture practices and the natural world (Noble, 2014).

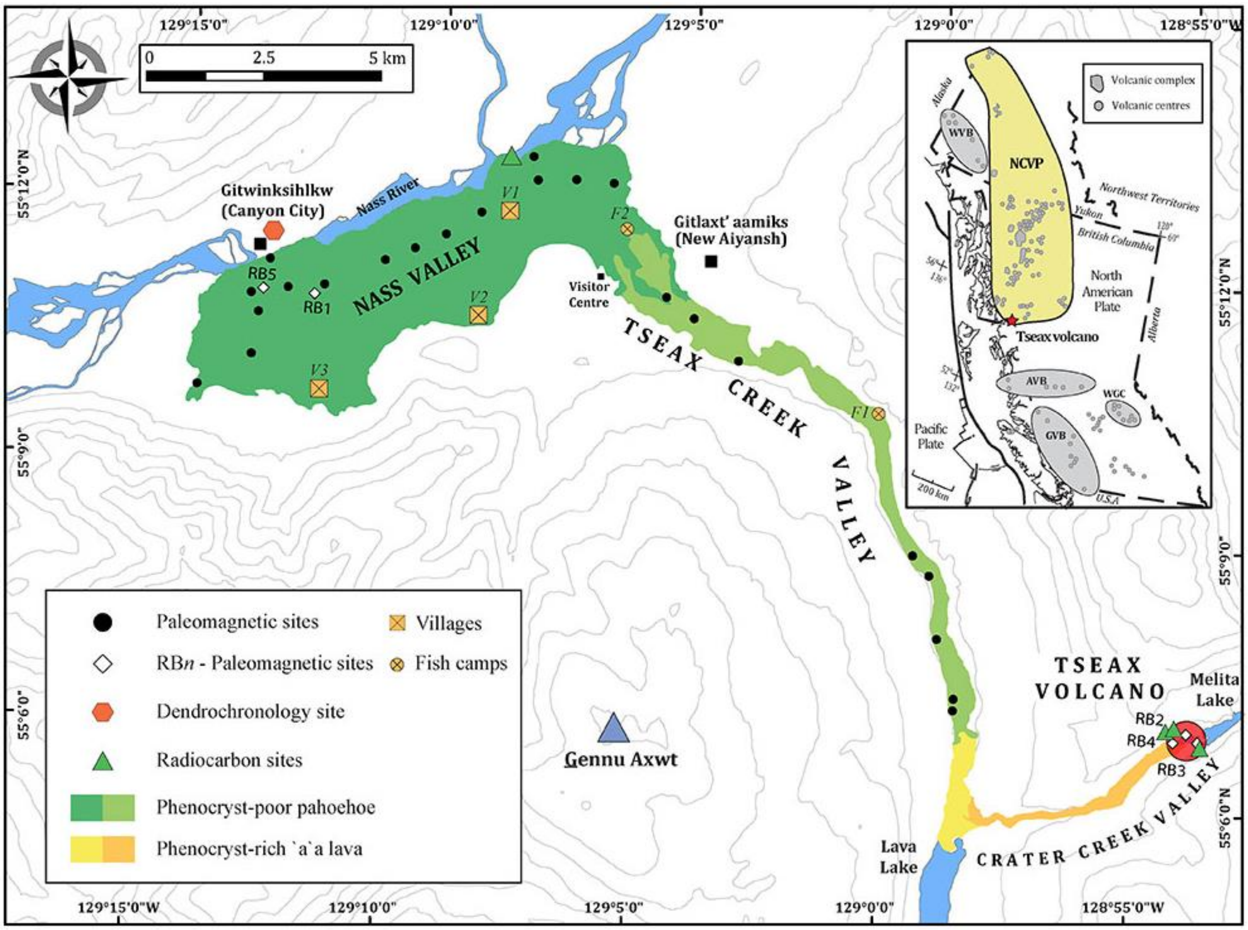
The Keeyask Hydroelectric project is a collaborative effort between the Keeyask Cree Nations (KCN) and Manitoba Hydro. The Keeyask project EIS makes reference to the world view of the KCN as being "interconnected and/or interrelated with all living things of the ecosystem with an emphasis on relationships, harmony and balance" (Noble, 2014). There is a major difference and disconnect between the Indigenous holistic and the scientific reductionist methodologies. The differences in the approach of the knowledge systems are significant and accepting of the other data can be problematic for both Indigenous people and the scientist. Many Indigenous cultures do not consider individual parts of a system but focus on the relationship of all elements of the natural world (Cajete, 2000). Indigenous cultures have practiced sustainability for millenia and science is just starting to understand the concept of over consumption and conservation, now requiring a global energy transition to reduce CO_2 emissions to mitigate global temperature rise.

The global Coronavirus pandemic is an example of science and society not understanding the traditional knowledge principle of interconnectedness of the natural world or choosing to ignore it. More than 210 million people have caught the virus and there have been more than 4.4 million deaths (Worldometer, 2021). The virus infiltrated every corner of the globe demonstrating that we are inextricably linked together. Health officials are concerned about species-to-species transmission and the ability of the viruses to mutate rapidly, as we have seen with the delta variant of the Covid-19 virus. The rise in global population and need for food will result in greater interaction between man and other species increasing the potential for species-to-species transmission. The demand for food will also increase the need for energy and water. Sustainability is part of Indigenous cultural practices, and the knowledge base is vast and untapped (Cajete, 2000). Examining traditional knowledge can be used, in conjunction with science, to improve society's sustainability practices and may provide insight on how a cultural shift may be required to achieve sustainable development.

Traditional knowledge is practical, holistic, and experiential in nature and is intergenerational. Language, culture, spirituality and social organization are important facets of traditional knowledge and it sets out practices governing the use, respect and obligation to share resources (Kennedy, 2020). When traditional knowledge is acquired by non-Indigenous researchers for EIA it must be done in a culturally appropriate manner and respected, as it is spiritual in nature and has survivability advantages for communities (Kennedy, 2020). Many Indigenous people still live off the land and major energy projects can have significant impacts on their ability to access traditional food sources. Federal guidelines require proponents to consider traditional knowledge when assessing impacts of energy projects on their societies, economies and environments. Oil and gas development, pipelines, and hydroelectric projects not only have impacts in the immediate area of project development but can have impacts kilometers or hundreds of kilometers away. Regulation downstream of the Peace River has potentially affected channel alteration, sediment availability, spring ice-jam flooding, and water supply to the Peace-Athabasca Delta (Peters, 2001). Changes in water levels in lakes and rivers can directly affect ecosystems and the species they support. Moose are a very important part of Indigenous people's traditional diet in the Site C area (Bouchard & Kennedy, 2011). Construction of the W.A.C Bennett Dam and the impounding of the Williston Reservoir had environmental impacts that affected the habitats for moose forcing them to relocate to find suitable areas for calving, feeding, and to escape predation (Bouchard & Kennedy, 2011).

Indigenous people have lived in their traditional territories for millenia, experienced major environmental changes since the last ice age, and have successfully adapted. Land based knowledge and the ability to adapt to changing ecosystems is critical for Indigenous peoples continued survival and to thrive as a community, while maintaining harmony with nature. Indigenous people's holistic approach to sustainability is culturally and spiritually engrained in Indigenous cultures across the planet. The metaphoric mind is not well understood by the scientific community and sometimes traditional knowledge is not regarded as important as science due to perception of knowledge hierarchy which may limit the efficacy of applying traditional knowledge to the EIA process (Eckert, 2020). However, in recent years there has been more collaboration between scientists and Traditional Knowledge Keepers. The Tseax River cinder cone (local name Aiyansh), in the territory of the Nisga'a People in northern BC, has been the location of some of the most recent volcanic eruptions in Canada (Global Volcanism Program, 2013). Figure 3 shows the lava field associated with the Tseax volcano on the Nisga'a Territory.

Figure 3: Tseax Lava Field.



Note: (Minke-Martin, 2020).

The Tseax volcano is part of the Northern Cordilleran Volcanic Belt that extends from north British Columbia to eastern Alaska (Le Moigne, Williams-Jones, Russel , & Quane, 2020). The volcano erupted approximately 250 years ago, killed about 2,000 Nisga'a people, and destroyed two villages (Albert, 2017). Nisga'a oral tradition tells of a "prolonged period of disruption" where villages were destroyed and people were killed by a “poison smoke” (Global Volcanism Program, 2013). The oral tradition was first described in 1935 and presented a better way to understand how the volcanic events unfolded because it is difficult to be deduced from solidified surface rocks (Albert, 2017). The oral histories recorded by local First Nations accurately described what typically happens during these types of eruptions and the “poison smoke” was probably a combination of carbon dioxide (CO_2), sulphur dioxide (SO_2) and water vapour which is typical of most volcanic eruptions. This is one of many examples of how traditional knowledge is not only corroborating the factual event but improving the scientific understanding.

Controlled burns were also used by Indigenous people to manage rangelands and forests. Forest fires currently burning in Oregon, California, and BC are very costly in terms of the environment, the economy, and the lives lost, both human and animal. As global temperatures continue to increase and precipitation patterns change the increased risk of mortality, health impacts, and cost of forest fires needs to be addressed. For Indigenous communities, forest fire management is an important element of their stewardship of the land; however, traditional knowledge is not currently being utilized in forest fire management (Mason, et al., 2012). Controlled burns were used to manage the buildup of combustible matter, pest control, creating grazing land, stimulate the growth of vegetation and creating fuel breaks around villages and camps (Indigenous Corporate Training Inc., 2019). The slash and burn practice used by settlers to clear vast tracts of forest for agricultural use, expose outcrops for geological surveys and maintain railways resulted in out-of-control fires as weather conditions were not taken into consideration, resulting in government policies that focused on forest fire suppression instead of management (Indigenous Corporate Training Inc., 2019). May 2016, the University of Royal Holloway London published a paper entitled *Traditional Knowledge Could Hold the Key to Management of Wildfire Risk* and the study used satellite imagery which suggested Indigenous lands had a lower incidence of wildfires (University of Royal Holloway London, 2016). This study examined fire practices in savannas and tropical forest; however, similar practices have been used by Indigenous peoples in North America on the plains extending to the boreal forests in Canada. Burns were used to create lush grazing land for the buffalo in preparation for buffalo jumps that happened in late summer and fall (Indigenous Corporate Training Inc., 2019). The buffalo would graze in these areas and then be driven down lanes and over the cliffs. Local knowledge is incredibly important in understanding how the wind and the weather will affect fire movement. This knowledge has been accumulated over thousands of years. There are also additional examples of collaboration with other fields of study including fisheries management and wildlife conservation as well as, using oral tradition to confirm the occurrence and timing of Tsunami's on the west coast of North America.

2.1.1 Traditional Land Use Studies

TLUS provide the documentation of an Indigenous communities' traditional way of life. The studies try to clarify the relationships between people and their land resources and territories both in the present and the past (Bouchard & Kennedy, 2011). The term traditional connects current land use to practices of the past (Bouchard & Kennedy, 2011). The TLUS in the Site C EIS varied in content depending on the availability of resources to do the study or whether they were directly impacted by the Site C project. Indigenous groups are becoming increasingly involved in impact assessments and Indigenous led assessments are becoming more common. The TLUS are a wealth of information and it is gathered through interviews with Knowledge Keepers, Elders, Cultural Advisors and community members. Traditional knowledge Keepers are responsible for how the knowledge is disseminated and to whom (Office of Indigenous Initiatives, n.d.). Knowledge Keepers, Elders, and Cultural Advisors play and integral role in the community as they are the teachers within and beyond the community (Office of Indigenous Initiatives, n.d.). Sanctioning of traditional knowledge through the proper tribal society acknowledgements and how knowledge about the natural world and relating to it is an important cultural tradition that focuses on the benefit and perpetuation of the community rather than the individual (Cajete, 2000). Knowledge within the community will be shared like a government leader or CEO disseminates information to best execute the strategy they desire. The Knowledge Keepers teachings can include but are not limited to: language, value systems, traditional biology, wellness, ceremonial knowledge and protocols, cultural and spiritual understandings, and governance structures (Office of Indigenous Initiatives, n.d.). This study will respect traditional and cultural sensitivities and will focus primarily on the knowledge of impacts to VECs.

2.2 Science Knowledge System

Science uses reductionist techniques, rapid data acquisition, short term prediction and is analytical based on the subsets of the whole (Kennedy, 2020). Traditional knowledge and science have very different methodological approaches. Science is learned through formal education with explanations based on natural laws, theories, models and hypotheses (Kennedy, 2020). Although it has powerful predictability in natural principles it is lacking in local areas of knowledge (Kennedy, 2020). Many scientific studies are rigorous in nature and contain large amounts of data. However, they are done over of shorter time frames (seasons or a few years) for specific purposes like Site C and may have significant gaps over longer periods of time or may have little relevance without other data to compare it to. Science is disciplined based where its knowledge is broken down into categories like physics, biology, or chemistry and the experiments are usually designed within these disciplines with controlled variables (Combining Two Ways of Knowing, n.d.).

Water is our most valuable resource and there are concerns that over use and climate change will impact the availability of this resource. The "heat dome" that settled over Canada in late June 2021 shattered temperature records in BC and Alberta. On June 29, 2021, Lytton, BC set a new national record high temperature of 49.6 ^{o}C and 7 other locations in southern BC exceeded the previous all time record high of 45 ^{o}C set in Yellow Grass, Saskatchewan (Uguen-Csenge & Lindsay, 2021). Aquatic species like clams, mussels and other shellfish experienced a massive die-off during the heat wave, crops were damaged and the hot and dry weather has led to drought conditions in BC and Alberta (Shivaram, 2021). Increased water uses from the oil and gas sector, agricultural production, and other industrial activities are putting increased pressure on Canada's water resources.

All life requires water and when we explore beyond our planet the first thing scientist look for is the presence of water and ability for other celestial bodies to support life. Environmental conditions on earth have changed over time and life has evolved to adapt to this change. The rock record documents the earth's history of environmental change. Our planet's history tells us that climate and environmental change is the norm not the exception; however, emissions are causing an additional impact in conjunction with the natural earth cycles and the consequences of this impact is unknown. Record breaking temperatures, droughts, and forest fires in Canada and the United States are exerting a huge financial toll on both countries and have caused increased deaths from the heat wave, increased health advisories from the smoke and particulate inhalation, and rationing of water. We are now in a period being informally referred to as the Anthropocene as man has become the most influential species on the planet. Our need for energy is continuing to grow and for some the energy transition to renewables is not happening fast enough; however, hydroelectric projects like Site C do provide low carbon electricity but it comes with environmental impacts that affect local communities.

Chapter 3. Environmental Protection and Assessment in Canada

The Canadian Environmental Protection Act (CEPA 1999) came into effect in March 2000 and pollution prevention is a cornerstone of national effort to reduce the release of toxic substances into the environment (Government of Canada, 2017). The Act sets out processes to manage risks to the environment and human health posed by toxic substances used commercially (Government of Canada, 2017). The Canadian Environmental Assessment Act (CEAA) was originally introduced in 1992 but was repealed in 2012, reducing the assessments required for projects under federal jurisdiction. However, the CEAA 2012 was expanded to include economic health and social effects of proposed projects including assessing the impacts to Indigenous groups and their treaty rights (Canadian Environmental Assessment Agency, 2019). The Site C Clean Energy project was assessed under CEAA (2012).

