Appendix Y

Final Climate Adaptation and Resiliency Technical Support Document

MARTEN FALLS FIRST NATION
COMMUNITY ACCESS ROAD

Climate Adaptation and Resiliency Technical Support Document: Existing Conditions & Effects Assessment

February 2026

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AECOM: 2024-12-21

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Revision History

Revision Number	Date	Revised By:	Revision Description
1	05-28-2024	Leah Deveaux	Revised to address technical comments from AECOM Technical Review
2	11-06-2024	S. Drueke, D. Gray, and L. Grimond	Additional information included in Attachment A and B
3	10-12-2024	S. Drueke, D. Gray, and L. Grimond	Incorporation of comments
4	12-04-2025	S. Drueke, D. Gray, and L. Grimond	Incorporation of comments from public consultation

Executive Summary

As part of the existing conditions and effects assessment a Climate Change Risk Assessment was conducted to identify and evaluate the risk that climate-related hazards may have on the Marten Falls First Nation Community Access Road, the Indigenous communities and the natural environment. Over the course of the Climate Change Risk Assessment, the historical and future climate portraits for the were established. Based on the identified climate hazards, the climate-change-related risks were assessed before recommendations to increase the resilience of Marten Falls Community Access Road were developed.

Key Messages

1	Heavier precipitation can cause dangerous driving conditions by reducing visibility and traction. Road conditions can deteriorate quickly, and flash floods occur suddenly. Flooding due to runoff or flash floods can cause erosion of the road surface, create rills and gullies and complete or partial road washouts, rendering the road impassable for extended periods. Road closures are possible, causing potential delays in mobilization and arrival of first responders during emergency situations.

2	Impacts of heavy rainfall are lessened, and the risk of flooding is decreased by, for example, oversizing culverts (e.g., future 100-year event), defining overland flow routes with expansive grade slopes and maintaining a crowned (4%) surface.

3	Warmer weather with less snow in winter along the Marten Falls Community Access Road will increase the likelihood of wildfires. These wildfires will burn hotter and faster and consume a greater area, causing the destruction of the built and current natural environment. Distant wildfires that do not directly threaten Marten Falls Community Access Road infrastructure can reduce air quality and lead to major health problems.

4	During construction, the use of steel or concrete instead of, for example, timber is recommended. Constant removal of ground litter and high ignition vegetation, especially near explosives storage, will lessen wildfire potential as does the installation of external sprinkler systems. During wildfire season, monitor air quality and limit the exposure of workers to smoke by modifying work schedules and maintain filter in air conditioning units. Develop and implement an Emergency Preparedness and Management Plan in the case of a wildfire event.

5	Heat exhaustion, heat stroke, dehydration, and heat stress are common health risks when adequate cooling is not available and while conducting heavy manual labour.

6	Develop heat mitigation and management strategies which include the enforcement of breaks and the provision of protective equipment for workers, flexibility of work schedules, the installation of air conditioning in the construction camp, and the communication of warnings and health safety tips.

7	The local ecosystem of native boreal forests and varied wetlands and its integrity and stability will be threatened increased temperatures, changes in precipitation patterns, disturbances in inter-species relationships and increases in pests and pathogens. The alterations to ecosystem services may include impairment of water supply and quality, increase of food insecurity, loss of medicinal plants, and threat to the maintenance of culture and tradition such as reduced capacity of community members to travel, hunt and trap during winter months.

Climate Change Along the Marten Falls Community Access Road

With global climate change, the local climatic conditions along the Marten Falls Community Access Road are changing. Climate models that provide projections of future climatic conditions show an increase in daily mean temperature and heat waves, a noticeable increase in rainfall events, the increase of extreme snowfall events and more wildfires, among other changes to the local climate.

Increasing the mean temperature makes winters milder with shorter snow cover duration, less snow accumulation and shorter frost seasons but longer growing season. The influence of heat waves during summer can extend into the transition periods of spring and fall. Consequently, an increased wildfire risk is likely. Extended periods of dry and hot weather make it easier for fires to ignite and spread rapidly. Fires can have a wide range of significant impacts on the Indigenous communities, air and water quality, increased risk of post-fire flooding and landslide, and the ecosystem.

The change in precipitation pattern will also lead to heavier and more frequent rainfall events. Extreme rainfall amounts over short periods, such as rain or thunderstorms, can lead to flooding due to runoff. Climate change also impacts winter precipitation with a decrease in freezing rain events and an increase in heavy snowfall events, leading to increase snow accumulation on the road.

Climate Change Impact on Ecosystems and Traditional Way of Life

The Marten Falls First Nation is located in the Hudson Bay Lowlands and the ecosystem is characterized by boreal forests and varied wetlands. Climate change with its different aspects will impact the integrity and stability by altering biodiversity, habitats, and ecosystem processes and services. It poses a threat to many species, mainly due to increased temperatures, changes in precipitation patterns, disturbances in inter-species relationships, increases in pests and pathogens, in addition to anthropogenic pressure on natural habitats. Social, cultural, and economic activities that revolve around land, such as hunting, trapping, gathering, and fishing, are, therefore, deeply impacted by the changing climate.

The ecosystem will transform slowly over decades and heterogeneously, depending greatly on seed dispersal ability, the deterioration of soil moisture and warming, as well as disturbances like diseases, pests, wildfire, drought, and windthrow that will advantage new species to shift in the disturbed ecosystem. Furthermore, human activities that cause habitat destruction and fragmentation and as such increase the speed of ecosystem transformation. Ecosystem services are also impacted by climate change as water supply and quality might be reduced, food security is endangered, medicinal plants are lost, and culture and traditions are threatened. For example, reduced snow and ice cover will alter the capacity of community members to travel, hunt and trap during winter months.

Climate Risk and Resilience Assessment

In addition to the impacts of climate change on the natural environment and the ecosystem along the Marten Falls Community Access Road, climate change has the potential to affect the road itself during Construction and Operations and the workers and users. The impacts can affect the health and safety of people, compromise the structural integrity of the road, impact the operations (e.g., road closures), and lead to increased financial costs to the Marten Falls First Nation and the road owners. For each component of the road and each aspect of climate change, the effects will be different.

The components include:

- Community Access Road
- Culverts and bridges
- Safety systems
- Illumination
- Construction camps
- Rest stops and road turnout
- People

For each of the assets, the effects of climate change were determined. As climate change is an ongoing transition and depends on the human behaviour over the next decades, the impacts were determined using two time-horizons (2041-2070 and 2071-2100), assuming continued and unabated emissions of greenhouse gases. The 2041-2070 time-horizon includes Construction and the near-future Operations, whereas the 2071-2100 time-horizon includes the far-future operations and the potential decommissioning. This approach allows for the assessment of the risks of the road in the worst-case scenario without adequate international efforts to reduce the emissions.

Climate change takes multiple forms and can be expressed in different ways. Not all of them pose a threat to Marten Falls Community Access Road. By focusing on a representative number of indicators for which the risk increases, a description of the vulnerabilities and risks to the road and its user was developed.

The indicators include:

- Extreme (high) temperature
- Heat wave
- Melting degree days
- Extreme daily rainfall
- Short-duration, high-intensity rainfall (50-year event)
- Multiple-day heavy precipitation
- Daily snowfall (50-year event)
- Wildfire
- Thunderstorm

Each combination of asset group and climate indicator has been evaluated individually, and a risk assessment was conducted. For example, extreme high temperatures or heat waves lengthen the wildfire season, and in combination with low precipitation amounts, increase the potential of wildfires due to low soil moisture and drier vegetation. In warmer environments, wildfires tend to burn hotter and faster and consume a greater area. These fires can cause major damage to the natural environment and can lead to dangerous driving conditions along the road. Even in the case of wildfires that do not occur in the direct vicinity of the road, the result in reduced visibility due to smoke and ash and reduced air quality can lead to significant health problems.