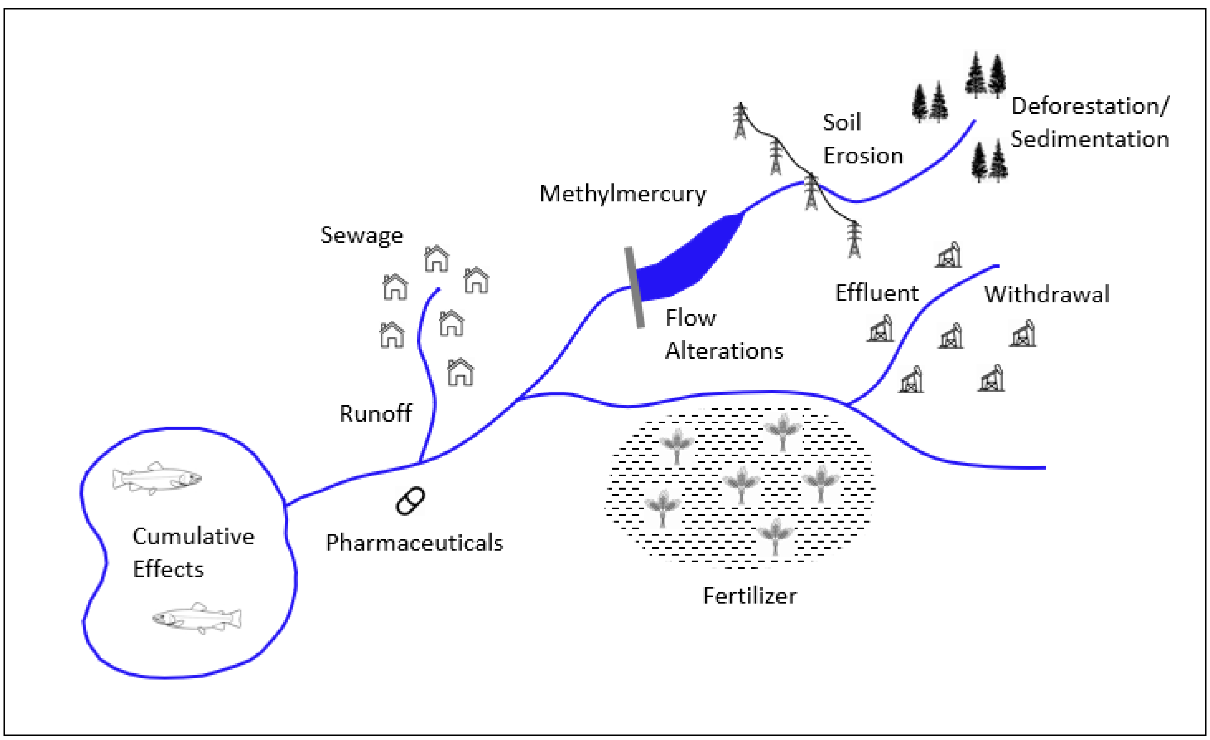
3.1 Impact Assessment Act/Canadian Environmental Assessment Act and Indigenous Inclusion

The IAA was enacted by the Federal Government of Canada in 2019 and has replaced CEAA 2012. One of the purposes of the IAA/CEAA is to ensure decisions are based on traditional knowledge, science, and other available sources of information. Indigenous people's experiential and scientific approach has served them well over the years, but very little work has been done to understand their connection to the environment and the planet and their ability to adapt to change. Traditional knowledge is a valuable resource and industry and governments need to clearly understand the message Indigenous peoples are trying to convey. There is sometimes a reluctance by governments and industry to accept traditional knowledge because it is holistic and qualitative in nature. Traditional knowledge is important for government and industry to consider, and when used in conjunction with scientific knowledge, it may provide a more comprehensive understanding of both shorter- and longer-term impacts. Traditional knowledge and science can vary over time and space but can also provide complementary sources of information filling in the gaps for the other.

3.1.1 Cumulative Effects Assessment

Cumulative Effects Assessment is a more comprehensive approach to EIA that takes into consideration the multiple interactions of natural processes and human activities that accumulate across time and space (Noble, 2014). Individual projects may not have large environmental impacts but when considered with other actions of the past, present, and foreseeable future, may collectively have significant effects. Examples of cumulative effects

Figure 4: Sources of Cumulative Environmental Effects in a Watershed.



Note: (Author, 2021). Adapted from Noble (2014).

include increased sedimentation due to soil erosion from transmission line crossings or deforestation, water withdrawals and discharges, oil and gas activity, runoff (sewage and fertilizer), and flow alterations from hydroelectric projects (Figure 4). Policies, laws and regulations for natural resource management focus on specific sectors like hydroelectric projects, forestry, mining or oil and gas.

In British Columbia, formal environmental assessments are required for large projects, however many of the projects are small in size and do not require an assessment. CEA is still evolving in Canada and there is more concern with project-induced stress and ensuring that the impacts of the project remain relatively small, rather than understanding the total impact of all stressors. Proponents are focused on meeting public acceptance and regulatory approvals and thus minimizing the effort of understanding cumulative effects (Noble, 2014). CEA are a very important part of understanding how Indigenous people and other communities are affected by multiple energy development projects over time. Cumulative effects may include roads, seismic cut lines, oil and gas well sites, pipelines, facilities, hydroelectric projects, power and transmission lines, forestry and mining operations. This project will map cumulative effects in GIS and these maps should be part of any TLUS or EIA submission.

3.1.2 The Valued Environmental Component

VECs are aspects of the physical and human environment that people value and are considered important from a public or scientific perspective (Noble, 2014). Once the VECs are identified they are studied in detail in impact assessments. Each impact assessment is different; therefore, careful consideration must be given when identifying what VECs require detailed examination. VECs can be part of the physical, biophysical, aquatic, terrestrial, atmospheric, hydrology and surface water, economic, health or socio-cultural environments (Noble, 2014). Societal values and ecological importance are common rationales for VEC selection but other rationales of importance to Indigenous communities include rarity, medicinal importance, spiritual importance, biodiversity, and conservation value (Noble, 2014).

Science undertakes extensive baseline studies that accumulate large amounts of data; however, if the baseline does not have clearly defined scope and objectives, they can often be a waste of time and resources (Noble, 2014). If the data collected is conducted over a short time frame or has no previous studies to be compared to, the data is not useful. For example, some studies in the Site C EIS used sightings of VECs to determine population numbers, where the studies were done over a season or a few years. Traditional knowledge has a significant advantage over science in this area because traditional knowledge collects data over decades or hundreds of years or longer. The challenge is this data is past down orally and detailed statistics are not often compiled. GIS can be used as a tool to compile both data sets to provide a more comprehensive understanding of the information gathered to determine a path for future work. A collaborative approach to participate in scientific studies and share traditional knowledge and science knowledge will be the first step toward better relationships and building trust to form long term partnerships that are sustainable for all parties involved.

The volume of data presented in the detailed TLUS is comprehensive. There is extensive mapping of traditional knowledge presented in the EIS that shows where favourable harvesting areas are located; however, there was very little mapping of watershed or species that have been impacted. This was also the case for science submissions and other studies. Impacts on species or surface hydrology can be the result of many things, so cumulative effects mapping is important in understanding how each development is contributing to overall change. Many Indigenous groups do not have the capacity to undertake these types of studies; however, GIS provides Indigenous communities with an inexpensive way of compiling and storing data.

3.2 Environmental Impact Assessment

An EIA, or in the case of Site C the EIS, is a tool to evaluate the environmental impacts of major energy projects that require government approval. EIA is an environment management tool that takes an integrated approach to prevent environmental problems. The intent of an EIA is to provide the federal government with an understanding of potential environmental consequences of a project. The EIA should identify unwanted impacts and determine appropriate mitigation measures and it also provides an opportunity for the government to alter or abandon a project plan if major environmental effects cannot be mitigated.

The *duty to consult* and accommodate is the constitutional responsibility of the federal and provincial governments in making decisions regarding the project. The Supreme Court of Canada has ruled on numerous cases regarding Indigenous rights and the *duty to consult*. The R. v. Sparrow case in 1990 was a precedent-setting decision by the Supreme Court of Canada on Aboriginal rights that led to the Sparrow Test to determine if the rights were existing, and if they were, how could the government infringe upon those rights (Salomons & Hanson, 2009). The first part of the test was whether or not a right has been infringed upon:

- Does the activity cause undue hardship on the First Nation?
- Does the court consider it unreasonable?
- Does it prevent the rights holder from exercising that right?

The second part of the test outlines what might justify an infringement upon and Aboriginal right. An infringement might be justified if:

- It has a “valid legislative objective”. A valid objective would be conservation of natural resources where Aboriginal interest would come second to that.
- Infringement was minimal to achieve the desired result.
- Fair compensation was provided, and
- Aboriginal groups were consulted or a minimum informed (Salomons & Hanson, 2009).

Outstanding questions regarding consultation were addressed in the *Haida Nation v British Columbia*. The Haida Nation was involved in a title claim to the Haida Gwaii Islands (Queen Charlottes) when the Ministry of Forests approved the transfer of a tree farm licence to Weyerhaeuser Company Limited (Raven, 2012). The Nation argued that without accommodation or consultation, by the time their title claim was decided upon the land and the forest would be cleared. The Supreme Court of Canada ruled that the Government of British Columbia had the legal *duty to consult* with the Haida, and where appropriate accommodate (Raven, 2012). Section 35 of the Constitution Act of 1982 has enshrined the rights of Indigenous people and the *duty to consult* and the Supreme Court of Canada has ruled on it. However, consultation is a two-way process and First Nations must also operate in good faith and must be engaged in the process to avoid loss of consultation opportunities because of a lack of engagement (Killoran, Denstedt, Wall, & Sutherland, 2018). The concepts of “meaningful consultation” and “good faith” are still vague, and agreeable definitions of these terms will require that governments, industry and Indigenous communities work together to avoid uncertainty for investors of large energy projects in Canada. Consultation should not only occur at the beginning of the process but Indigenous groups should be involved during the construction, operation and decommissioning of the projects to ensure that the government and proponents are holding up their end of the agreement and that treaty rights are being protected.

Chapter 4. Methodology

The Site C EIS was accessed through the Impact Assessment Agency of Canada website. All 29 TLUS and 7 First Nations community baseline reports were reviewed for available traditional knowledge pertaining to VECs+ and surface hydrology as well as, science information provided by BC Hydro submissions and other technical reports. The BRFN and Kelly Lake Metis Settlement Society (KLMSS) TLUS were selected for the study. The BRFN was selected due to the comprehensive nature of the study and the Site C project was entirely within its traditional territory. The KLMSS TLUS was chosen because of the direct references to water including changes in surface hydrology and groundwater supplies. Relevant science information on hydrology and species were selected in the Site C EIS and additional information was sourced on Google Scholar and internet searches for information related to areas of interest in this report. All relevant information on impacts to species and watersheds were mapped using colour coding to show the impacted species or impacted rivers and lakes (red), species or surface hydrology of concern (yellow) or increased species population or surface hydrology with low impacts (green).

4.1 Understanding Spatial Relationships

GIS provides a platform for information to be represented spatially and temporally. The set of relationships that spatial features (polygons, points and lines) have with one another is referred to as spatial topology. Spatial topology is important because it is a formal way to represent what is happening in space and GIS allows spatial features of importance to be represented on maps (Robinson, 2020). This project will map the surface hydrology impacted by pollution and water level changes and species impacted by water availability or changes in their habitat. Water may be impacted by contamination or extraction for industrial uses like oil and gas production and processing, mining, pulp and paper, farming, other industrial activities, or by regulation due to hydroelectric projects. Mapping rivers with variable chemical concentrations may lead to a better understanding of the sources of pollution distribution and are also useful in conservation management and monitoring. Indigenous communities and non-Indigenous community members that live off the land have an intimate knowledge of changes in species populations. This information can be used for interpreting where changes have occurred or identify areas of concern for protection or restricted development. Identifying and mapping how watersheds and species are impacted by energy development allows for a more regional graphical representation of the cumulative impacts of projects.

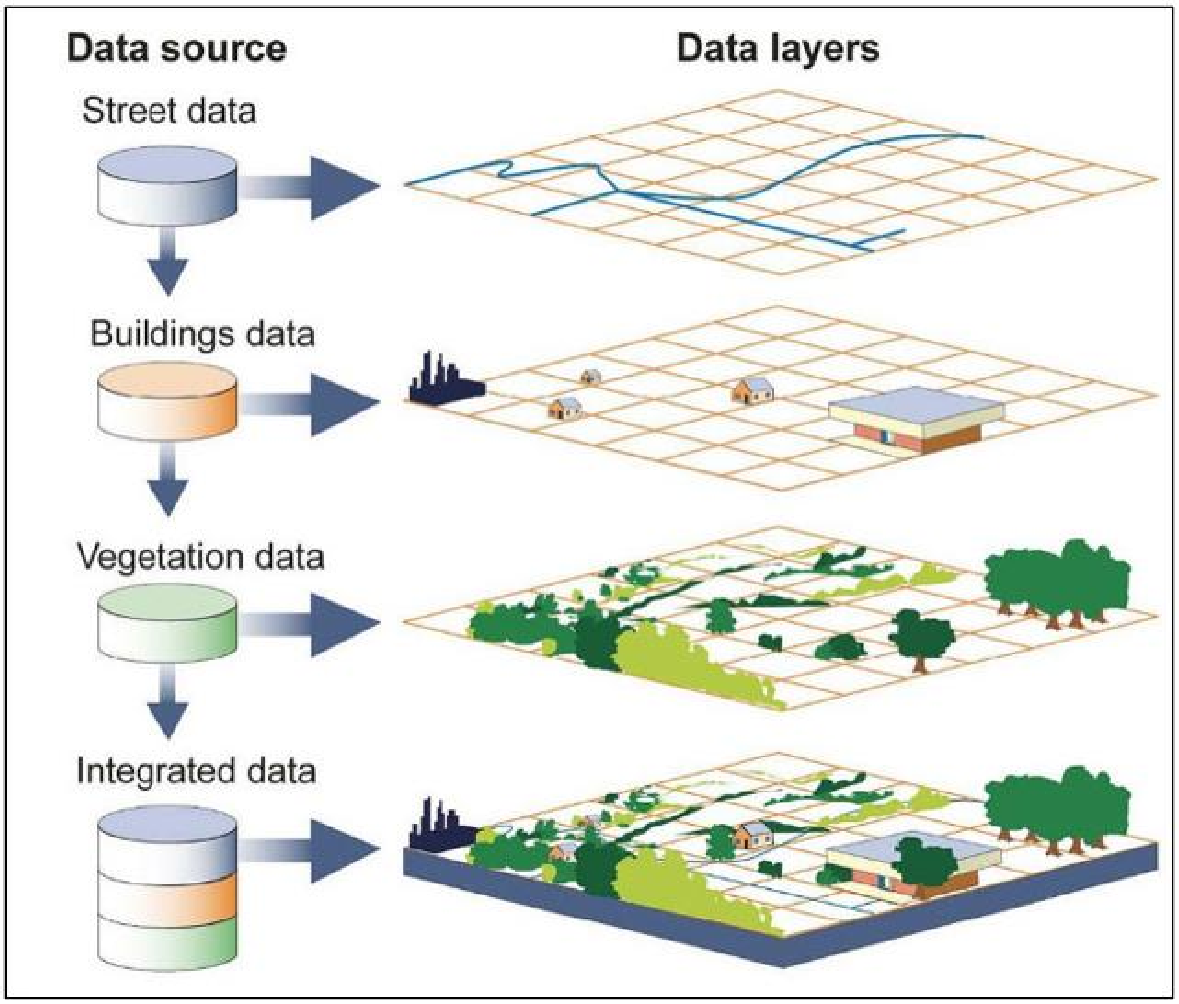
4.2 Review of EIA/EIS Mapping Tools

BC Hydro and their consultants utilized sophisticated GIS mapping tools for mapping products provided in the EIS. Many different types of GIS were used in the study and more sophisticated systems were required for detailed mapping in AutoCAD which was used for engineering designs and drawings. These sophisticated tools have spatial analysis capabilities that can map geographic, topological, and geometric properties. These systems can provide the highest quality maps available which are ideal for presentations and reports and have dedicated support staff to produce these maps. Most GIS have the capability to make temporal and spatial maps which are suitable for project reports and regulatory submissions. Some First Nations have inhouse GIS and the staff to operate them which provides them the flexible to present traditional knowledge in a manner that suits the needs of the community.

4.2.1 GIS System Capabilities

GIS is a computer system that allows for capturing, storing and displaying information that relates to a position on the earths surface. Data is captured and stored in database project files. Annotations are created in layers and can be added or removed by toggling the layer files off or on and this allows the user to compare different data sets and enables decision makers to more

Figure 5: How Geographical Information Systems Work.



Note: Image from National Geographic (2021) provided by U.S. Government Accountability Office.

easily see, analyze relationships, and understand patterns and how changes are occurring (Figure 5). Areas can be calculated from closed polygons and lengths can be measured from line segments in most GIS. Having the ability to download air photos and use satellite images can be useful in mapping changes in the physical environment over time. This is useful for mapping dynamic environments like rivers and deltas but can also be used to maps land use changes. Data gathered from field surveys can be easily stored into GIS. Global Positioning System (GPS) applications (apps) are available online and can be used in field surveys to identify and store latitudinal and longitudinal information for positioning of points of interest. Thousands of data points can be captured and downloaded into GIS and stored in layers. Indigenous communities can use GPS and GIS to precisely locate any area of interest which may include monitoring stations, harvesting areas/tracking of big game, sacred sites, and burial sites. In the wake of the recent discovery of unmarked graves, communities can also use temporal mapping by importing older georeferenced air photos or images to identify where ground disturbances have occurred to locate potential areas for ground penetrating radar surveys.

4.3 Developing Mapping Tools for Traditional Knowledge and Science

Developing GIS tools will allow Indigenous groups to handle the large historical and spatial information requirements of traditional knowledge. This valuable information needs to be gathered, digitized and stored, which can be used by the community for any purpose they see fit. Although this practice is contrary to Indigenous oral tradition, the information can be of significant historical importance and a way to digitally store traditional knowledge of passing generations. It is also important to gather and store science knowledge to further understand exactly how and what are causing environmental change. TLUS and science are currently part of the requirements for EIS and the potential for further future collaboration is promising and inevitable. On February 23, 2021, Geoscience BC announced a new research program to gather science and traditional knowledge to increase the understanding of water quantity and quality in the Peace Region (Geoscience BC, 2021). The water monitoring program will include groundwater, surface water, and climate change monitoring stations (Geoscience BC, 2021). These programs are long overdue and should be expanded to include the monitoring of all watersheds of importance. The water monitoring programs will provide useful baseline information prior to impoundment of the Site C Reservoir. The Halfway River First Nation, Blueberry River First Nation, Doig River First Nation, West Moberly First Nation, Saulteau First Nation and McLeod Lake Indian Band will be part of the program (Geoscience BC, 2021). Data volumes will be large and mapping will be required to understand the spatial relationships of the information and how it relates to local rivers and lakes of interest.

4.3.1 GIS and Project Mapping

The first step in the mapping process was to survey the area using satellite images and to understand the topography and surface drainage of the study area. Air photos and stereo imaging was widely used for engineering and scientific purposes until affordable and widely available software made satellite images available to the general public. Satellite images and remote sensing allow the user to obtain information about an area or objects and GIS is the tool to map this information. Applications include military intelligence and warfare, regional planning, cartography, recreation, geology, forestry, oil and gas, agriculture, conservation and climate change.

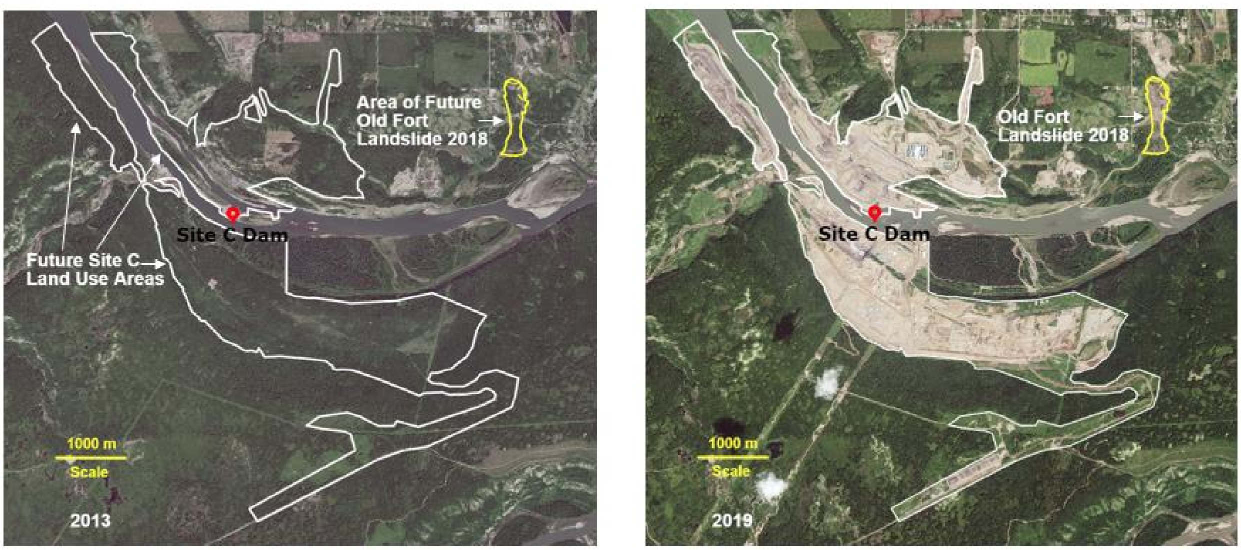
The use of satellite images has become widespread. Google Maps allows the user to switch between satellite imagery and road maps, provides 360° panoramic views and can be used for route planning for walking, bicycle, public transit, car, and airplane. The satellite images used in Cartofact GIS are supplied by Earthstar Geographics SIO, © 2021, © Microsoft Corporation. GISs can have extensive catalogues of information that are stored in layers like oil and gas, land, logistics, electricity, industry, and social and leisure features. These catalogue layers can be used interactively with other layers to support mapping projects like cumulative effects. Temporal satellite images also allow the user to observe natural and man-made changes over time which is of particular interest to Indigenous groups to demonstrate the impacts of energy projects in their traditional territories.

4.3.2 Mapping of Surface Hydrology and Land Use Features

The rivers and lakes layers in Cartofact GIS were activated to assess the comprehensiveness of the database. The river and lake segments database were not complete so line segments were created for surface hydrology of interest. Cartofact GIS allows for up to 15 layers to be saved which was not enough for the mapping project so the additional line segments were created in the shared folder. The layers were created in order to change the colour to identify bodies of water that have been impacted by regulation, pollution, or are of concern. The purpose of colour coding is to try to better understand the regional impacts of rivers, streams or lakes, how it might be affecting species of interest, and possibly identify the cause.

Satellite images allow the user to zoom in and observe topographic and bathymetric features in detail. Geomorphological features can form over thousands or tens of thousands of years or longer. However, surface hydrology features like rivers and deltas can change dramatically over decades or a few years. Temporal maps provide the user with the opportunity to introduce time as another dimension to spatial mapping. These maps are good for identifying changes in geomorphological features. Figure 6 shows the change in land use that occurred from 2013 to 2019 at Site C and the image of the Old Fort landslide that occurred in September 2018. Temporal maps can be used to roughly identify the timing of when changes occurred. Although the cause of the Old Fort Landslide is still unknown a group of residence from the town of Old

Figure 6: Temporal Mapping of Site C Project Area and Old Fort Landslide (2013 and 2019).

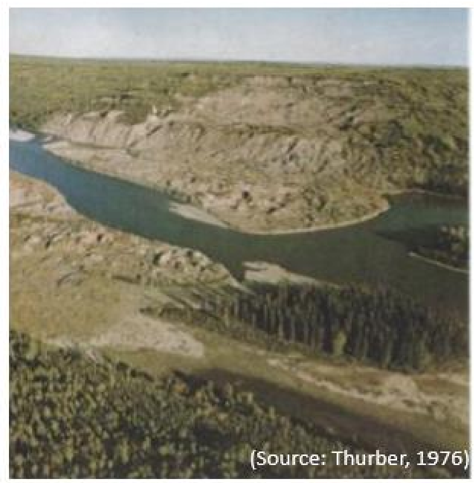


Note: (Author, 2021). Temporal satellite images for 2013 (left) and 2019 (right) provided by Cartofact GIS.

Fort have filed a lawsuit against BC Hydro, Deasan Holdings Ltd. (owners of a gravel pit just above the scarp face of the slide), City of Fort St. John, Peace River Regional District and the Province of British Columbia (Alaska Highway News, 2021). There is history of slope instability along the Peace River Valley and BC Hydro identified 4 major slides that have occurred since the early 1900's which include reactivation of the Cache Creek Slide at Mile 51 measured from the Alberta-

BC border (Site C is located at Mile 39), the collapse of the highway bridge on the north bank near Taylor Flats, the Attachie Slide in 1973 and the north bank failure at Mile 31 in 1974 (Figure 7) (Hoffman, n.d.). Hoffman also noted that lead project engineer for BC Hydro, Andrew Watson, admitted that there were concerns about the stability of the banks and how the valley would respond to a new reservoir (Hoffman, n.d.). Figure 7 is an interpretation of the Attachie Landslide from drawings by BC Hydro 1016-C14-D1214 and a photo of the landslide (Fletcher, 2000).

Figure 7: Attachie Landslide West of the Mouth of the Halfway River on the Peace River, BC.



Note: Interpretation of Attachie landslide (Author, 2021) (left). Image from Hoffman (2013) sourced from Thurber Report (1976) (right).

Geotechnical problems are the reason Site C costs have increased so dramatically.

4.3.3 Mapping Valued Environmental Component Species

VEC species mapping was built using icons in the drawing tools application. New points can be spotted on a map and then the point can then be converted to an icon of choice. Cartofact has icon sets for various sectors including animals, industrial, nature, and ecology. These icons are useful when representing species of interest on a map and they can be colour coded to represent impacts. The species icons were placed on the map in the general vicinity of where the impact occurred.

4.3.4 Comparative Analysis of Traditional Land Use Studies and Science

This study will conduct a comparative analysis of traditional knowledge from the TLUS and submissions by BC Hydro. Icons representing species that have been affected in the area of study were mapped for both traditional knowledge and science. Rivers and lakes that have been impacted in the area were mapped qualitatively to identify what bodies of water have been impacted by regulation or pollution and identify which watersheds are of future concern due to either regulation or other energy projects in the area. Once the maps have been completed, they will be compared to determine where the two knowledge systems are complementary and where they differ. Utilizing both knowledge systems may provide further insights into understanding the impacts of hydroelectric projects and other energy projects on ecosystems and the species they support.

Chapter 5. Literature Review

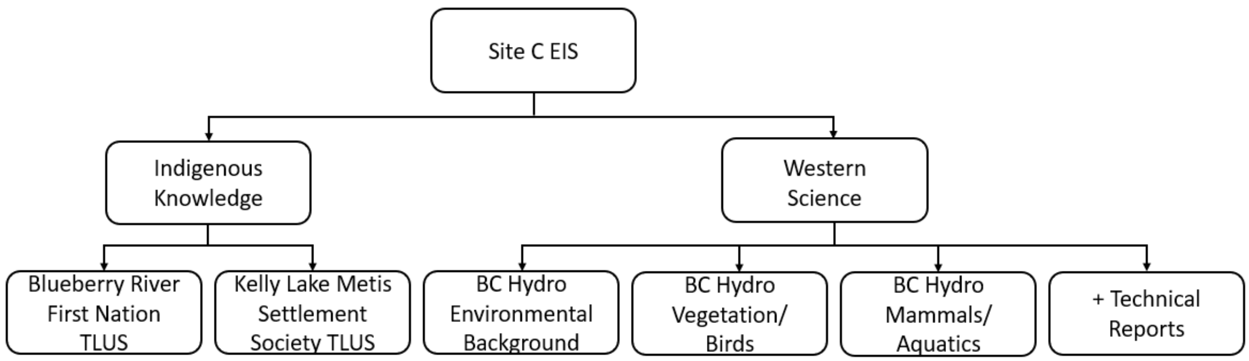
The purpose of the EIS is to meet the EIS guidelines and includes the rationale for the project, identifying project benefits and impacts, and proposing efforts to mitigate or avoid environmental impacts (BC Hydro, 2013a). The EIS contained all the TLUS from Treaty 8 signatories and Metis communities. The EIS was conducted to assess the potential impacts of 22 VECs related to heritage, health, social, economy and the environment (BC Hydro, 2013a). BC Hydro confirmed that the project will potentially result in changes; however, they assert that mitigation measures have been proposed. BC hydro concluded that the impacts of the project could be mitigated through careful planning, mitigation programs, and monitoring through construction and operations (BC Hydro, 2013a). There are still many opponents to the project and there are calls for transparency and accountability for the cost overruns. Indigenous groups have been critical of the project and feel that the project infringes on their treaty rights, that the consultation process was inadequate, and the project is not safe (Dhillon Kane, 2021).

5.1 Literature Selection

The study focused on the most comprehensive TLUS and the science data that was relevant to the study. The literature review revealed that there was no regional mapping of impacted watersheds and VEC species in either the TLUS or science studies. The information selected proved to be the most comprehensive and relevant to the study (Figure 8). Twenty-nine Traditional Land Use Studies were submitted with the Site C EIS from First Nation signatories of Treaty 8 and Metis Settlement Communities impacted by the Site C hydroelectric project (BC Hydro, 2013a). All TLUS were reviewed and the results tabulated. The table included the

Indigenous group, study name, author, year of the study, location, accepted for use, VEC information, and mapping products.

Figure 8: Literature Selection for the Study.



Note: (Author, 2021).

Many of the TLUS submissions were excluded as many felt that the project would have no impact on their communities. Ten studies were selected for comprehensiveness and this number was further reduced to select those studies that were proximal to the project area where data could be compared to that of BC Hydro. The BRFN and KLMSS TLUS were selected for the review for traditional knowledge. Both TLUS were in the vicinity of the project and made references to impacts on surface hydrology and VEC species. Although the KLMSS TLUS was not as comprehensive as other studies it was chosen due to direct knowledge of changes in water levels.

The Site C EIS is a sizeable document that contains 5 volumes of information listed below:

Volume 1: Introduction, Project Planning and Description
Volume 2: Assessment Methodology and Environmental Effects Assessment
Volume 3: Economic and Land and Resource Use Effects Assessment
Volume 4: Social, Heritage and Health Effects Assessment
Volume 5: Asserted or Established Aboriginal and Treaty Rights, Aboriginal Interest and Information, Environmental Management Plans and Federal

Information Requirements.

Volume 2 was the primary source of information used for the science portion of the study; however, additional studies and articles were reviewed. The following Appendices in Volume 2 were reviewed in detail for information regarding surface hydrology and VECs:

Appendix B: Geology, Terrain and Soil
Appendix E: Water Quality Baseline Conditions in the Peace River
Appendix G: Downstream Ice Regime Technical Data Report
Appendix I: Fluvial Geomorphology and Sediment Transport Technical Data Report
Appendix O: Fish and Fish Habitat Technical Data Report
Appendix P: Aquatic Productivity Reports
Appendix R: Terrestrial Wildlife and Vegetation Effects Assessment
Appendix T: Climate Change Summary Report

5.2 Traditional Knowledge and Traditional Land Use Studies

Indigenous peoples' traditional way of life provides a distinct advantage over scientists who spend less time in the field. Indigenous people that live off the land observe changes that occur on a regular basis and these observations can extend generations, or more. Hunting and fishing require an intimate understanding of the environmental conditions that will affect habitat and movements which can be associated with water availability. Predators who rely on these food sources will adjust their movements accordingly. Indigenous people can contribute knowledge about short and long-term fluctuations in water flow rates, sediment levels, ice conditions, flooding events, lake levels, and water quality. These studies contain the knowledge of behaviors, abundance, health and distribution of all local species but more importantly they observe the change.

TLUS have large data requirements with information that can span over large areas and time periods. These studies can include, but are not limited to, historical documentation of the people before Europeans arrived, such as: changes that occurred after arrival, signing of treaties, alienation of Indigenous lands, and historical developments on their traditional land. Contemporary land uses, traditional ecological knowledge, areas of cultural significance and harvesting studies are common components of TLUS. First Nations using their own GIS tools, or those used by consultants, provided excellent quality land use maps. GIS can provide First Nations with their own mapping capabilities which allow them the flexibility and versatility to develop their own map making techniques and to share the information they desire or require. For example, many of the cultural and sacred sites are represented in a general form to preserve the confidentiality of specific sites. The TLUS mapping in the Site C EIS is in various stages of development and GIS can provide the capabilities Indigenous groups need. Changes in river flow of the Peace River tributaries and the impacts on VECs were documented textually but this information was not mapped. Changes in animal behavior and movements can provide useful information for scientists to better understand how traditional knowledge is used. Traditional knowledge provides industry and government with an opportunity to understand long- and short-term impacts on their traditional way of life but also an opportunity to share data that will provide insights on harvesting trends over decades or longer.

Several First Nations submitted TLUS either written by the First Nation or in conjunction with a consulting firm. Interviews with community members and Knowledge Keepers are a critical part of the study. Some TLUS have provided their own summaries of traditional knowledge referencing science-based information from technical papers so some integration of the two knowledge systems is already being done. It should be made clear that I am not attempting to merge these two knowledge systems together. It is important that the two knowledge systems remain in their current form to honour the integrity of the data. It's important for the scientific community to recognize and respect the difference between these knowledge systems from a cultural perspective. The methods of acquiring knowledge are very different but both provide valuable information in understanding mans impact on the environment.

Indigenous led TLUS are valuable sources of information. Hunters, gatherers and Knowledge Keepers have documented impacts from the W.A.C. Bennett Dam, Peace Canyon Dam and identified concerns regarding the Site C project. A review of the TLUS indicates that there have been significant impacts on Indigenous communities from the development of hydroelectric projects on the Peace River. The problem is further exacerbated by the development of agriculture, oil and gas development, and other industrial activities in the area. The cumulative effects are a concern for all communities especially for those in the vicinity of oil and gas development. There are many reports of hunters having to drive farther distances to find game. Interviews indicate that the flooding of Williston Lake and lowering of the Peace River have impacted many species along both watersheds.