People's health can also be impacted by hot periods. Extreme temperature events will directly affect people's well-being and productivity. During high temperature regimes, heat exhaustion, heat stroke, dehydration, and heat stress are common health risks when adequate cooling is not available. These ailments affect the vulnerable population such as elderly people, children, pregnant women disproportionately and in extreme cases could lead to death. Also at risk are construction workers who are exposed to high temperatures while working outside.

The increased likelihood of extreme precipitation has the potential to increase the occurrence of flooding due to runoff or flash floods. These events may lead to erosion and complete or partial washouts of road segments. Flooding and flash floods cause dangerous driving conditions. Road closures are possible, causing potential delays in mobilization and arrival of first responders during emergency situations.

In summary, climate change alters the risk to the Marten Falls Community Access Road. The increased risk of higher temperature and heat waves poses an increased risk to workers during the construction of the road and users. Wildfire poses direct and indirect risk by causing dangerous driving conditions and reduced air quality. Additionally, heavy rainfall will increase the risk level because of the associated risk of flooding and the potential of washouts and damages to the road. Other risks include the increase in heavy snowfall events potentially leading to high snow accumulation.

To reduce the risk to the Marten Falls Community Access Road, recommended adaptation measures include:

Extreme Temperature and Heat Wave

- Enforce breaks for workers during construction, provide protective equipment and air conditions in camps, and implement flexible work schedules during heat waves.
- Implement an alert protocol designed to identify and communicate hot weather and heat wave conditions that could impact the well-being of community members, visitors, and workers.
- Communicate the health risks of extreme heat events with the public, as recommended by Health Canada (2011). For example, share heat wave warnings and health safety tips on display signs in construction camps and in community buildings.
- Provide designated cool, shaded, or air-conditioned areas for workers in order to limit their exposure to extreme temperatures and heat.

Extreme Rainfall

- Design drainage systems to cope with heavy rainfall with well defined overland flow routes (expansive grade slopes).
- Choose oversized culverts to take into account the increase in the recurrence of floods and extreme rainfall of 172 mm (i.e., a 100-year rainfall in 2071-2100).
- Conduct frequent grading and maintenance of the road to fill potholes and maintain a crowned (4%) surface that can handle heavy rainfall more effectively.
- Communicate the condition of the road with the public in order to encourage people to be careful when traveling. For example, share the location and status of floods or road washouts in construction camps and in community buildings.

Wildfire

- The use of timber in bridge structures is discouraged, and steel/concrete shall be incorporated.
- Conduct regular maintenance and inspection of the road and its cleared 60 m right-of-way to prevent the accumulation of flammable debris and improve safe travel.
- Implement early warning systems to prepare for wildfire events and make informed decisions about road closures.
- Develop and implement an Emergency Preparedness and Management Plan in the case of a wildfire event.

Thunderstorm

- Establish a storm warning system that alerts road users in advance so that they can plan their travel.
- Establish and communicate guidelines on what to do in case of a thunderstorm to road users.

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1. Introduction

This report presents the existing conditions and effects assessment for the Climate Adaptation and Resiliency Discipline and is being prepared in support of the Marten Falls Community Access Road Environmental Assessment / Impact Statement.

Marten Falls First Nation is a remote First Nation community in northern Ontario, approximately 430 km from Thunder Bay, Ontario, located at the junction of the Albany and Ogoki rivers. Marten Falls First Nation is proposing a multi-purpose all-season Community Access Road (the Project) that will connect the community to the Ontario provincial highway network.

The Project includes the construction and operation of an all-season road with the following key characteristics:

- Approximately 184 km of two-lane gravel all-season road on a new right-of-way;
- Approximately 100-m wide right-of-way cleared to a width of 60 m; and
- Proposed designated speed limit of 80 km per hour.

Marten Falls First Nation is currently accessible year-round by air transportation out of Thunder Bay, Ontario and Nakina, Ontario, and by a winter access road constructed on an annual basis, if winter conditions permit. Since the 1990s, Marten Falls First Nation has received provincial funding to maintain the 140 km of winter road to the community.

1.1 Project Overview

The Project consists of a Community Access Road from Painter Lake Road located approximately 57 km north of Nakina, Ontario to the Community of Marten Falls First Nation. The Community Access Road will serve community access and industrial supply needs for both the community (e.g., fuel, construction supplies, water treatment supplies) and industrial proponents (e.g., mining, forestry), thereby minimizing infrastructure corridors in the Far North. Therefore, the Project will be for a multi-purpose road built to meet industrial use specifications.

In April 2018, Marten Falls First Nation signed an agreement with the Ministry of the Environment, Conservation and Parks to prepare an environmental assessment under the Ontario *Environmental Assessment Act*, for the design, construction, and operation of the Project (Government of Ontario, 1990a). A study under the Act was formally initiated by Marten Falls First Nation in March 2019, when the Notice of Commencement for a Terms of Reference for the Project was published.

All-season public roads that require 75 km or more of new right-of-way, as per Schedule 1(51) of the Physical Activities Regulations under the *Impact Assessment Act*, may be subject to the Act (Government of Canada, 2019). After considering the detailed Project description, the Impact Assessment Agency of Canada (the Agency) determined that a federal impact assessment is required for the Community Access Road and an Impact Statement needs to be submitted to the Agency for review and approval. The Agency prepared and released the *Marten Falls Community Access Road Project: Tailored Impact Statement Guidelines* in February 2020 (Impact Assessment Agency of Canada, 2020a) to outline the information and studies necessary to conduct the impact assessment.

The federal and provincial governments are co-operating on the assessment of the Community Access Road, in accordance with the Co-operation Plan (Impact Assessment Agency of Canada, 2020b). The Co-operation Plan allows Marten Falls First Nation to prepare one single Environmental Assessment / Impact Statement submission to satisfy both the federal and provincial processes.

1.2 Qualifications of Individuals

A list of names and qualifications of the authors and technical reviewers of this report is presented in **Table 1-1**.

Table 1-1: Qualifications of Individuals

Name	Title / Role	Years of Experience	Qualifications
Laurence Grimond	Environmental Scientist / Climate Change Specialist	3	M.Sc.
Sonja Drueke	Atmospheric Scientist / Climate Change Specialist	11	Ph.D.
Derek Gray	Climate Change Specialist	30	P.Eng., A.A.E., I.R.P.

2. Project Description

The Project will be executed in three main phases:

- Planning and design, which includes the preparation of the Environmental Assessment / Impact Statement, obtaining regulatory approvals, and detail engineering design;
- Construction, which is anticipated to last between 3 and 10 years; and
- Operations, for a permanent road.

2.1 Project Components

2.1.1 Roads

The Project consists of an approximately 184 km all-season road within a 100-m wide right-of-way, 60 m of which will be cleared of vegetation. Additional temporary clearing occurring in certain locations to accommodate construction activities, access, borrow areas, aggregate source areas, quarry sites, and temporary infrastructure such as staging areas, camps and debris, and / or timber stockpiles will be required. It has a roadway approximately 11 m in width to accommodate a two-lane gravel road with culverts and two-lane bridges at water crossing locations. Traffic levels for the Project have been estimated at under 500 vehicles per day. However, the Ministry of Transportation has requested that the Project be designed using an annual average daily traffic amount of 1,000 vehicles per day.

The predominant building materials will be blasted rockfill and composite excavation material capped with granular surface material. The majority of blasted rockfill will be obtained from rock outcrops within and / or adjacent to the right-of-way.

Early investigations on permafrost have shown the Project is located within a sporadic discontinuous permafrost zone, with known locations documented and monitored. Excavation within identified permafrost areas will be avoided, whenever possible, as cutting into surface vegetation can disturb the permafrost regime resulting in thaw and unstable ground. As a precaution, the design will primarily use fill to minimize any permafrost degradation and will follow the recommendations outlined in a Permafrost Management Plan.