Loss of wetlands is a concern for moose populations as they rely on wetlands for food and to escape predation. However, beaver populations are thriving in areas closer to the Dam where water releases are higher in the winter allowing for more open water conditions. The impoundment reservoirs will flood all habitats along the river valley which can include bears' dens, birds' nests, beaver dams and islands used for calving by moose The full impacts on all species as a result of changes in habitat due to regulation needs to be better understood. There are also significant concerns about methylmercury (MeHg) amongst Indigenous communities. Methylmercury is produced by bacteria activity in soils and water that is enhanced by organic carbon in soils and flooded vegetation (Kelly, 1997). These organism's uptake elemental mercury and start a methylation reaction forming methylmercury which is stored in the fatty tissue of fish and humans. Over consumption of this bioaccumulative environmental intoxicant can result in increased mercury concentrations in humans, which can affect the neurological system and cause nerve cell damage (Bystrom, 2008). Methylmercury has contaminated fish in Williston Lake and it is a concern for all communities in the area and many no longer eat the fish from the lake at all.

TLUS provide information from community members, Cultural Advisors and Traditional Knowledge Keepers. TLUS studies submitted by participating Indigenous groups of the Site C EIS were reviewed for information relating to VECs. The BRFN TLUS contained a detailed summary of contemporary land use and traditional ecological knowledge. The report covered big game hunting, small game hunting, fishing, bird hunting and plant foods and plant medicines. Detailed harvest maps were provided for various VECs throughout the BRFN traditional territory and the information went well beyond the study area for the Site C Project and provided additional insights on environmental changes that are occurring. The BRFN provided a summary table of fish species caught in rivers and creeks in the study area (Figure 9). This information is important to understand what species are caught in what rivers and where changes are occurring. Quantifying the catches would provide additional data to analyze fish populations in a specific watershed area and this could be done for any of the VECs. This is a good example how Indigenous communities can utilize community members to gather quantifiable information in the field for their own studies and work collaboratively with governments and industry to gather baseline information and for follow up monitoring.

Figure 9: River and Species Caught and Recorded by Garnett Davis.

River/ species	Pine River	Moberly River/ lake	Cache Creek	Halfway River	Farrell Creek	Lynx Ck.	Cameron Creek	Dunlevy Creek and environs	Williston Lake
Dolly Varden			■ At mouth	■				■	■
Ling				■					
Whitefish				■					
Grayling				■	■		■		
Sucker				■			■		
Rainbow trout			■ At mouth	■ At mouth					
Kokanee				■			■		
Pike				Formerly					
Walleye									
Jackfish				■					
Squawfish				■	■				
Lake Tout		■							■
"Catfish"								■	

Note: (Blueberry River First Nation Traditional Land Use Study, 2011).

5.3 Science Knowledge

A literature review was conducted on information provided in the Site C EIS and supplemented by available hydrological studies of Williston Lake, Peace River, and the Peace-Athabasca Delta. The studies of interest in this report include geology, terrain and soil, surface water and groundwater, downstream ice, water temperature, fluvial geomorphology and sediment transport, mercury report, fish and fish habitat, terrestrial wildlife, and impacts on vegetation. According to the literature, the W.A.C. Bennett Dam and regulation of the Peace River had the biggest impact of the three hydroelectric projects. The flow regime of the Peace River changed when the dam was constructed as did the seasonal water levels due to higher discharges in the winter time when there is a higher need for electricity generation (BC Hydro, 2013). Farther downstream the impacts are less attenuated due to the contribution of flow by the Peace tributaries (Peters, 2001). Downstream, ice jams and flooding events are important for replenishing perched basins in the Peace-Athabasca Delta and low-lying areas along the Peace River. Peters and Prowse (2001) noted that annual peak flows were 35-39% lower, average winter flows increased 250% and overall variability in daily flow was decreased at the Peace Point hydrograph for post-regulated flow. Upstream, at the Hudson Hope hydrograph, mid-winter flows increased by about 1,000 m^3 s^{-1} and peak summer flows had decreased by 3,000 m^3 s^{-1} (Peters, 2001). Work done on the Site C Dam indicates that the project will not have a major impact on the flow regime downstream as the major change in river flow was associated with the construction of the W.A.C. Bennett Dam.

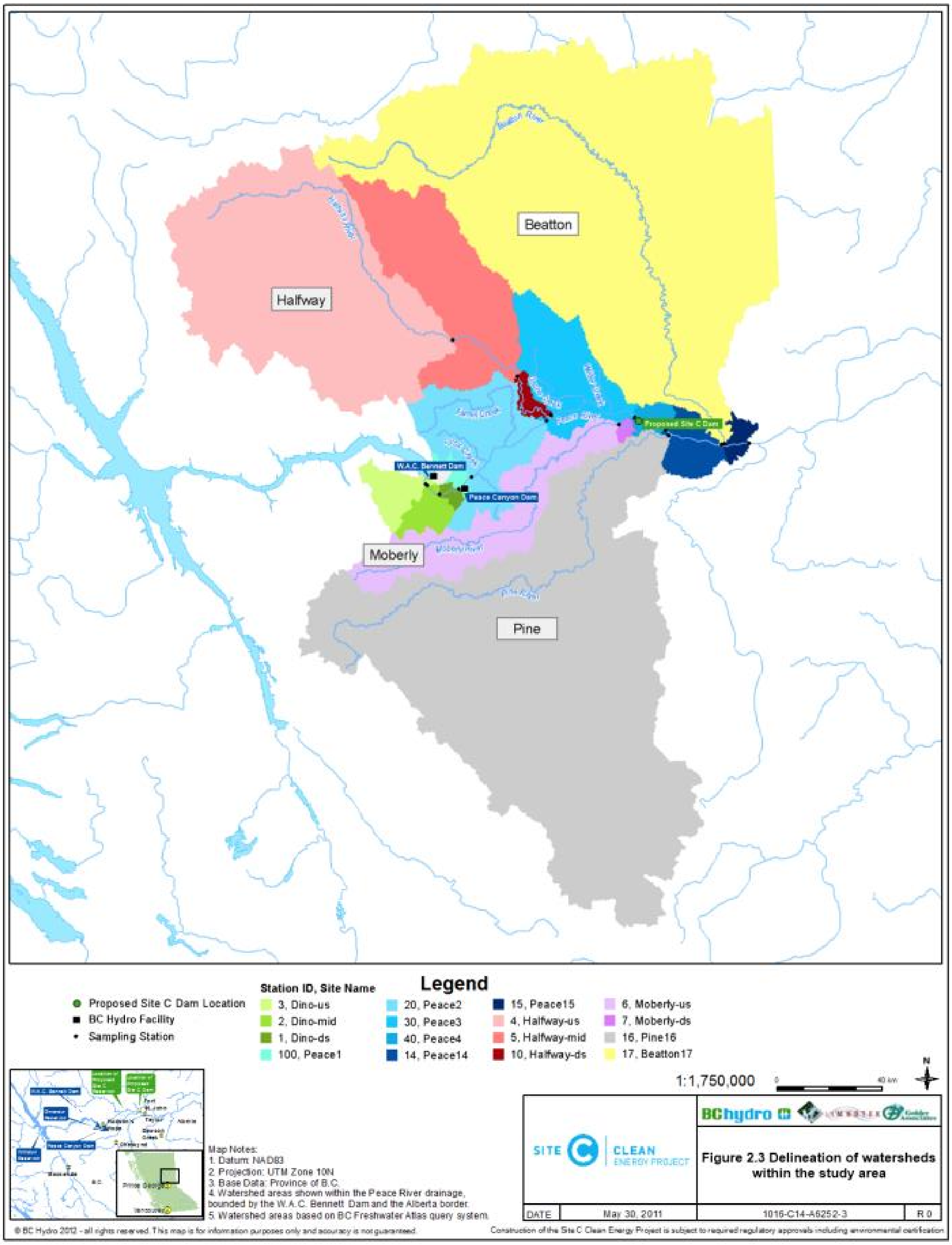
There is much debate about the impacts of the hydroelectric projects on the Peace River, but this literature review of the Site C EIS, provides an opportunity to identify congruencies in traditional knowledge and science methodologies. It is understood that qualitative and quantitative data sets are being analysed and compared in this report and care and consideration must be taken in how the traditional knowledge and scientific information are being represented. The challenge will be to compare and contrast a holistic subjective and experiential approach of indigenous people with a reductionist, objective and analytical approach of science. Both methods have their pros and cons so its important to recognize the strength and weaknesses of both knowledge systems.

Chapter 6. Results

The mapping project was undertaken to determine if GIS would help to improve the integration of traditional knowledge and science in EIA. Spatial topology is important as it helps us understand the relationship of spatial features on a map and GIS provides a platform for this analysis to occur. Regulation of water in the Peace River by hydroelectric projects and oil and gas development have had significant impacts in the Peace Region and its water resources. The tributaries of the Peace provide freshwater and sediment originating in the alpine area of the Rocky Mountains. Dam building along the Peace River has reduced the amount of sediment supply impacting the riparian zone (interface between river and land) and geomorphology of the river downstream of the dams. Figure 10 outlines the watersheds in the study area. Rivers and lakes were mapped using layers so the colours could be toggled to identify surface hydrology impacted by regulation and pollution and to identify rivers and lakes of concern. The study identified the Halfway, Moberly, Pine and Beatton Rivers as major tributaries of concern for the area. The Beatton River was reported by BRFN to be contaminated and the assessment was confirmed by mean chemical concentration analysis conducted by science. Watersheds that have been impacted by industrial activity will impact the health of the ecosystem and the VEC species.

The information provided in the BRFN and KLMSS TLUS provided information well beyond study areas that extended to the upper reaches of the Beatton, Halfway, Moberly and Pine River watersheds, whereas the Site C study area only focus on the lower reaches of these watersheds in the immediate area around the Site C project.

Figure 10: Watersheds in the Study Area.

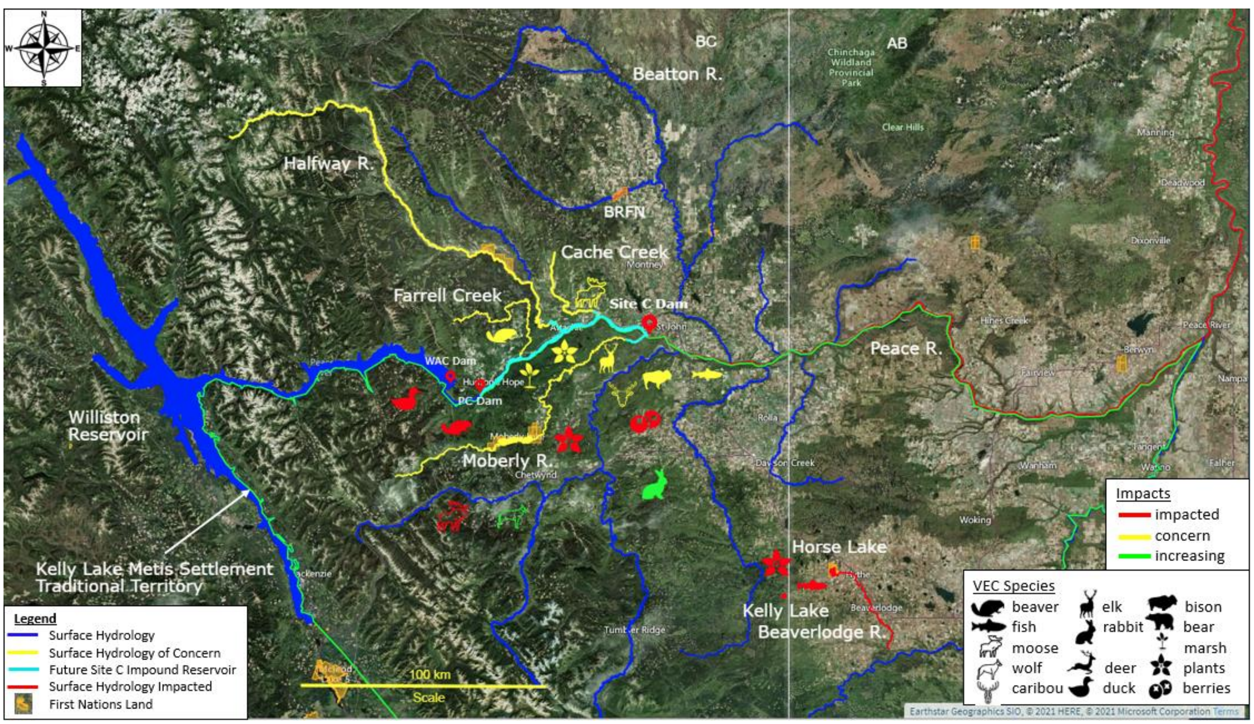


Note: Map from BC Hydro (2011) found in the Site C EIS (2013).

6.1 Mapping of Kelly Lake Metis Settlement Society Knowledge of VECs

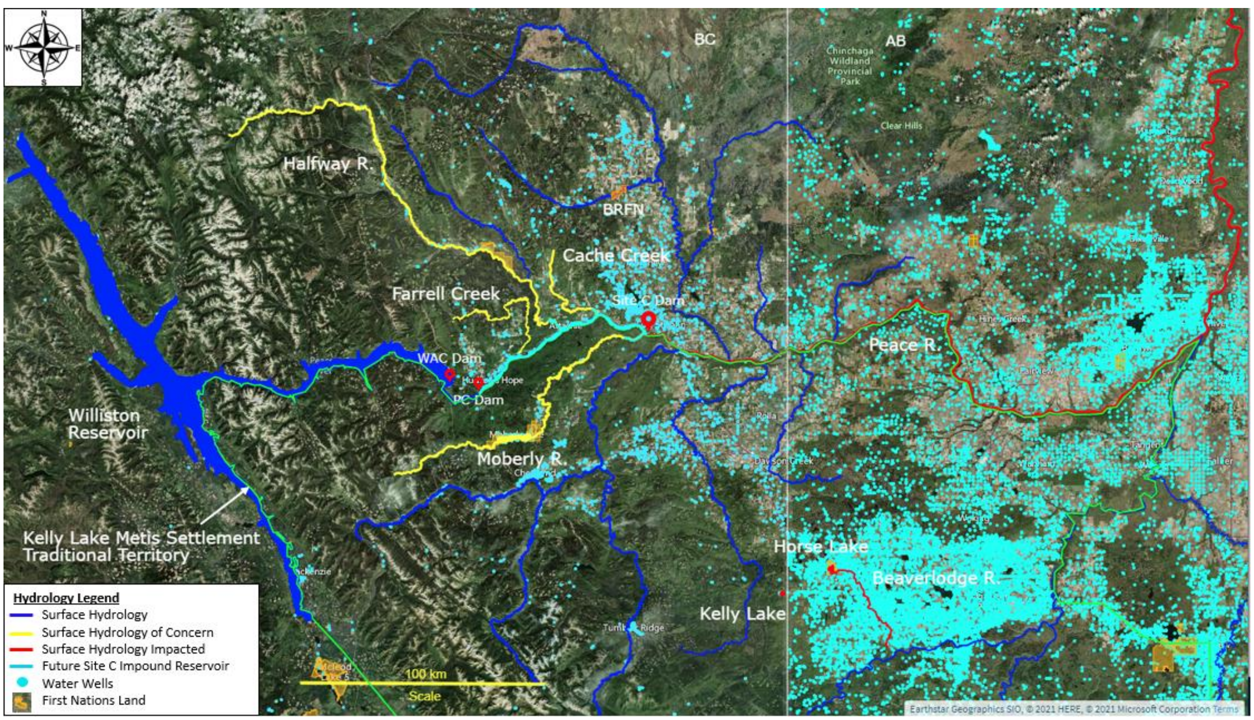
The KLMSS TLUS was focused on water levels and water quality as part of their study. It was the most comprehensive when it came to concerns about surface hydrology and the KLMSS were focused on upstream and downstream impacts of the dam on the Peace River. Traditional knowledge observed a significant decline in water quantity in local creeks and rivers and made specific references to Hythe River (undefined), Beaverlodge River, Horse Lake, Kelly Lake and the Peace River which are coloured red (Figure 11). The study noted that many of the creeks had already run dry at the time of the interviews, however the location of some of the creeks and

Figure 11: KLMSS Traditional Knowledge of Surface Hydrology and Species of Interest.



rivers are unknown (KS Davison and Associates, 2012). Traditional knowledge attributed the impacts to the surface hydrology to cumulative effects of the W.A.C. Bennett Dam and lower than average seasonal precipitation and the impacts to Horse Lake where the result of man-made changes to surface flow conditions led to a decline in ecological health and availability of vegetable-based foods and medicinal plants (KS Davison and Associates, 2012). Rivers of concern upstream of the project include the Halfway River, Moberly River and the Upper Peace and other tributaries that low into the Peace River. There were concerns about upstream flooding of the tributaries and there are concerns about downstream water levels and water flow and this extends as far east as Peace-Athabasca Delta and north to the Slave and Mackenzie Rivers. KLMSS also noted a "collapse" in the drinking wells from artesian conditions due to industrial activity

Figure 12: Location of Water Wells in the Study Area.