2.1.2 Bridges and Culverts

Bridges will be required over the various waterways to provide grade separation with sizes ranging from single-span to multi-span bridges to carry two lanes of traffic with appropriate shoulder widths. The foundation support for the bridge abutments is expected to consist of driven steel piles, drilled concrete piles or concrete spread footings.

Equalization culverts will be installed at locations where it is determined that spring-melt or storm runoff needs to pass from one side of the Project to the other to prevent flooding and / or erosion. The purpose of equalization culverts is to maintain the existing surface water drainage patterns in the area. Culverts will be put in place as construction progresses along the Project.

2.1.3 Pits and Quarries

Pits and quarries will be developed to provide crushed rock and granular materials for the construction of the Project and temporary access roads. These sites have been identified and considered in this Environmental Assessment / Impact Assessment. Most of the rock required for construction is expected to come from quarry sites in the vicinity of the Community Access Road route. Temporary access roads will be established to connect the various Project components as required and will be limited in length to the extent feasible. All materials will be subject to a geotechnical verification process in order to check they possess the desired physical properties for use in construction. The development and operation of all pits and quarries will be subject to the aggregate permitting process under the *Aggregate Resources Act* (Government of Ontario, 1990b; Ministry of Natural Resources and Forestry, 2020, 2023). Permitted pits and quarries will follow the progressive and final rehabilitation requirements outlined in the approved site plans under the Act.

Only material that has been cleared through a geochemical verification process will be used for the road surface to avoid acid rock drainage or metal leaching. Monitoring of runoff will be conducted from an erosion and sediment control perspective; further details about this specific type of monitoring will be available in the Erosion and Sediment Control Plan.

2.1.4 Temporary Infrastructure for Construction

Temporary access roads may be required to access the right-of-way during construction. The purpose of the temporary access roads is to facilitate emergency access, equipment and personnel access, and to provide access to and from quarries, borrow sites, and aggregate source areas. The temporary access roads will be cleared, but not grubbed, to approximately 10 m wide to accommodate equipment movement.

Upon completion of construction, sand and gravel pits, including temporary access roads leading to the pits will be rehabilitated (progressive and final rehabilitation) and surrendered in accordance with the *Aggregate Resources Act* (Government of Ontario, 1990a).

Temporary construction camps, staging areas, and stockpile areas are anticipated to be established at various locations along the right-of-way and / or near other Project components. These components are proposed to support crews, store equipment, vehicles, materials, and supplies.

3. Information Shared by Indigenous Peoples and Other Interested Persons Which Informed This Report

In the course of completing the description of existing conditions and effects assessment for this report, information provided by Indigenous knowledge holders, Indigenous community members, regulators, and public stakeholders was used to develop the approach and assessment conducted for this study. This information and how it informed the development of this report are described below. This section does not detail all the information, comments, or questions received related to the Project and is limited to only the information which informed this report. For a full description of all consultation and engagement related to the Community Access Road, refer to the Record of Consultation and Engagement for the Environmental Assessment / Impact Statement. Information related to the Indigenous Knowledge Program can be found in the *Aboriginal and / or Treaty Rights and Interests Technical Support Document* (Appendix O of the Environmental Assessment / Impact Statement).

3.1 Indigenous Knowledge

Indigenous Knowledge refers to Indigenous systems of knowledge as well as cultural practices related to the production of knowledge based on traditional belief systems, relationships to the environment, and community practices. It is the accumulated and living knowledge built upon the historic experiences of peoples living on the land and adapting to social, economic, environmental, spiritual, and political change (Chiefs of Ontario, no date). It includes knowledge about the natural environment (e.g., locations of caribou seasonal use and calving areas), the relationships between environmental changes and species or ecosystems, and how potential effects to the environment can be avoided or reduced.

Indigenous land and resource use refers to specific areas and resources used for traditional purposes when Indigenous peoples learn and practice their Indigenous Knowledge (Garvin et al., 2001). This includes the areas and sites used for hunting, trapping, fishing, and gathering and the resources harvested, as well as cultural sites, features and practices—sometimes referred to as Traditional Land Use.

In 2019, the Marten Falls Community Access Road Project Team launched a program to collect Indigenous Knowledge. The Indigenous Knowledge Program is a critical component of the information base upon which the assessments will rely. The information generated through the Indigenous Knowledge Program has been woven with scientific approaches, and both knowledge systems will be given equal consideration in forming the foundation for existing conditions, predicting potential project effects, and determining appropriate mitigation and monitoring methods.

The Indigenous Knowledge Program occurs in two concurrent phases:

- Collecting existing Indigenous Knowledge and information on Indigenous land and resource use to help inform the early stages of the assessments; and
- Completing Project-specific Indigenous Knowledge and Lands and Resource Use studies.

The protection and confidentiality of Indigenous Knowledge and information on Indigenous land and resource use is of the utmost importance to the Project Team. To honour and respect this important information, Indigenous Knowledge Sharing Agreements were established with interested communities prior to the use of community information. The Sharing Agreement outlines how confidential and sensitive information will be woven into the environmental / impact and design processes.

All Indigenous communities and groups identified by the Ministry of the Environment, Conservation and Parks and the Agency through the Indigenous Engagement and Partnership Plan have had the opportunity to participate in the Indigenous Knowledge Program. The Indigenous Knowledge Program provides interested Indigenous communities an opportunity to: share existing Indigenous Knowledge and information on Indigenous land and resource use and cultural values that may be relevant to the Project, and / or complete Project-specific studies to collect and share Indigenous Knowledge and information on Indigenous land and resource use and cultural values. The Indigenous Knowledge Program included opportunities for Indigenous communities and groups to meet with the Proponent to discuss the program, ask questions, and share concerns and interests.

The Proponent strove to respectfully collaborate with Indigenous communities on how Indigenous Knowledge and information on Indigenous land and resource use and cultural values were considered in reporting, and how potential effects to Aboriginal and / or Treaty Rights and Interests were assessed. Measures to support this included but were not limited to: engaging Indigenous communities to solicit information on Indigenous Knowledge and Indigenous land and resource use and cultural values; to inform existing conditions, providing Indigenous communities with draft sections of the Environmental Assessment / Impact Statement; to illustrate how Indigenous Knowledge and information on Indigenous land and resource use and cultural values has been integrated, and to confirm it has been presented appropriately, and completing collaborative working sessions with Indigenous communities for the effects assessment on Aboriginal and / or Treaty Rights and Interests. Further information on how potential effects on Indigenous rights were assessed is provided in the *Aboriginal and / or Treaty*

Rights and Interests Study Plan (Appendix O, Attachment A of the Environmental Assessment / Impact Statement).

Information provided by Indigenous knowledge holders, recognized as such by their Indigenous community, has been obtained through literature review and shared directly by Indigenous nations in support of this Project through face-to-face meetings or receipt of Indigenous Knowledge reports (**Table 3-1**).

Table 3-1: Indigenous Knowledge

Valued Component	Indigenous Community	Details	Section Reference
General	■ Fort Albany First Nation and Kashechewan First Nation	■ Reported migration route changes of waterfowls has negative economic impacts on Fort Albany First Nation.	■ **Attachment C**
General	■ Fort Albany First Nation and Kashechewan First Nation	■ A significant fish die-off has been reported in 2005 and was linked to regional climate change. Due to the importance of fishing to members of the Fort Albany First Nation, the associated decline in fish population (e.g., whitefish, lake cisco, jackfish, suckers, walleye) threatens food security.	■ **Attachment C**
General	■ Marten Falls First Nation	■ Marten Falls First Nation members have observed a decline in native bird species while simultaneously noting an increase in non-native species. ■ It is suggested that climate change has affected migratory paths or disrupted habitats.	■ **Attachment C**
General	■ Kitchenuhmaykoosib Inninuwug	■ Kitchenuhmaykoosib Inninuwug members have reported that regular migratory rhythms of waterfowl are disturbed, and their arrival times cannot longer be predicted.	■ **Attachment C**

Valued Component	Indigenous Community	Details	Section Reference
General	■ Wapekeka First Nation	■ It has been mentioned that the seasonal rhythm of hunting is impacted changes in the migratory pattern of animals (e.g., geese).	■ **Attachment C**
General	■ Weesnuk First Nation	■ Changes in staging areas for migrating waterfowl has been noted as a direct impact of climate change on food security for the community.	■ **Attachment C**
General	■ Weesnuk First Nation	■ Climate change and sudden river thaws have increasingly limited access to traditional caribou hunting areas for community members over their lifetimes.	■ **Attachment C**
General	■ Marten Falls First Nation	■ The local and regional study area is dominated by upland boreal forest and extensive wetlands associated with the Hudson Bay Lowlands. ■ Conifer forests are dominated by black spruce, balsam fir and trembling aspen with willows close to bodies of water. ■ The area is comprised of bogs, open fens, small ponds with standing water interspersed by higher areas, conifer swamps.	■ **Attachment C**
General	■ Marten Falls First Nation	■ The prediction of extreme high temperatures and high rainfalls is interesting. Right now, we see drought conditions with little rainfall and in the winter, there is also a lack of snow. Historically what we have experienced in the summer is thunderstorms that build up late afternoon which can produce heavy rainfall in a short period	■ **Section 5.1; Attachment C**

Valued Component	Indigenous Community	Details	Section Reference
		of time. These storms can also generate a lot of wind and do a lot of damage and lately in some areas in Northwestern Ontario tornadoes have been reported, which can cause a lot of damage to trees, houses and possibly loss of life. With climate change and an increase in temperature storm systems can be more severe, intense and we need to be prepared for the worst.	

3.2 Indigenous Community Knowledge

Indigenous community knowledge is knowledge about Indigenous communities provided by Indigenous community members and staff living either on or off reserve. While this knowledge may be connected to Indigenous Knowledge, it is also distinguishable based on local understandings and lived experiences, which could include place-based information about housing, education, social services and infrastructure, and governance. This information may be based on and presented in ways that reflect different and diverse community members' social identities.

Indigenous community knowledge was obtained primarily through the climate change workshop using in-person discussions. Where it was provided and made available, Indigenous community knowledge was woven into the this report to include community insights, perspectives, lived experiences, and knowledge(s) about different socio-community conditions, as well as perspectives and concerns. Indigenous community knowledge, which informed this report, is described in **Table 3-2.**

Table 3-2: Indigenous Community Knowledge

Valued Component	Details	Section Reference
General	■ There has been a noticeable decrease in trapping of fur bearing animals around Marten Falls First Nation except for martens (ID 443 from the Indigenous Knowledge table).	■ **Attachment C**

3.3 Indigenous Engagement

In addition to the Indigenous Knowledge provided by Indigenous knowledge holders, information was collected from all Indigenous community members with interests in this Project.

The Indigenous communities were engaged primarily through the Climate Change Webinar and an accompanying online anonymous survey. Where it was provided and made available, Indigenous community knowledge was woven into this report to include community insights, perspectives, lived experiences, and knowledge(s) about different socio-community conditions, as well as perspectives and concerns. Indigenous community knowledge, which informed this report, is described in **Table 3-3**. No valued components were developed using Indigenous community knowledge.

Table 3-3: Indigenous Engagement

Section Reference	Details
Attachment B	■ The Indigenous insights collected during the Climate Change Webinar guided the development of qualitative research into the impacts of climate change on ecosystems and traditional way of life (i.e., knowledge and experiences of community members regarding observed climate changes).

3.4 Regulator and Public Stakeholder Input

The Proponent engaged with regulators and public stakeholders with technical knowledge related to the valued components to inform aspects of this report. The information and how it informed the development of this report are described in **Table 3-4**.

Table 3-4: Public, Agency and Other Input

Valued Component	Provided By	Details	Section Reference
General	■ Ministry of Environment Conservation and Parks Senior Policy/ Program Advisor	■ When conducting risk assessments, it is recommended to use the best available climate data and information.	■ **Section 4.4.3**

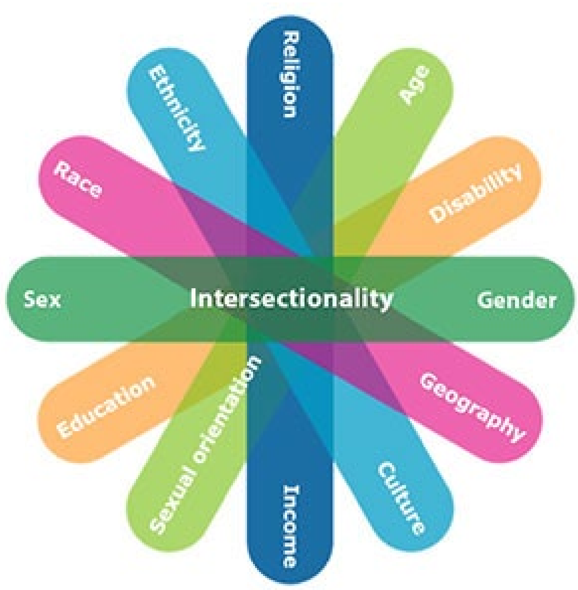
Valued Component	Provided By	Details	Section Reference
		■ Using the best available science will narrow the range of uncertainty for each emission scenario that is being used.	

3.5 Gender-Based Analysis Plus

The *Impact Assessment Act* (Government of Canada, 2019) requires Gender-Based Analysis Plus to be applied to impact assessments in Canada. Gender-Based Analysis Plus is not a specific set of methods for impact assessments, but rather an approach that is adapted to the Project and the communities potentially impacted and / or being engaged.

Gender-Based Analysis Plus is an approach to assessing inequalities and impacts of policies, programs, and projects on diverse groups and identities. These identities could include (but are not limited to): gender, sexual orientation, age, race, ethnicity, class, religion, and mental or physical disability(**Figure 3-1**) (Women and Gender Equality Canada, 2022). These identities can also intersect or overlap (e.g., where an individual identifies as being both Indigenous and an Elder or youth).

Figure 3-1: Gender-Based Analysis Plus Intersecting Identity Factors



Source: (Canadian Institutes of Health Research, 2022)

The Gender-Based Analysis Plus approach involves understanding how certain vulnerable groups—such as Indigenous peoples, women, Elders, youth, and Two-Spirit, Lesbian, Gay, Bisexual, Transgender, Queer, Questioning, Intersex, and Asexual (2SLGBTQQIA+) persons—experience, and could be disproportionately impacted by a project. Understanding how these groups could be affected by projects allow for more targeted, sensitive, and appropriate enhancement measures, mitigations, monitoring, and follow-up (Impact Assessment Agency of Canada, 2025a).

It is important to understand that vulnerability in impact assessment is understood primarily, but not solely, as a structural vulnerability. This means that in many cases it is the systems and power structures that make certain groups more vulnerable (Impact Assessment Agency of Canada, 2025a). For Indigenous peoples this includes historic and ongoing colonialism, loss of lands and culture, intergenerational trauma, and the residential school system that have resulted in significant social, economic, health and well-being disparities relative to the non-Indigenous Canadian population (Kim, 2019). Exceptions to this are where vulnerability may be associated with biological sex, pregnancy, or age in relation to environmental determinants of health and exposure to contaminants.

3.5.1 Climate Adaptation and Resiliency Gender-Based Analysis Plus Approach

The Gender-Based Analysis Plus approach for the Climate Adaptation and Resiliency study involved a more limited, but still important application of Gender-Based Analysis Plus. This approach varied from the Gender-Based Analysis Plus approach used in other disciplines (e.g., socio-economic disciplines) in that it primarily involved identifying how vulnerable groups that could be disproportionately impacted by the Project informed the study, which included:

- Weaving Project-specific Indigenous Knowledge from Indigenous Elders that has been provided, verified, and made available through the Indigenous Knowledge Program into this report (**Section 3.1**).
- Identifying and including interests and concerns specific to this study through the Consultation and Engagement Program from groups who could be more vulnerable to, and disproportionately impacted by, the Project, which include Indigenous communities (**Sections 3.3 and 3.4**).