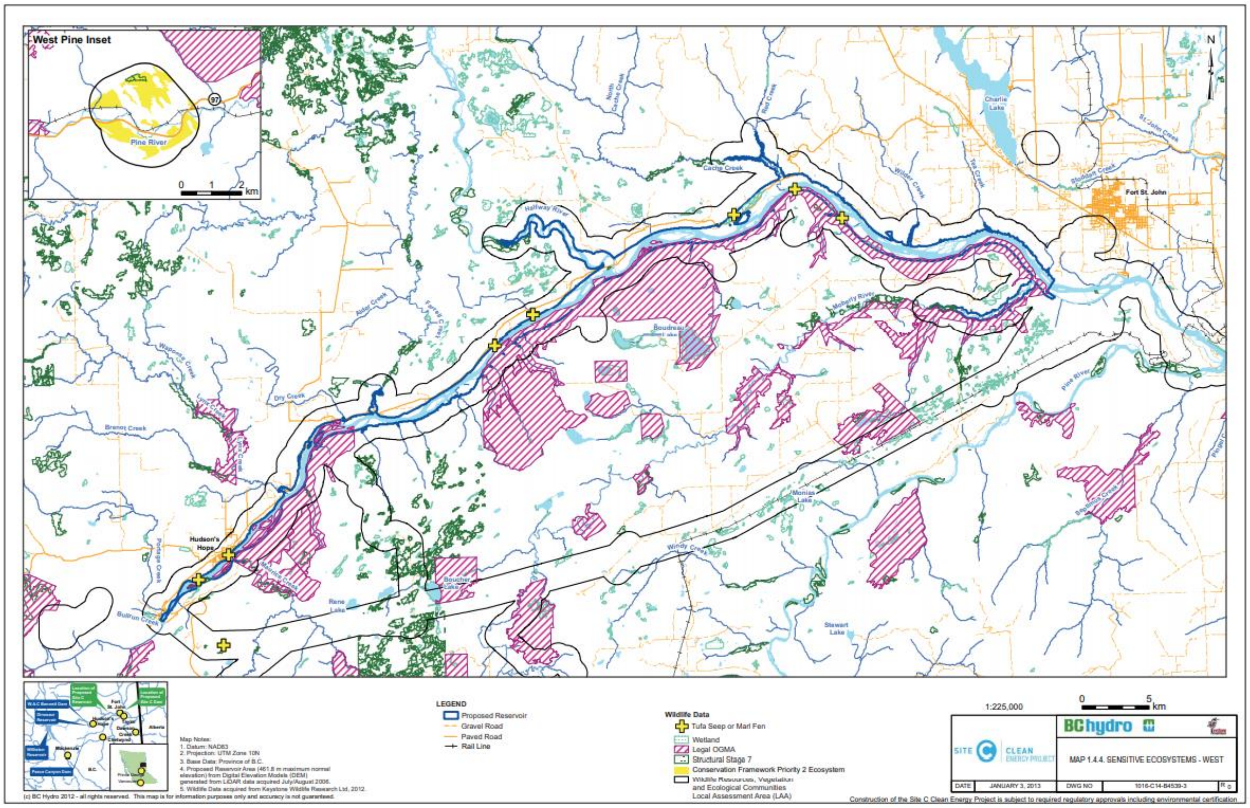
Note: (Author, 2021). Water well data provided by Cartofact GIS.

and the water recovered had an oil-like scent and there has been observed combustible gas (through ignition) in water pipes (KS Davison and Associates, 2012). Figure 12 shows the location of water wells in the study area. Note the high density of water wells around Horse Lake and

Beaverlodge River. Monitoring of water well levels and identifying wells that are contaminated can be captured and displayed on a map. Taking water levels in wells would provide data to map the potentiometric surface of the groundwater aquifers and water analysis may help identify the source of pollution. There is the possibility of surface casing vent flows from oil and gas wells or improper disposal of waste water in the area that may be contaminating potable water resources on the Kelly Lake Metis Settlement.

The traditional knowledge regarding VEC species was very specific in the TLUS and the drier conditions mentioned earlier would impact plants, berries and other vegetation in the area. There has been a significant decline in moose, duck, beaver and fish populations according to the traditional knowledge. Wolf populations are increasing and rabbit populations are rebounding after a long decline. It is possible that moose declines are in response to the increase in wolf populations and the decline in duck populations is being attributed to habitat destruction from the W.A.C. Bennett Dam (KS Davison and Associates, 2012). Figure 13 shows that many of the sensitive ecosystems lie to the south of the Peace River. There is concern for the habitat of ungulates, including moose, elk and caribou as well as, habitat for bison and beaver. Moose will use islands in the Peace River for calving and to escape predation and these habitats will be flooded when impoundment of the Site C Reservoir occurs. Although fish is not a large part of the communities' diet there are concerns that poor water quality will impact ecological productivity and therefore fish populations (KS Davison and Associates, 2012). Medicinal plant

Figure 13: Sensitive Ecosystem Areas.



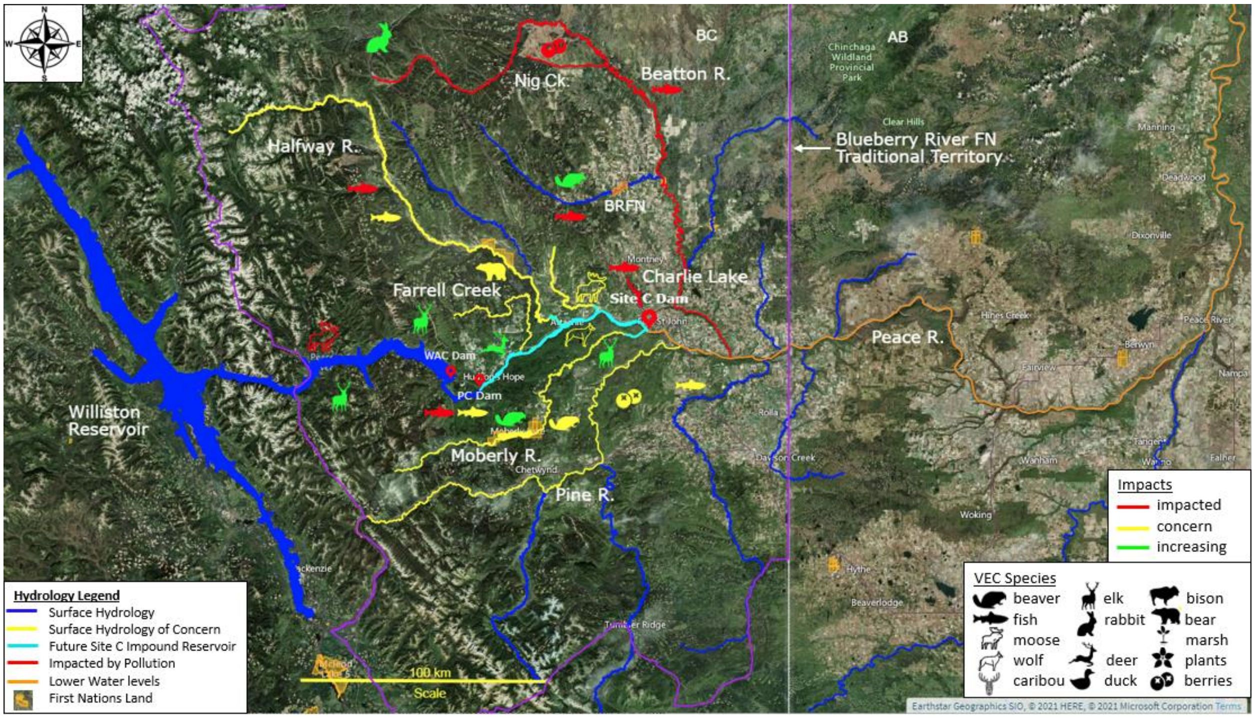
Note: Map from BC Hydro (2011) found in the Site C EIS (2013).

harvesting was addressed, however because it is sacred in nature, the information was kept confidential by the community (KS Davison and Associates, 2012).

6.2 Mapping of Blueberry River First Nation Knowledge of VECs

The BRFN TLUS was one of the more comprehensive and interesting studies presented in the Site C EIS. The study contained extensive mapping of hunting and harvesting areas and it provided a detailed history of their people and changes that occurred over time, and extensive knowledge applying to all aspects of their traditional way of life. There is considerable knowledge regarding current hunting and harvesting areas which is useful in understanding the current health of the ecosystems and these areas are of concern to the BRFN people. There was abundant information

Figure 14: BRFN Traditional Knowledge of Surface Hydrology and VEC Species from the TLUS.

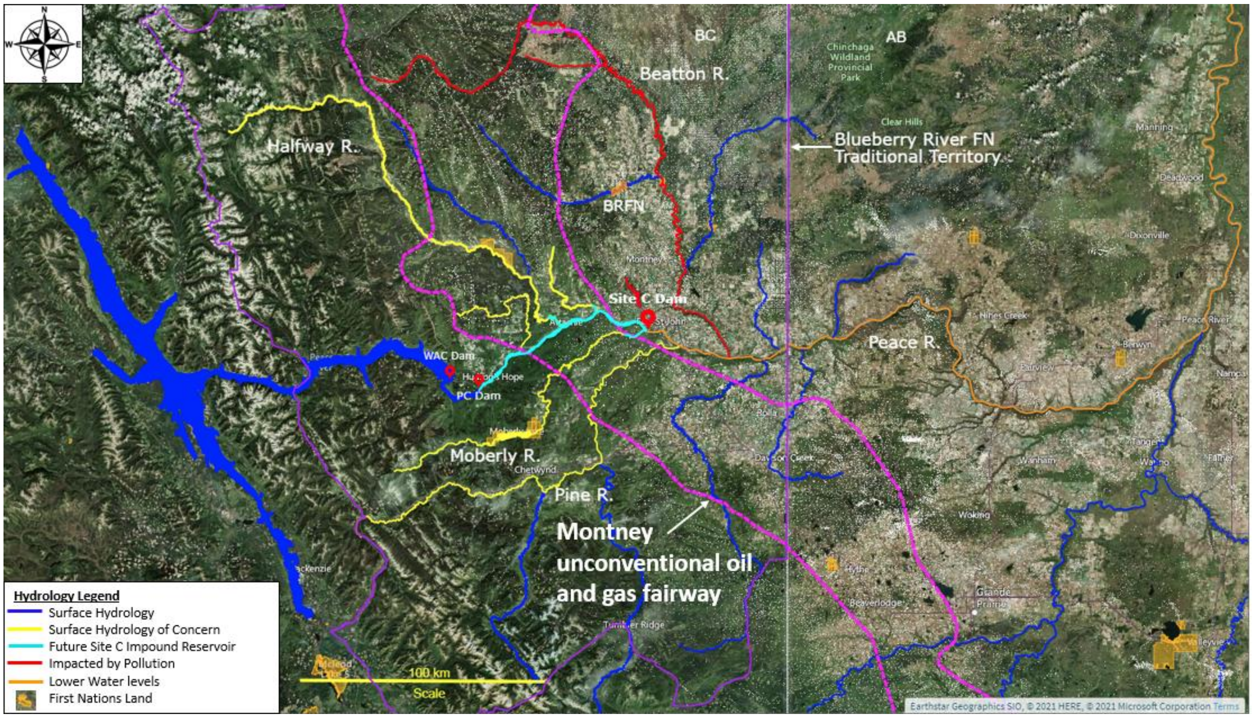


species throughout their traditional territory; however, they still rely predominantly on game (Bouchard & Kennedy, 2011). The BRFN had similar concerns to the KLMSS in regards to stream flooding of the Site C Project. This includes the Halfway River, Upper Peace River (Site C impoundment reservoir), Moberly River, Moberly Lake and other smaller tributaries. The BRFN identified Beatton River, Nig Creek and Charlie Lake as 3 watersheds that have been impacted by pollution and identified the Peace River as having lower water levels post regulation (Figure 14). The pollution source according to BRFN is from oil and gas activity.

The BRFN had a comprehensive review of VEC species, provided site specific places with cultural significance and areas associated with particular animal behaviors. The cultural/spiritual knowledge and location of sacred sites were protected in the study. The BRFN addressed both water quality and water quantity and the impacts it had on species, plants and medicines. Two interviewees commented that the stocks of Dolly Varden (bull trout) are declining in the Halfway River and where it flows into the Peace River; and it was noted that the Halfway was an important spawning river for the bull trout (Bouchard & Kennedy, 2011). Beaver and elk populations are increasing in the Moberly River and Blueberry River areas and there was a notable increase in deer towards Hudson Hope. According to the TLUS, moose populations declined in the Williston Reservoir area after impoundment and there is a concern the same will happen after Site C is built. There is concern for fish populations both upstream and downstream of the dam. Charlie Lake and minor rivers around it used to be good areas for fishing and berry picking; however, pollution from recreation vehicles and release of sewage into these watersheds has created health concerns (Bouchard & Kennedy, 2011). As a result, berry production and some medicines no longer grow in Nig Creek and the Beatton River valley and fish are no longer eaten out of those rivers due to pollution (Bouchard & Kennedy, 2011).

The unconventional Montney oil and gas play started undergoing development with the advent of horizontal drilling and fracking in the early 2000’s (Figure 15). Development of the Montney play expanded north of the Peace River in the late 2000’s and the entire fairway is still very active today. The Montney formation is a low porosity low permeability siltstone that requires 1500-2000m length horizontal wells that are hydraulicly fractured. These fracture completions are costly and can require large amounts of water. The Montney formation has a low water saturation and therefore much of the frack fluid is lost to the formation. Completions in the Montney can vary, but an average 50 tonne frack can require approximately 100,000 barrels (~16,000 m^3) of water with only 1/3 - 2/3’s of the frack fluid recovered on flowback. Large

Figure 15: Montney Unconventional Oil and Gas Fairway.



water resources are required to develop unconventional oil and gas plays and conservation and reuse of the fluids is common practice for producers. Oil and gas development in the Montney will continue to grow when the Coastal Gaslink natural gas pipeline becomes operational. The natural gas will be converted to liquid natural gas (LNG) on the west coast and transported by ships to Asian markets. Urban, agricultural and other industrial developments are also increasing the need for water in the area.

6.3 Mapping of Science Knowledge of VECs

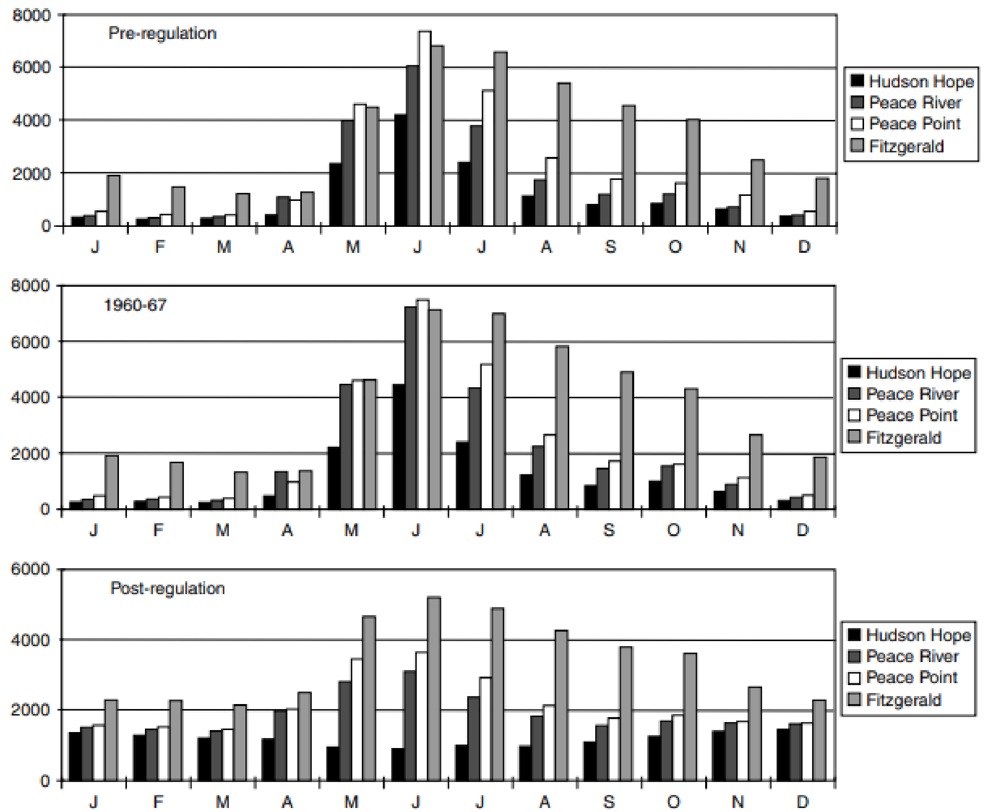
BC Hydro recognizes that understanding environmental changes associated with previous hydroelectric projects provides context for the environmental assessment of Site C and that ongoing anthropogenic and environment factors have impacted the Peace River watershed (BC Hydro, 2013). The most significant impacts on the Peace River occurred when the W.A.C. Bennett

Dam was constructed, however BC Hydro never addressed the full environmental impacts from the project.