4. Study Methods and Assessment Scope

This section contains excerpts from the *Draft All Season Community Access Road: Climate Adaptation and Resiliency Study Plan* (**Attachment A**) and prepared for the Impact Assessment Agency of Canada at the outset of this Project. The original study plan and workplan, including comments from regulators can be found in **Attachment A***.* In some instances, the approach to this study deviated from what was described in the original study plan, these deviations are outlined in **Section 4.6, Table 4-12**. General changes such as changes to section headings, organization of sections and subsections and, changes to phrasing and tense have been made throughout.

4.1 Study and Work Plan Purpose and Objectives

As required by the *Impact Assessment Act* (Government of Canada, 2019) and referenced in the *Tailored Impact Statement Guidelines* (Impact Assessment Agency of Canada, 2020a)*,* Study plans and work plans were developed for disciplines as required. The purpose of the study plan is to explain:

- An existing conditions study methodology that will result in a comprehensive description of the existing environment potentially impacted by the Project;
- The process for ensuring efficient and transparent data management and analysis was completed; and
- Developing the discipline-specific Effects Assessment methodology.

Work Plans included details on how to action the study plans; containing information such as location of sampling sites, scheduling, and sequencing.

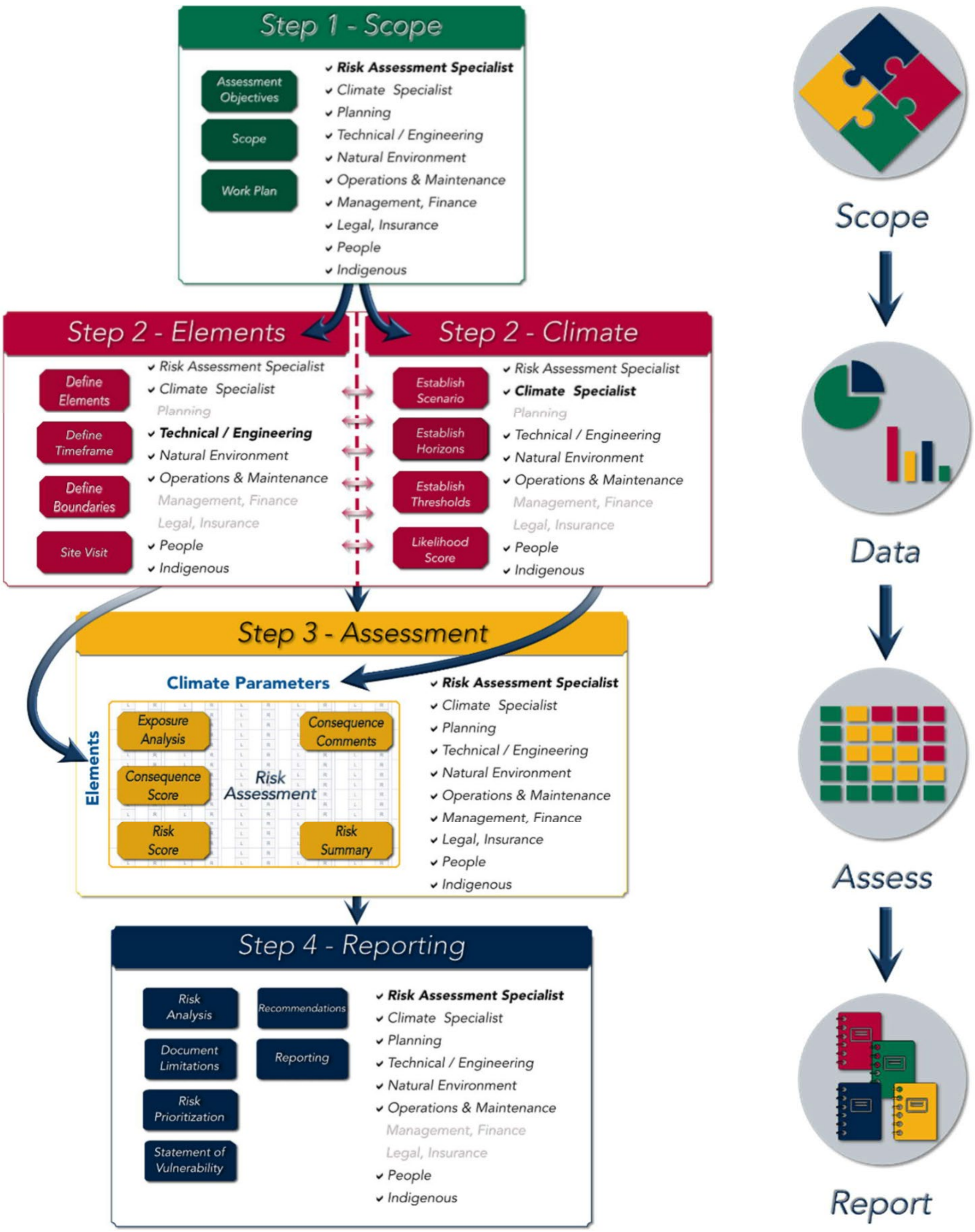
As noted above the *Draft All Season Community Access Road: Climate Adaptation and Resiliency Study Plan* can be found in **Attachment A**.

4.2 Public Infrastructure Engineering Vulnerability Committee High Level Screening Guide

Contrary to what was presented in the study plan, the Climate Change Risk Assessment was undertaken following the four key steps described in the *PIEVC High Level Screening Guide*, developed by the Public Infrastructure Engineering Vulnerability Committee (PIEVC), in alignment with *ISO 31000: Risk Management - Guideline* (PIEVC Program, 2021; International Organization for Standardization, 2018). The High Level Screening Guide was released in November 2021, after the study plan (May 2021), and was favored since it provided more detailed guidance on the process of the

Climate Risk and Resilience Assessment. The four steps of the *PIEVC High Level Screening Guide* are described on **Figure 4-1**.

Figure 4-1: The Application Map of the Public Infrastructure Engineering Vulnerability Committee High Level Screening Guide



Step 1 – Scope

This step established the objectives and the context (e.g., spatial and temporal boundaries) of the Climate Change Risk Assessment, in close collaboration with the engineering team during this and subsequent steps.

Step 2 – Data

During this step, the data for the Climate Change Risk Assessment, including assets and surrounding environment were collected to be assessed along with past experiences of extreme weather and climate impacts and other relevant traditional knowledge that the Marten Falls First Nation would consider sharing. Other climate information was extracted from publicly available sources for historical data and two future climate projections (i.e., 2041-2070 and 2071-2100) for the area.

Step 3 – Assess

This step completed the main portion of the Climate Change Risk Assessment. The risk assessment was undertaken by determining if the assets have been affected or will experience any impacts from historic and future climate projections and to assess the consequences of these impacts by developing associated and applicable risk scoring. High level feedback was sought to provide a relevant and useful Climate Change Risk Assessment.

Step 4 – Report

For the final step in the Climate Change Risk Assessment, the identified risks were evaluated and assessed and recommendations for the Marten Falls First Nation and the future owner and operator of the Community Access Road were developed.

4.3 Study Scoping

4.3.1 Temporal Boundaries

Project phases, which are temporal boundaries, are developed to establish the timeframes within which potential effects of the Project will be considered. The Project is planned to occur in three phases, which are briefly described below.

- **Construction:**
  The time from start of construction, including site preparation activities, to the start of operations of the Community Access Road. Decommissioning of construction works is included during construction. Construction is anticipated to take approximately 3 to 10 years to complete.
- **Operations:**
  Operations starts once construction activities are complete and lasts for the life of the Project. It is considered to be permanent based on the expected timeline for when major refurbishment of road components (e.g., bridges), is anticipated.
- **Decommissioning:**
  There are currently no plans to decommission the Community Access Road as there is no expected / known end date for its need. Therefore, future suspension, decommissioning, and eventual abandonment will not be considered in this report. It will be considered if and when a decommissioning or abandonment application is made for the road.