Approximately 360 km of the Parsnip, Finlay and Peace Rivers were inundated to form the Williston Reservoir. This changed the ecosystems upstream and down stream of the W.A.C. Bennett Dam. Seasonal flow patterns changed and flow extremes were damped resulting in less variability in the annual regime (Prowse, Peters, Church, & English, 2002). Prowse also noted that pronounced changes in river morphology and vegetation have occurred along the lower reaches of the Peace River, which include channel narrowing by the abandonment of secondary channels and in-channel shoaling (Prowse, Peters, Church, & English, 2002). Lower overall water levels on the Peace River have resulted in the succession of vegetation onto abandoned bars. BC Hydro chose to focus on impacts upstream and downstream of the PC Dam and any impacts caused by the PC Dam would have been magnified by the construction of the W.A.C. Bennett Dam.

Upstream of the PC and W.A.C. Bennett Dams methylmercury studies were first conducted in 1980 to assess the methylmercury concentration in environmental receptors, like fish, water, sediment and invertebrates, and found that there were elevated levels than surrounding lakes and that some species of fish had concentration levels that exceeded Health Canada standards for consumption (BC Hydro, 2013a). However, a consultant's report in 1999 indicated that methylmercury levels have declined and are expected to continue to decline but there is some uncertainty on how long it will take to return to pre-regulation levels (BC Hydro, 2013a). Changes to the flow regime downstream of the dam are dependant on the time of year; however, the flow regime returned to pre-dam levels once the Williston Reservoir was filled but seasonal shifts persisted (Prowse, Peters, Church, & English, 2002). Mean summer flow at Hudson hope declined by 50% but the winter flow increased by 400% (Prowse, Peters, Church, & English, 2002). Mean monthly flows are shown in Figure 16.

Figure 16: Pre- and Post Regulation Mean Monthly Flows for Hydrometric Stations Along the Peace River.



Note: (Prowse et al., 2002).

Since regulation, flow in the tributaries has been lower on average which has been attributed to a reduced snowpack in the Rockies (Prowse et al., 2002). There has been some debate about the impact regulation has on ice conditions in the Peace River. Break-up ice jam flooding is considered an important critical ecological component for the flooding of perched basins in the Peace-Athabasca Delta and it also has implications for flooding of the riparian zone along the Peace

River. Only certain species of trees are water tolerant and can survive in areas with periodic flooding which would be impacted by ice-jam flooding and once flooding ceases other species will succeed. Formation of ice on the Peace River has been delayed due to regulation and may not form at all near the point of regulation (Prowse, Peters, Church, & English, 2002). A flowing river responds more quickly to atmospheric conditions than a lake or reservoir so temperatures at the mouth of the reservoir outlet would be cooler in the spring/summer and warmer in the fall/winter delaying ice formation on the Peace River; however, regulation has not impacted freeze-up downstream of the town of Peace River (BC Hydro, 2013).

Golder Associates conducted a mean chemical concentration by stations that extended from the Williston Reservoir to the Dinosaur Reservoir and along the Peace River east to the mouth of the Kiskatinaw River. The water chemistry study analysed alkalinity, pH, nitrogen, ammonia, suspended and dissolved solids and dissolved components of oxygen, organic carbon, nitrogen and phosphorus (Table 1). The Halfway, Moberly, Pine and Beatton Rivers had monitoring stations downstream near the mouths of the rivers. Concentrations were relatively similar in the Williston Reservoir, Dinosaur Reservoir and the five stations along the Peace River which could be considered a baseline for the area. The Beatton River had elevated levels of dissolved organic carbon, ammonia and total suspended solids compared to any other station along the Peace River or the other tributaries. The Halfway and Moberly Rivers had elevated levels of some chemical concentrations but not to the same extent as the Beatton River. A qualitative map of pollution levels was created to show which rivers had high, medium or low

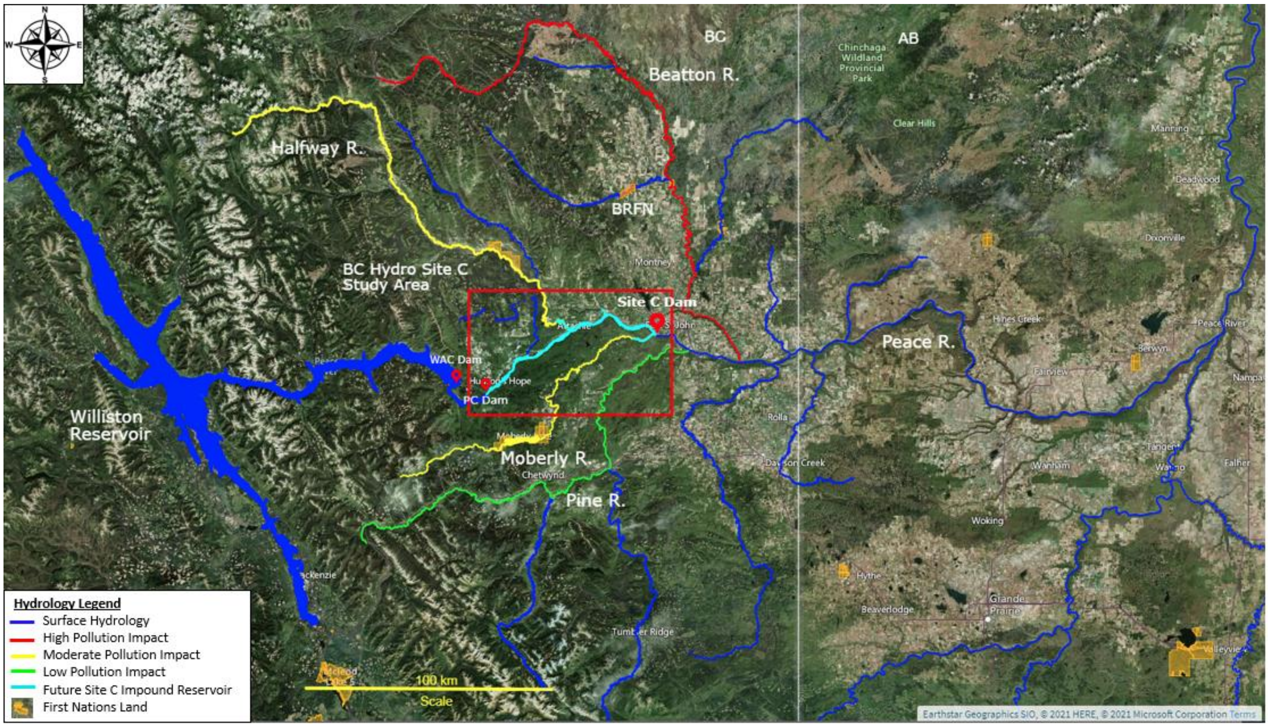
Table 1: Mean Chemical Concentrations by Station

Analyte	Mean concentration ± standard deviation by Peace River stations in Series1								Mean concentration ± standard deviation in tributaries in Series1			
	W1	Dino-ds	Peace1	Peace2	Peace3	Peace4	Peace14	Peace15	Halfway-DS	Moberly-DS	Pine	Beatton
Alkalinity (mg·L^{-1})	82±1	83±1.5	82±1.7	84±2.7	94±8.3	94±7	98±5.4	95±8	162±6.4	110±9	108±9	42±10
Dissolved oxygen (percent saturation)	93±15.2	86±30.1	99±4.9	99±3.9	99±1.1	100±1.5	99±0.9	99±1	99±3	98±2.2	98±1.3	96±1.8
pH	8.2±0.1	8.1±0.2	7.9±0.2	8.0±0.1	8.0±0.4	8.2±0.1	8.2±0.1	8.2±0.1	8.2±0.2	8.2±0.2	8.2±0.2	7.9±0.2
Total dissolved solids (mg·L^{-1})	106±3.1	107±2.8	107±3.1	108±3.9	121±13.3	120±13.4	124±9.8	122±10.7	229±11.5	151±33	154±25	93±21
Temperature (°C)	12.3±4.4	11.1±3.3	10.4±3.9	11.0±3.5	12.1±3	12.8±2.4	13.2±2.8	13.4±2.8	16.2±3.2	15.5±3.4	14.4±3.7	17.3±2.8
Turbidity (NTU)	58±60	65±59	20±25	22±25	37±62	45±56	48±49	95±38	46±39	72±56	46±48	364±499
Dissolved organic carbon (mg·L^{-1})	2.4±0.2	3.4±1.2	3.6±2.1	3.8±1.5	3.6±1.8	3.5±1.1	3.4±1	3.8±0.5	4.5±1.9	6.3±1.9	3.8±2.5	21±4.4
Ammonium-N (µg·L^{-1})	4.7±2	3.4±2.8	4.4±1.6	2.2±0.5	2.6±0.9	3.3±1.4	2.8±1.1	3.1±0.7	2.4±1.2	2.8±1.8	2.8±1.5	20±17
Nitrate-N (µg·L^{-1})	48±12.5	44±8.2	45±7.1	43±8.1	32±12.2	29±10	32±27	19±8	6±8.2	18±28	30±40	8±1.8
Dissolved inorganic nitrogen (µg·L^{-1})	53	47	50	46	35	32	34	22	9	21	32	28
Soluble reactive phosphorus (µg·L^{-1})	1.1±0.2	1.2±0.4	1.2±0.4	1.2±0.3	1.5±0.7	1.4±0.2	1.4±0.5	1.1±0.1	2.0±1	1.9±0.8	1.1±0.6	4.3±1.9
Nitrogen:phosphorus (molar ratio)	108:1	90:1	95:1	87:1	52:1	52:1	56:1	44:1	9:1	25:1	66:1	14:1
Total dissolved phosphorus (µg·L^{-1})	5.6±1.5	5.2±2.1	4.4±1.3	6.4±4.4	6.9±1.3	7.6±3.6	6.6±2.7	6.6±1.6	13±7	11.2±4.6	6.5±3.5	75±59
Total nitrogen (µg·L^{-1})	307±138	258±58	253±91	251±80	276±60	292±165	311±140	391±148	446±254	400±121	260±231	1715±439
Total phosphorus (µg·L^{-1})	8±3.2	7.9±6	6.6±3	11±10	12±6.3	28±33	33±42	19±6.6	78±40	74±75	31±41	217±137
Total suspended solids (mg·L^{-1})	<3	3.1±0.4	3.5±1	4.7±2.9	4.3±0.6	4.7±2.9	7.7±4.5	11±8	63±47	25±18	12±6.1	121±89

Note: (Golder Associates, 2012).

chemical concentrations relative to the Peace River and the two reservoirs (Figure 17).

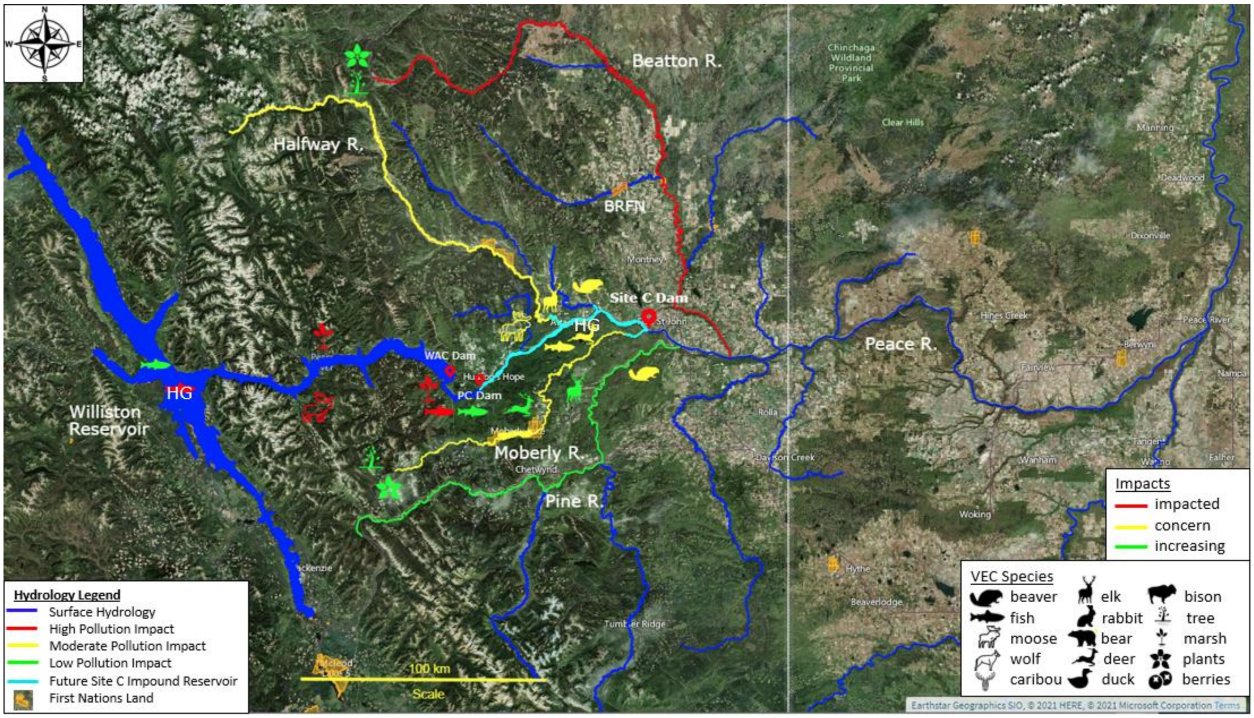
Figure 17: Pollution Impacted Rivers Qualitatively Derived from Mean Chemical Concentrations.



Interestingly, the Pine River (green) had chemical concentrations similar to the stations located along the Peace River.

BC Hydro utilized consultants like Golder Associates, Limnotek, Essa Technologies and Keystone Wildlife Research for many of the studies regarding VEC species. Hydroelectric projects can alter fish habitat upstream and downstream of the dams. A study of fish populations in the Williston Reservoir, 20 years after construction of the dam, observed a considerable drop in mountain whitefish and Arctic grayling and an increase in kokanee and bull trout (Golder Associates, 2012). This was in response to a change from a river system to lake or reservoir environment. In the Site C Reservoir, group 1 fish (lake trout, burbot, walleye, rainbow trout and northern pike) and group 3 fish (kokanee and lake white fish and planktivorous fish species) are

Figure 18: Science Impacted Surface Hydrology and VEC Species

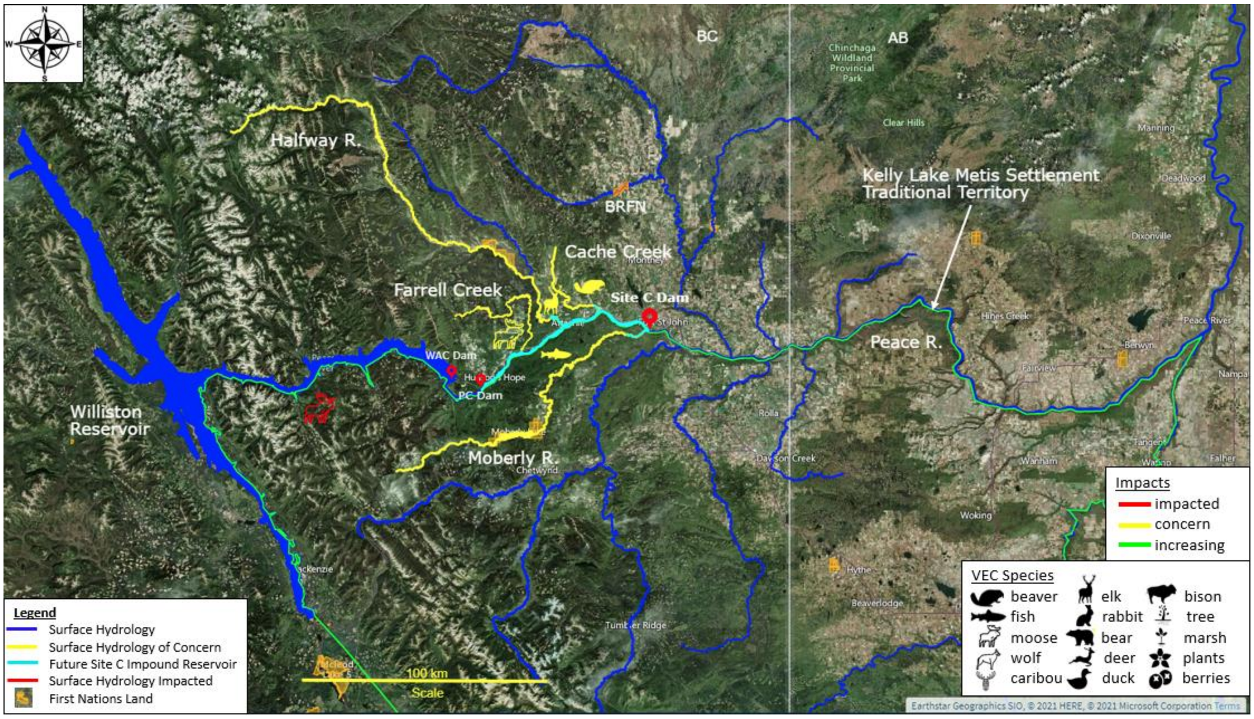


expected to increase (Golder Associates, 2012). Passage sensitive species like Arctic grayling, mountain whitefish and bull trout are expected to decline. Figure 18 shows the impacted VECs and surface hydrology for the study area. Deer and elk species have increased in the area and the moose population have been holding steady; however, the survey data was sparse and accounted for only four years between 1991 and 2011 (Simpson, et al., 2012). Habitats for bear, beaver, ungulates and birds will be flooded during impoundment of the Site C Reservoir.

6.4 Comparison of the Surface Hydrology and VEC Impact Maps

Figure 19 shows the VECs that are in common between the KLMSS and science. There was agreement that moose populations have declined in response to the change in habitat associated

Figure 19: VECs in Common for KLMSS and Science.



with the impoundment of the Williston reservoir. There was concern from both traditional knowledge and science about the impacts fish moose, elk and beaver populations due to impoundment of the Site C Reservoir. The KLMSS had concerns about impacts on Moberly Lake, Moberly River and the Halfway River and the science mean chemical concentrations indicated that the Halfway River and Moberly Rivers had elevated levels of pollutants compared to the Peace River. The KLMSS did not mention the Pine River as a river of concern and science mean chemical concentrations in the Pine River were similar to the Peace River. Combining the VECs and surface hydrology impacts provide a more comprehensive assessment of the species not covered by the other knowledge system (Figure 20). The map shows all potential impacts from both science and the KLMSS. The map provides a visual of what species and watersheds are being impacted by energy projects in the area and by colour coding the VECs the reader can get a sense of impacts and how it relates to the surface hydrology.

Figure 20: KLMSS and Science Combined VEC Impact Map.

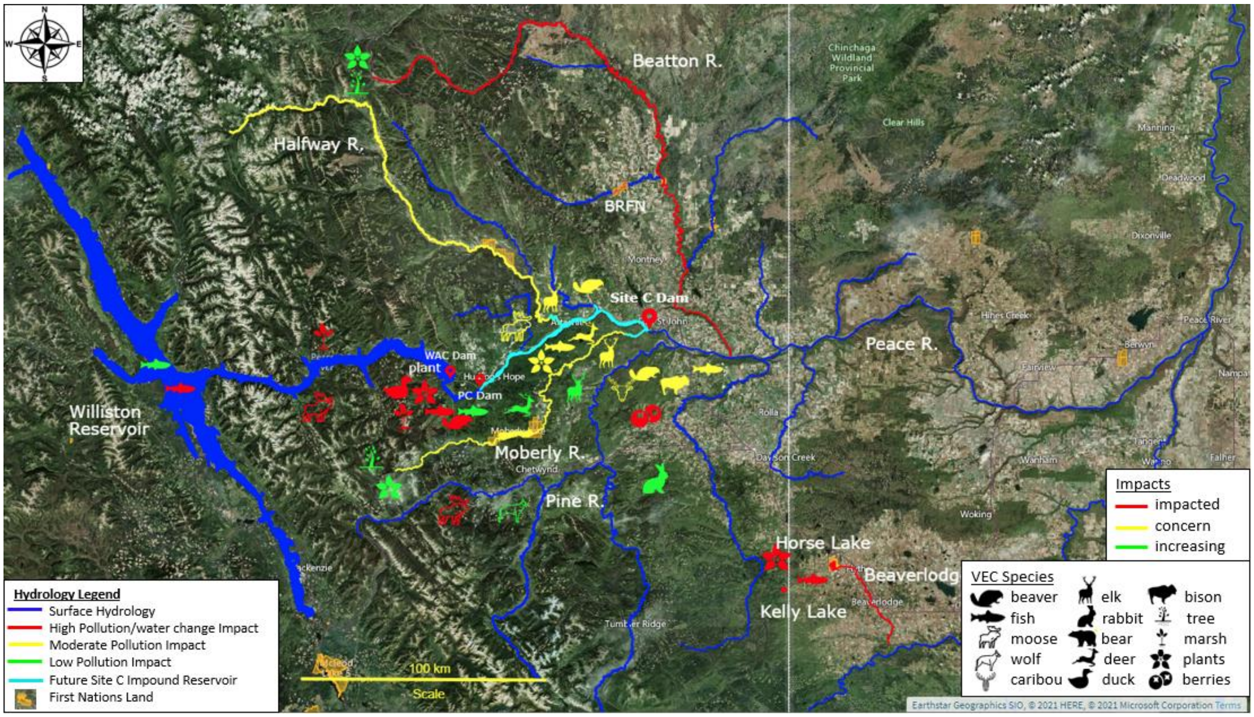
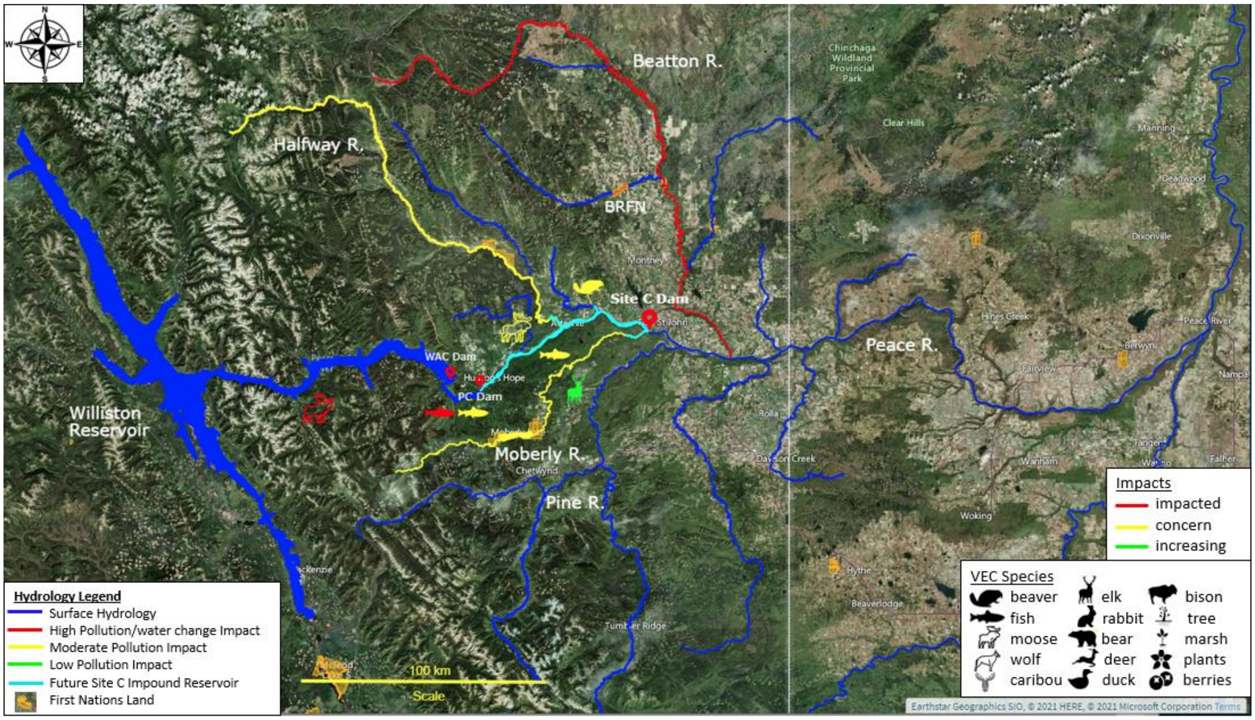


Figure 21 shows the VECs that are in common between science and the BRFN. There was agreement in the decline of moose due to the loss of habitat around Williston Lake; however, there was an increase in elk that was confirmed by both BRFN and science. The BRFN focused more on fish stocks that the KLMSS and the BRFN noted an overall decline in fish stocks and there were also habitat concerns for fish and beaver in the area. The impacts and concerns about surface hydrology of the BRFN were very similar to the qualitative mean chemical concentration map from science data. There was agreement that the Beatton River was contaminated and the BRFN was specific in their assessment that the pollution was the result of oil and gas activity and the mean chemical concentrations provided by science indicated levels are much higher than all other watersheds of concern. The BRFN expressed concern for the Halfway and Moberly Rivers

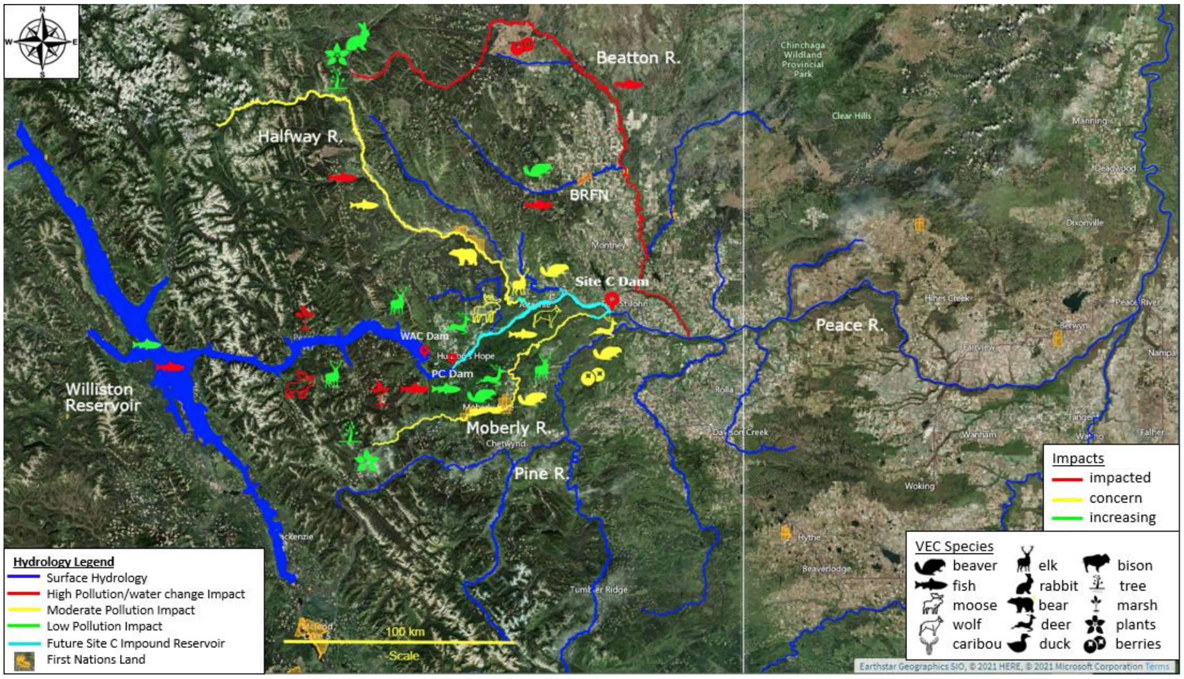
Figure 21: VECs in Common for BRFN and Science.



and the elevated levels of the mean chemical concentrations is something that needs continued monitoring. The Pine River was not noted as a river of concern for the BRFN; however, there were many references to the importance of the Pine in the TLUS. There was disagreement between the BRFN and science regarding the Peace River itself. Interviewers indicated that the Peace River water levels have dropped since the 1950’s (Bouchard & Kennedy, 2011). Science acknowledged that water levels may have changed along the Peace River but the cause was not regulation and it may have been related to other factors like climate change.

Figure 22 shows the combined impacts on VEC species and surface hydrology for the BRFN and science. The map shows a more comprehensive view of the impacts in the area. Similar to

Figure 22: Combined Impacts on VECs and Surface Hydrology for the BRFN and Science.



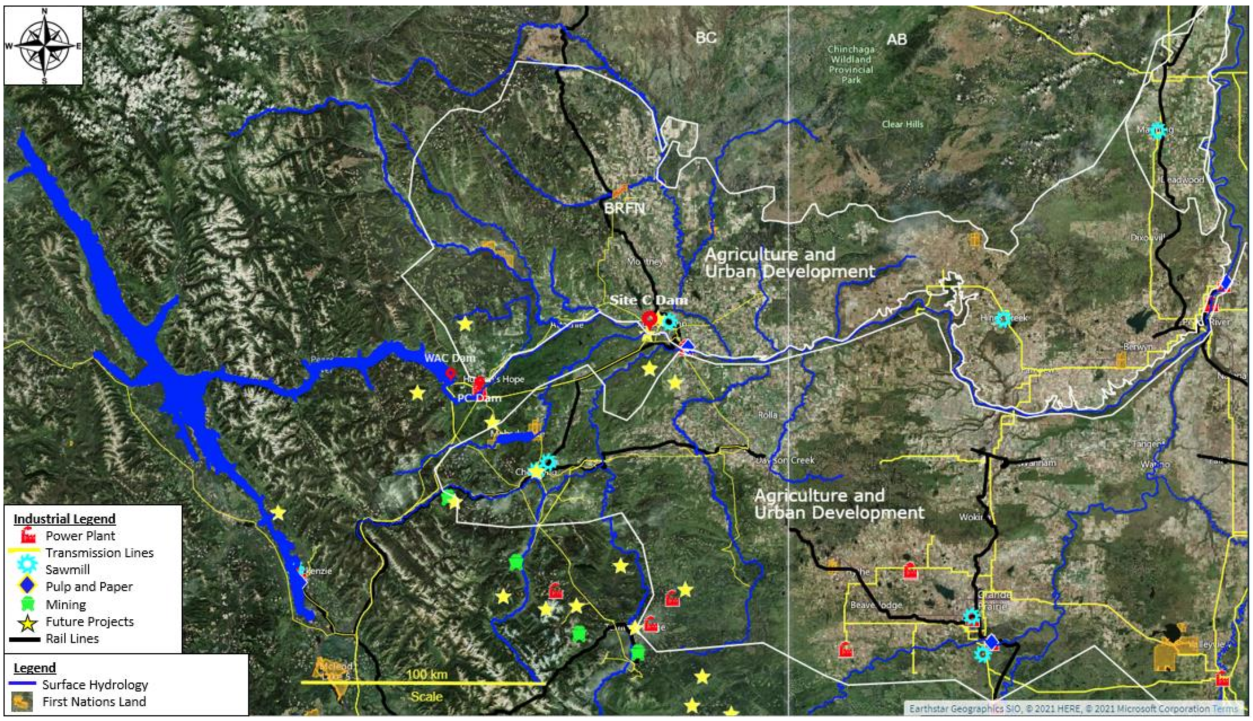
the KLMSS and science combined impacts the species most impacted occurred in the Williston Reservoir area and along the Beatton River. The BRFN reported that some berries have been impacted and no longer grow along Nig Creek and fish are no longer eaten out of the Beatton River *(Bouchard & Kennedy, 2011)*. Elk and deer species are increasing and beaver populations are doing well on the Moberly and Halfway Rivers. Most of the yellow icons (species that may be impacted) occur around the future Site C Reservoir.

6.5 Cumulative Effects Mapping

Cumulative effects assessment is a critical component of any EIA and allows decision-makers to evaluate the impacts of multiple projects that accumulate over time and space. The Peace Region is rich in natural resources and it has undergone significant development over the last 70 years.