In the context of this study, two time-horizons were used to produce the Climate Change Risk Assessment. The 2041-2070 time-horizon includes construction and near-future operations, whereas the 2071-2100 time-horizon includes far-future operations and potential decommissioning.

In determining the temporal boundaries, in particular the long duration of operations, consideration was given to the long-term effects on the well-being of present and future generations.

4.3.2 Spatial Boundaries

Project Study Areas

Study areas identify the geographic extents within which potential effects of the Project are likely to occur and will be considered in the Environmental Assessment / Impact Statement. General project boundaries were established for the scoping of field programs, and to delineate study areas for discipline-specific surveys. These general project boundaries are described in **Table 4-1**.

Table 4-1: Project Study Areas Definition and Description

Study Area	Definition	Description
Construction Disturbance Area	■ Area of expected direct disturbance	■ 100 m-wide right-of-way, temporary construction access roads, work areas, worker camps, and pits, quarries and associated access roads.
Project Study Area	■ The area where most of the direct effects of the Project are likely to occur	■ The area within 2.5 km (total of 5 km) of the centreline of the route alternatives.

Climate Adaptation and Resiliency Study Areas

Discipline-specific Local Study Areas and Regional Study Areas have been defined for the Project. In defining these areas, the following was considered:

- Location and other characteristics of the discipline relative to the Project;
- The anticipated extent of the potential Project effects;
- Federal, provincial, regional, and local government administrative boundaries;
- Input from Indigenous communities;
- Community knowledge and Indigenous Knowledge;
- Current or traditional land and resource use by Indigenous communities;
- Exercise of Aboriginal and Treaty Rights of Indigenous peoples, including cultural and spiritual practices; and
- Physical, ecological, technical, social, health, economic and cultural considerations.

The Climate Change Risk Assessment was only completed on the preferred alternative, as it is not possible to differentiate between the different alternatives. Existing gaps in historical observations and general uncertainty in the generation of climate projections limit the resolution of climate information. As such, there is no discernible difference for the alternatives from a Climate Adaptation and Resiliency perspective.

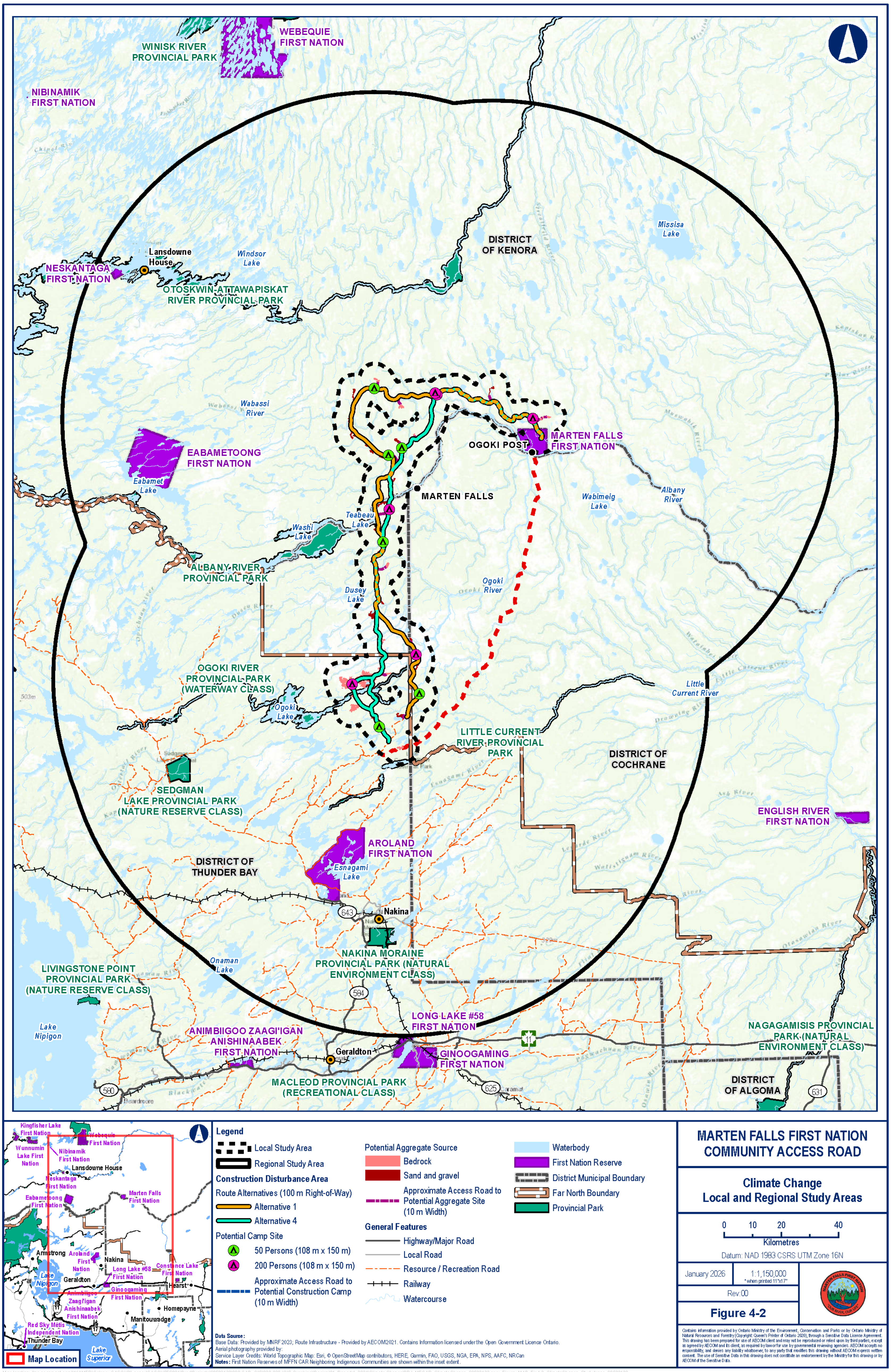
The Local and Regional Study Areas for Climate Adaptation and Resiliency and the rationale for their selection are described in **Table 4-2** and shown on **Figure 4-2**.

Table 4-2: Discipline-Specific Study Areas Description and Rationale

Study Area	Geographic Extent	Rationale	Preferred Alternative Area Size
Local Study Area	■ Project development area plus a 5 km on either side of the centreline of the preferred alternative.	■ Area in which climate change effects on the project are expected.	■ The precision of climate projections does not allow for the differentiation between the two alternatives
Regional Study Area	■ The climate data were developed for: ○ Marten Falls; ○ Aroland; and ○ Neskantaga.	■ Climate change effects on the project are constrained to the local study area, therefore the regional study area is defined based on the geographic extents from available regional climate data.	

The study areas included in this document cover the extent to which readily available information suggests the Project may have noticeable effects on the environment.

Figure 4-2: Climate Change Local and Regional Study Area



4.3.3 Valued Components and Indicators

The Impact Assessment Agency of Canada describes **valued components** as the environmental, health, social, economic, or additional elements or conditions of the natural and human environment that may be impacted by a proposed project and area of concern or value to the public, Indigenous peoples, federal authorities, and interested parties (Seabridge, 2013).

Indicators represent the resource, feature, or issue related to the valued component that, if changed, may demonstrate an effect on the environment. Indicators may be characterized quantitatively or qualitatively. For example, effects from changes to the availability and distribution of valued components are often expressed through quantitative assessment of direct vegetation removals as well as predicted indirect effects on retained vegetation. Indicators are used in this study as climate indicators as defined in the *PIEVC High Level Screening Guide*.

The Draft Study Plan presented indicators and rationale for selection known to the Proponent at the time of drafting. The table and the factors that influenced it can be found in Section 9.2 of the *Draft All Season Community Access Road: Climate Adaptation and Resiliency Study Plan* (**Attachment A**).