Oil and gas development, hydroelectric projects, agriculture, forestry and mining have contributed to cumulative effects. Developing these projects requires a transportation network and the land needed to be cleared for agriculture and urban development. Agriculture and urban development have occurred along Peace River valley from Hudson Hope, BC to Peace River,

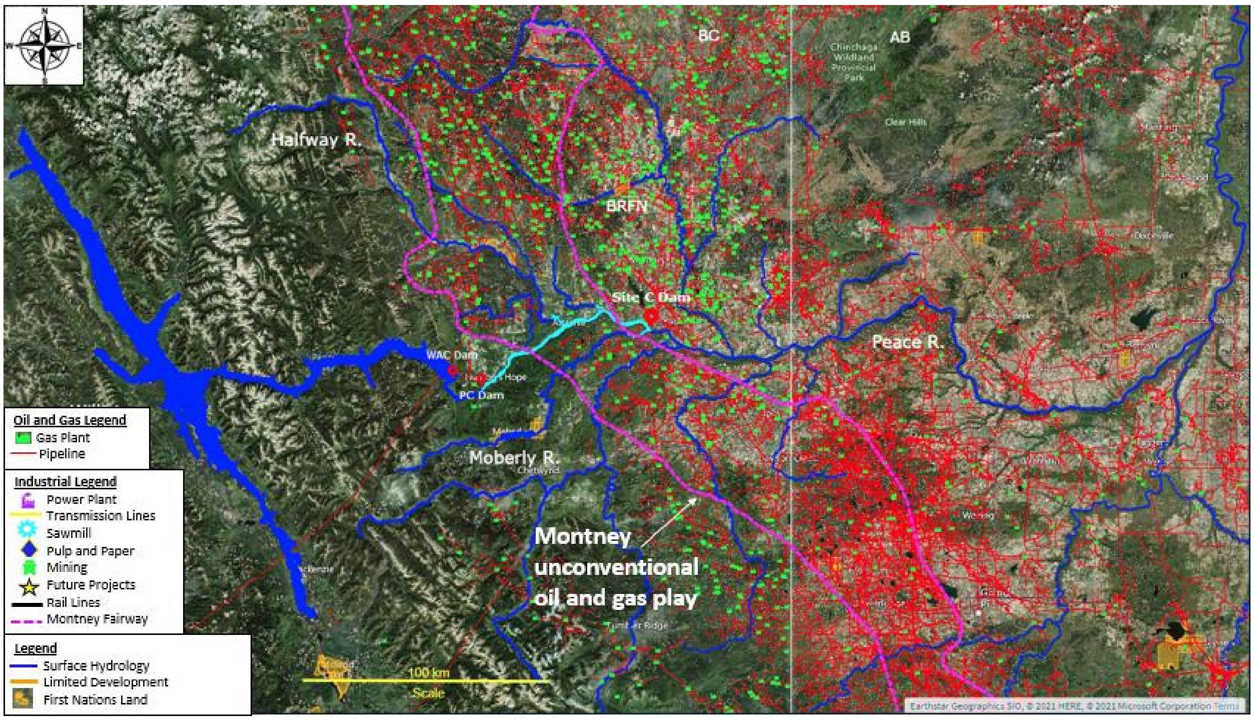
Figure 23: Urban, Agricultural and Industrial Development and Rail.



Note: (Author, 2021). Industrial information provided by Cartofact GIS.

Alberta. Transportation infrastructure is critical to expand resource development as well as, agricultural and urban development, however these developments also add to the cumulative effects in the area. Much of the urban and agricultural development occurs in the Peace River, Grande Prairie and Fort St. John areas. Rail lines extend from Prince George to Fort Nelson, BC and in Alberta from Edmonton to Grande Prairie, then north to Hay River, NWT. Figure 23 shows the impacts of urban and agricultural development as well as, other industrial activities like mining, including several coal mines at the headwaters of the Pine, Sukunka and Murray Rivers, wind farms, oil and gas facilities and the Site C Project (Cartofact, 2021). he modern oil and gas industry began with the oil discovery at Leduc in 1947. The first discovery in BC was spud just

Figure 24: Oil and Gas Development and Montney Play Fairway.



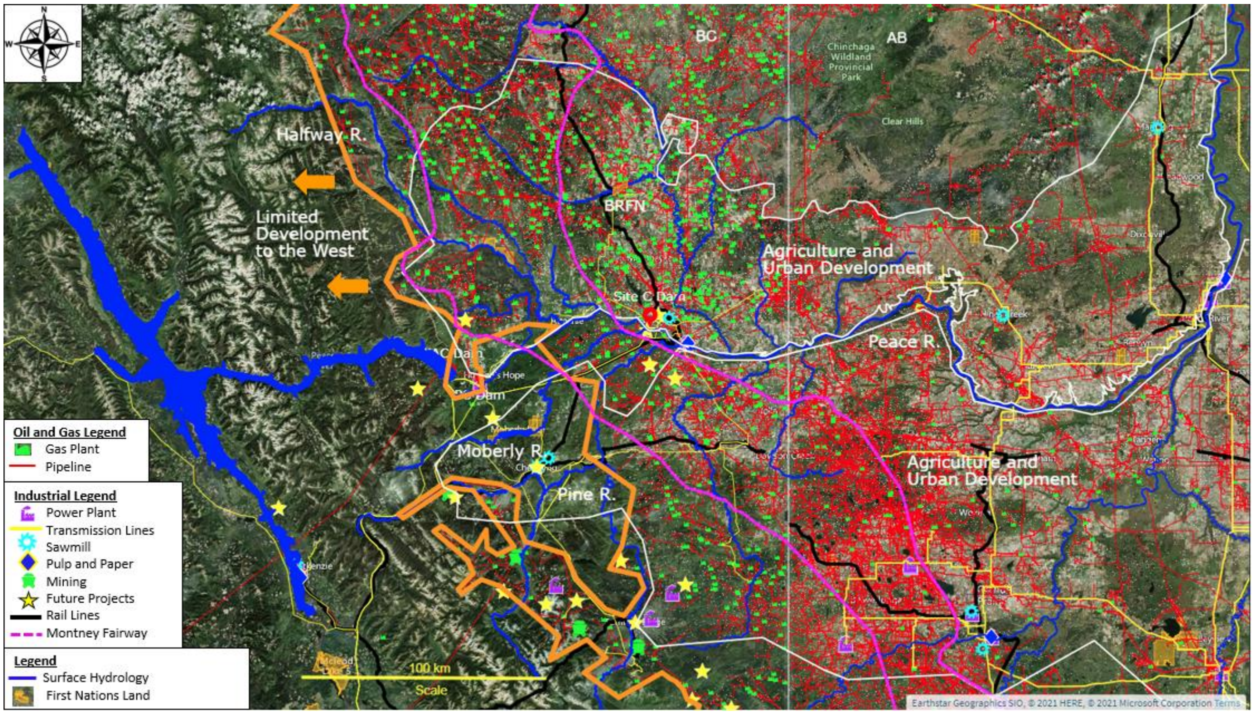
Note: (Author, 2021). Oil and gas information provided by Cartofact GIS.

north of the town of Rolla also in 1947 (Government of British Columbia, n.d.). Oil and gas development in British Columbia took off in the early 2000's with the development of the Montney play. The Montney is a tight gas play that requires horizontal wells and hydraulic fracking to allow the gas to flow. This development technique has transformed the oil and gas industry in North America but the wells are very expensive to drill and complete and require large amounts of water for the frack completions. Figure 24 illustrates the impacts of oil and gas development in the Peace Region. The Montney play is the largest unconventional resource in

Canada. The formation can reach thicknesses of 300 meters with marketable gas estimates exceeding 4,000 trillion cubic feet. The Montney represents 45% of western Canada's gas supply and produces 1.5 million barrels per day of oil equivalent and is expected to grow Canada's output to 57% by 2025 and 65% by 2030 (Nickel, 2020). In order to achieve these targets, more wells, pipelines, and facilities will be needed and the necessary infrastructure and resources, like roads, energy and water, will be required to develop these resources.

Figure 25 is the combination of the two previous maps creating a cumulative effects map of all developments in the area. of writing. The roads map closely follows and infills the outline of the agriculture and urban development polygons. The cumulative effects map shows the location of the 3 hydroelectric projects on the Peace River, the urban, agricultural, industrial, and oil and gas development. All these developments are having significant impacts on the environment and this will continue into the future. After the Coastal Gaslink pipeline is built, natural gas development in the Montney will be the feedstock for LNG on the west coast. The orange line marks the limit of oil and gas development to the west and identifies an area where species would be impacted less by development. The upper Moberly River, Moberly Lake and the upper part of the lower Moberly River lie to the west of the limited development line. Although 80% of the Halfway River lies within the oil and gas development area there has been limited development along this watershed thus far. However, elevated levels of chemical concentrations show that the Halfway and Moberly Rivers may be indicating impacts of pollution from oil and gas, agriculture or urban development are occurring.

Figure 25: Cumulative Effects for the Peace Region.

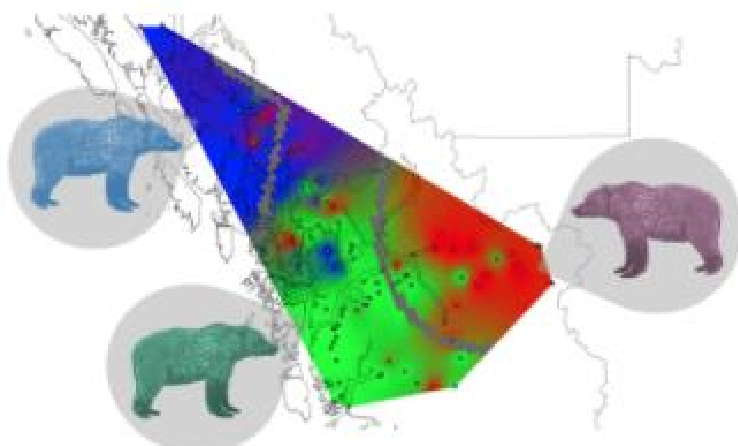


Note: (Author, 2021). Oil and gas and industrial information provided by Cartofact GIS.

6.6 Discussion

The Site C Project is one of many energy projects that are impacting the Peace Region and the traditional lands of the BRFN and KLMS. The TLUS and the science studies provided valuable information on the impacts of surface hydrology and the species of interest and only information that indicated change was used in the study. The TLUS and science information mapped indicated that the studies had more in common than they differed; in fact, there was very little information that was contradictory. A recent study on grizzly bears in central BC is a good example of how collaboration between traditional knowledge and science can lead to some interesting observations. The study found three distinct genetic groups of bears, using microsatellite DNA markers, but could not understand how these groups could form when there was no physical barrier to keep them apart (Figure 26) (Fritts, 2021). The researchers were looking at Indigenous language maps and found a striking similarity to the genetic bear maps. Bears and humans have similar needs, and if an area is rich in resources there is little need for either to leave allowing the genetics of the bears and languages of Indigenous people to coexist in the same area (Fritts, 2021). This type of collaboration is beneficial to both traditional knowledge and science and can provide both knowledge systems with a better understanding of the interconnectedness of nature and in the case of this study how biological and cultural diversity are intertwined (Fritts, 2021).

Figure 26: Three Distinct Genetic Groups of Grizzly Bears Which Align with Indigenous Language Families.



Note: (Fritz, 2021).

When the impacts to VECs were combined from both TLUS and the science studies, there was a more comprehensive understanding of the information that was being presented. Traditional knowledge focused on the impacts of the W.A.C. Bennett Dam where species were impacted the most and on impacts from oil and gas activity. Impacts to the Beatton River were evident from both knowledge systems and the TLUS studies provided useful information that extended beyond the study area. Impoundment of the Site C Reservoir will impact all species in the valley when the reservoir is filled.

One of the biggest unknowns is the impact of upstream flooding on the Halfway and Moberly Rivers and other smaller tributaries. The Site C Reservoir is expected to go through similar changes as the Williston and Dinosaur Reservoirs. Methylmercury levels are expected to rise in the Site C Reservoir and contamination of fish is expected to occur. Fish species are expected to change from river to lake-based species and there is some uncertainty on how the tributaries will be impacted by the change. The Halfway River is important for bull trout and there is concern about the spring spawning migration in this watershed (Bouchard & Kennedy, 2011). The Halfway, Moberly, Pine, Murray and Sukunka Rivers have alpine origins and provide sediment and freshwater for the basin. Impoundment of the Site C reservoir will disconnect the sediment supply from tributaries upstream of the dam and this will impact the geomorphology of the Peace River downstream. Once the reservoir is full, river flows should resume to pre-Site C levels allowing the discharge of the upstream tributaries to remain the same.

Development in the Peace Region has made it difficult for First Nations communities to exercise their treaty rights. The BC Supreme Court ruled on June 29, 2021 that the province of BC breached its treaty obligation to the BRFN (Prepost, 2021). Madam Justice Emily Burke acknowledged that the province has the ability to take up lands but their power was not infinite. Cumulative effects of all industrial development that were authorized by the province has diminished the ability of the BRFN to exercise their rights to fish, hunt, and trap in a manner consistent with their traditional way of life (Prepost, 2021). Indigenous groups signed treaties and were promised there would be no forced infringement on their traditional way of life and that they would be free to live their way of life as if they never signed onto the treaty at all (Prepost, 2021). Justice Burke noted that the Province of British Columbia was aware of the concerns of the cumulative effects of development; however, they failed to address the manner that was consistent with promises made in Treaty 8 and that decision-making process does not adequately consider how cumulative effects impacts their treaty rights (Prepost, 2021). This ruling has significant implications for the recognition of the impacts of cumulative effects of energy and industrial development and the impacts it has on Indigenous people's ability to exercise their treaty rights.

Chapter 7. Conclusion

7.1 Recommendations

GIS are relatively inexpensive and easy to use, however there is some training required. Databases can be very large and knowledge of how they work will enable the user to effectively search for data and to create their own data for internal or external purposes. The Site C Dam is not expected to be completed until 2025 so this provides Indigenous communities with an opportunity to gather data before the dam is operational. Water quality and quantity data would be useful in understanding impacts on VEC species before and after impoundment. Based on the research and analysis in the report, the following recommendations are suggested.

- More active engagement with Indigenous communities by proponents and governments and sharing of data (past, present and future) and GIS provides the platform for this to happen. Data can be downloaded and shape files can be imported into GIS and shared amongst interested parties.
- Increased Indigenous led studies for input into EIA to ensure Indigenous concerns are being addressed and more collaboration with universities for joint studies.
- Increased resources for TLUS to ensure the traditional knowledge is properly represented in EIA and increased participation in monitoring programs with proponents and government agencies.
- Indigenous peoples should be part of the high-level decision making at the beginning of the decision-making process because their lands and traditional way of life are impacted most.
- Include cumulative effects mapping in all TLUS and EIA's

7.2 Limitations and Future Work

There were many TLUS studies that provided traditional knowledge of impacts to surface hydrology and species of interest that would have contributed greatly to the understanding of the impacts of development; however, time constraints were the major limitation of the project. The proponents EIS was the major source of science knowledge used in the study along with selected studies that focused on the effects of regulation on the Peace River. The report was a qualitative assessment of the two knowledge systems as most of the traditional knowledge was qualitative in nature. The cumulative effects maps were limited by the capabilities of Cartofact GIS.

Future work would include incorporating additional TLUS in the study to get a more comprehensive assessment of impacts. Future work for Indigenous communities would be to familiarize themselves with these GIS and develop their own mapping projects for TLUS. I would like to meet with the Traditional Knowledge Keepers and spending time in their communities would be beneficial to hear the traditional knowledge straight from the source along with anecdotal information. I have spent the last 8 months scouring images of the countryside of the Peace area, zooming in and out in Cartofact GIS, and I have developed a remote understanding of this area. I have only been to Fort St John once and I plan to revisit the area in the near future to get a greater understanding of the scale of these hydroelectric projects and the impacts they have. I have spent a considerable amount of time in the field as a geologist and that is where the most memorable learning experiences have occurred.

7.3 Conclusions

Hydroelectric projects on the Peace River have impacted the flow regimes of the Peace River Basin by creating shifts in seasonal patterns and reducing peak flows (Prowse, Peters, Church, & English, 2002). The Site C Dam will impound the Site C Reservoir flooding upstream rivers like the Moberly and Halfway Rivers and altering the habitat of all species living in the river valley. GIS is a tool that can be used to understand these changes spatially and temporally. Traditional knowledge and science provided their interpretation on impacts to species and regional surface hydrology from different perspectives and the study found that they had more in common than they differed. Combining the information from both knowledge systems provided a more comprehensive understanding of the impacts on species and watersheds and where it is occurring spatially. GIS provide the user with layers of information on oil and gas development, logistics, demographics, power grids, surface hydrology, industry and the environment that can be overlayed to produce cumulative effects maps. GIS provides a platform to download data from spreadsheets or import shape files or satellite images to map spatially and temporally. GIS is widely used by proponents for their mapping needs and it can be utilized effectively by Indigenous communities to gather and store information that is important to their traditional way of life.

There is an opportunity for Indigenous groups, governments, and proponents to work collaboratively and share information regarding impacts to the environment. This is starting to happen and scientists are starting to understand the comprehensiveness and complexity of traditional knowledge. Traditional knowledge provides governments and industry with a different approach to analysing the biological and ecological complexity of the natural world. The most important outcome of the project was the significance of cumulative effects mapping. Hydroelectric, oil and gas activity and other industrial developments have significantly impacted the natural resources important to Indigenous communities in the Peace Region. It is important for Indigenous communities to include the cumulative effects mapping to demonstrate how multiple projects over time can impact their traditional way of life. These maps should be included in all TLUS and EIA submissions.

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