An updated list of Climate Adaptation and Resiliency Indicators can be found in **Table 4-3**.

Table 4-3: Public Infrastructure Engineering Vulnerability Committee High Level Screening Guide Project Components and Climate Adaptation and Resiliency Indicators

#	Valued Component	Description	Indicators	Rationale for Selection
1	**Community Access Road**	▪ Approximately 184 km of unpaved, gravel road ▪ Different designs according to soil substrates (earth, peat or rock) ▪ 11 m width with 1.5 m rounded shoulders ▪ Ditches of various width, revegetated ▪ Temporary gravel roads (e.g., accessing pits)	▪ Extreme (high) temperature ▪ Heat wave ▪ Melting degree days ▪ Extreme daily rainfall ▪ Same day high-intensity rainfall (50-year event) ▪ Multi-day heavy precipitation ▪ Daily snowfall (50-year event) ▪ Wildfire ▪ Thunderstorm	▪ Parameters selected are variables and indices for assessment of changes to climate that are relevant to road infrastructure design and corridor routing consideration. The climate change-driven events selected have potential to induce impacts to the Project and surrounding environment.
2	**Culverts and Bridges**	▪ Two major bridge water crossings (Ogoki and Albany rivers) ▪ Culverts are minimum 900 mm diameter corrugated steel ▪ Climate change already considered in the design		
3	**Safety Systems**	▪ Roadside barriers are minimalized and only where needed ▪ Safety signs mainly for wildlife passing, remote road, no services, beginning and end among others		
4	**Illumination**	▪ Solar powered ▪ Only at intersecting roads		
5	**Construction Camps**	▪ Temporary infrastructure (~10 years) ▪ Trailers ▪ Powered by generator systems ▪ Hauled water ▪ Incinerator ▪ Explosives in steel containers ▪ Aggregate sources (e.g., pits)		

#	Valued Component	Description	Indicators	Rationale for Selection
6	**Rest Stops and Road Turnout**	■ Washrooms and picnic areas; also for maintenance turn around areas		
7	**People**	■ Community members ■ Workers ■ Visitors		

4.4 Data Analysis Methods

4.4.1 Effects Assessment Methodology

The following is a high-level overview of the approach for the identification, assessment and evaluation of the potential effects:

- Review construction and operations activities to identify potential interaction(s) that could result in environmental effects;
- Characterize the existing environment for both route alternatives;
- Identify potential environmental effects Preferred Route and recommend mitigation measures to avoid or minimize identified effects, as well as identify opportunities to enhance benefits to the environment;
- Predict and assess potential environmental effects remaining after taking into consideration the recommended mitigation measures (i.e., residual effects) using direction, magnitude, geographic extent, duration, frequency, reversibility and likelihood;
- Predict cumulative effects that may result from a combination of the residual effects of the Preferred Route with the effects of other past, present and reasonably foreseeable projects; and
- Identify a follow-up program for the Preferred Route that includes monitoring to verify the prediction of the effects assessment and effectiveness of the mitigation measures, and a requirement for monitoring of the commitments made in the Terms of Reference and the Environmental Assessment / Impact Statement.

The following sections provide discipline-specific input and considerations as they pertain to the methodology for effects assessment. For detailed descriptions of the methodology used to inform this study refer to the Environmental Assessment / Impact Statement.

Climate Adaptation and Resiliency does not consider residual and indirect effects, as the objective of this study is to assess the impacts of climate change on the Project instead of the Project’s impact on the environment. The interactions between the Project and the environment are related to the impacts of climate change on the Project. These impacts and the associated adaptation and mitigation measures were assessed through Step 3 and Step 4 of the *PIEVC High Level Screening Guide*.

4.4.2 Existing Climate Data Analysis Methodology

The review of the observations collected by Environment and Climate Change Canada at meteorological stations in the study regions revealed few stations with intermittent date records (**Table 4-4**). Short time series and time series with large gaps are of limited use for the development of an existing climate description. Consequently, these station data were excluded from the subsequent analysis.

Table 4-4: Meteorological Environment and Climate Change Canada Station in the Study Area (Since 1981)

Station Name/Location	Distance to Road (mid-point)	Data Availability
Ogoki Post A	56 km	2014 to 2024
Lansdowne House A	117 km	2005 to 2013 2013 to 2024
Lansdowne House (Aut)	117 km	1994 to 2024
Lansdowne House	118 km	1953 to 1989
Geraldton A	190 km	1981 to 2015 2015 to 2022 2016 to 2024
Geraldton Airport	191 km	2018 to 2024

Instead, meteorological data for the 1950-2012 period were obtained from a gridded observational dataset produced by Natural Resources Canada while the data for 2011-2023 were extracted from the gridded ground-based observations called Daymet provided by Oak Ridge National Laboratory for the study area. This dataset provides daily minimum and maximum temperature and precipitation information based on the interpolation of meteorological stations (Pacific Climate Impacts Consortium, no date (a); Thornton et al., 2022). The location for which the historical data were obtained is 51°29'15"N, -86°40'1.56"W.

4.4.3 Methods for Predicting Future Conditions

Climate Projections

To obtain projections of future climate change, numerous global climate models have been employed to simulate global trends in extreme weather and climate. For this study, the simulations that build the basis for the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, part of the Coupled Model Intercomparison Project Phase 5 were used. All simulations include decadal hindcasts (1950-2005) and projective simulations (2006-2100; Taylor et al., 2012). In these simulations, the consequences of the anthropogenic emission of greenhouse gases are directly simulated.

As future global emission of greenhouse gases and other pollutants are uncertain, simulations with four scenarios with different greenhouse gas concentration trajectories have been conducted. These Representative Concentration Pathways (RCP) are named after their associated level of radiative forcing (i.e., the change in the atmosphere’s energy balance) in 2100 relative to the pre-industrial levels in 1750 (**Table 4-5**). Hence, as an example, the RCP2.6 corresponds to 2.6 W/m² of radiative forcing and a surplus of energy of 2.6 W/m² in Earth's atmosphere. Projected greenhouse gas concentration levels [including carbon dioxide (CO_2) and methane (CH_4)] depend on the anticipated population growth, changes in economic activity and energy consumption, shifts in land use, and climate policies (Intergovernmental Panel on Climate Change, 2014).

Table 4-5: Description of the Different Representative Concentration Pathways

RCP	Description
■ **RCP2.6**	■ Stringent mitigation scenario: representative of a scenario that aims to keep global warming likely below a 2°C increase above pre-industrial temperatures. An ambitious reduction of greenhouse gas emissions is required for this scenario for emissions to peak around 2020, then decline, and become net negative before 2100.
■ **RCP4.5**	■ Intermediate mitigation scenario consistent with relatively ambitious emissions reductions. The greenhouse gas emissions increase before starting to decline between 2040 and 2050. This scenario will likely fall short of the 2°C limits agreed upon in the Paris Agreement.
■ **RCP6.0**	■ Intermediate to high emissions scenario with emissions peaking in 2080 and declining for the rest of the century.
■ **RCP8.5**	■ Very high greenhouse gas emissions: consistent with no policy changes to reduce emissions – the most conservative emission scenario.

Source: (Intergovernmental Panel on Climate Change, 2014)

The future climatic conditions will vary in line with the different emission scenarios. While the global temperature increase is likely to exceed the limit of 2°C set in the Paris Climate Agreement (United Nations, 2015) for all Representative Concentration Pathway scenarios but the RCP2.6 scenario (Intergovernmental Panel on Climate Change, 2014), the corresponding levels of decarbonization necessary to achieve the RCP2.6 scenario are beyond most ambitious decarbonization plans. In contrast to this stringent mitigation scenario, the RCP8.5 represents the high end of possible greenhouse gas emissions over the course of this century. Although countries have outlined various climate actions in their Intended Nationally Determined Contributions, the greenhouse gas emissions keep increasing (United Nations Framework Convention on Climate Change, 2022; Monroe, 2023; Hook and Campbell, 2020), and a good agreement between the RCP8.5 scenario and historical cumulative carbon dioxide emission has been found (Schwalm et al., 2020). To capture this potential worst-case scenario, the RCP8.5 scenario is considered for the assessment of future climatic changes to allow for an appropriate, if conservative, assessment of the risks. Hence, the sole focus of this Climate Change Risk Assessment lies on the high-emission RCP8.5 scenario.

The regional climate simulations used for this study are statistically downscaled climate simulations whereby the Bias Correction/Constructed Analogues with Quantile Mapping Reordering methods were used by the Pacific Climate Impacts Consortium [Pacific Climate Impacts Consortium, no date (b)]. Using gridded observations of the historical climate for the calibration of the downscaling method, regional variations are derived from the coarser global climate simulations. Consequently, the historical part of the simulations (1950-2005) is, in its statistical properties, closely aligned with the observations.

From the 27 available climate models and the 3 available emission scenarios (RCP2.6, RCP4.5, and RCP8.5), 12 representative models for the high-emission scenario were selected for this study (**Table 4-6**). These simulations represent the full range and uncertainty of the simulations. This ensemble of climate change models was used to address the uncertainties that lie in climate projection. All simulations have a spatial resolution of 300 arc seconds (about 10 km) and a temporal resolution of 24 hours. The available variables are daily minimum temperature, daily maximum temperature, and daily precipitation rate [Pacific Climate Impacts Consortium, no date (a)].

Table 4-6: Selected Global Climate Models

Global Climate Models		
■ **ACCESS1-0**	■ CSIRO-mk3-6-0	■ IPSL-CM5A-MR
■ **CanESM2**	■ GFDL-CM3	■ MIROC5
■ **CCSM4**	■ GFDL-EMSM2G	■ MPI-ESM-LR
■ **CNRM-CM5**	■ inmcm4	■ MRI-CGCM3

The historical observations and future projections were analyzed using CLIMEX A - a climate data extraction and analysis program developed by AECOM. This tool extracts average values, trends, extreme values, and other climate indicators and calculates their return periods and probabilities for the climate reference period and future time-horizons. Over 50 climate indicators with thresholds pertinent to the site location are calculated. These climate variables passed then through rigorous quality control. Some relevant climate indicators such as the winds are determined using additional publicly available databases.

With the publication of the Sixth Assessment Report of the Intergovernmental Panel on Climate Change in 2021 (Intergovernmental Panel on Climate Change, 2021) and 2022 (Intergovernmental Panel on Climate Change, 2022a, 2022b), which relies on the next generation of simulations, the first tranche of updated regional climate data has recently become available, and more will be published over the coming years. As the regional datasets had yet to be completed at the time of the development of the climate profile, the regional climate information derived from the previous generation of simulations was used for this project. Furthermore, the new simulations will have to be used with care as they exhibit a warm bias that can lead to an overestimation of projected climate change if it is not considered appropriately (Hausfather et al., 2022).

Prediction Confidence

Climate change projections are made using a wide range of models to account for different future possibilities. Although these models include a very large number of variables and use sophisticated equations to simulate climate changes over time, they remain simplifications and approximations of reality. Therefore, AECOM's CLIMEX A provides projections that are not based on a single model, but on 12 models that were created independently by teams of researchers to be free to explore different ways of modeling the climate. Therefore, the 12 climate models have certain differences depending on the way in the atmospheric and climatological processes and their interactions are represented.

Some atmospheric processes and variables are well understood and their representation in models achieves high precision. For other aspects of the atmospheric and climate system, understanding continues to grow with new knowledge acquired each year. Therefore, representations of these processes are associated with greater uncertainty. The confidence levels of the projections for each of the variables based on the quantity, quality and consistency of evidence, the degree of consensus between the models and the judgement of AECOM experts are presented in **Table 4-7**.

Table 4-7: Confidence Level for the Climate Variables

Climate Variables	Confidence Level
Temperature-Related Variables	
Annual temperature (°C)	High
Number of hot days (days)	Medium-high
Heat waves (#)	Medium-high
Cold spells (#)	Medium-high
Freeze-thaw cycles (#)	High
Precipitation-Related Variables	
Annual precipitation (rain- and snowfall; mm)	High
Annual rainfall (mm)	High
Annual snowfall (mm)	High
Extreme rainfall (mm)	Medium-high
Extreme snowfall (cm)	Medium
Drought	Low-medium

Climate Variables	Confidence Level
Agriculture-Related Variables	
Frost-free season (days)	High
Growing-degree days	High
Corn-heat units	High
Wind-related Variables	
Annual wind speed	Low
Storm-Related Variables	
Freezing rain/ice storm	Low-medium
Thunderstorm	Low
Other	
Relative Humidity	Medium
Wildfire	Medium
Biofouling	Low-medium

Additional limitations arise from the underlying climatological dataset. Climate projections and the underlying assumptions about human behaviour (i.e., population and economic growth which ranges from slow and progressively reliant on alternative fuel for the intermediate-emission scenario to fast and heavily reliant on fossil fuel without systematic climate change mitigation efforts for the high-emission scenario) introduce uncertainties into the risk assessment process. The results of this risk assessment must be reviewed once new scientific findings regarding the climate change trajectory become available, human behaviour leads to significantly changed conditions, or site characteristics are altered.

Climate Likelihood

To determine the climate-related risks to the Project, climate indicators and their relative changes were analyzed for both the climate reference period (1981-2010) and in the context of a changing climate. The list of analyzed climate indicators includes high temperatures and heatwaves as well as precipitation-related variables such as extreme rainfall and dry periods (**Table 4-8**). Some climate indicators are defined by a threshold such as heat wave and cold spell. These thresholds are based on the local climate data and professional judgement. Not all climate indicators are applicable or relevant to the Project.

Table 4-8: List of Climate Indicators and their Definition

#	Climate Indicator	Definition
1	Air temperature	Annual increase in daily temperature
2	Extreme (high) temperature	Daily max temperature or 10-year return event
3	Extreme (low) temperature	Daily min temperature or 10-year return event
4	Heat wave	Daily maximum temperature greater than 28°C for at least 3 consecutive days
5	Cold spell	Daily minimum temperature lower than -30°C for at least 3 consecutive days
6	Freeze-thaw cycles	Number of freeze-thaw cycles per year
7	Heating Degree Days	Heating degree days
8	Cooling Degree Days	Cooling degree days
9	Freezing Degree Days	Freezing degree days
10	Melting Degree Days)	Winter melting degree days, where winter is defined as Nov-March
11	Frost-free season	Consecutive number of days without daily minimum temperatures <0°C
12	Growing-degree days	Annual degree days with basis 4°C
13	Corn-heat units	Corn-heat units
14	Annual rainfall	Annual rainfall sum
15	Annual snowfall	Annual snowfall sum
16	Heavy daily rainfall (10-year event)	10-year return values for daily rainfall
17	Extreme daily rainfall (100-year event)	100-year return values for daily rainfall
18	Short-duration, high-intensity rainfall (50-year event)	50-year return values for 15-min rainfall
19	Multi-day heavy precipitation	Maximum 5-day precipitation
20	Daily Snowfall (50-year event)	10-year return values for daily snowfall
21	Snow depth	Snow depth (snow on the ground)
22	Snow depth max	Max snow depth (accumulated snow on the ground)
23	Dry period	Period of at least 14 consecutive days without precipitation
24	Drought	Monthly precipitation is less than the 1st decile of the historical precipitation for the corresponding month

#	Climate Indicator	Definition
25	Heavy wind	Maximum sustained wind (1 minute)
26	Relative humidity	Annually averaged relative humidity
27	Freezing rain	Maximum of monthly hours with fogs
28	Fog	Annual number of hours with freezing rain
29	Wildfire	Wildfire threat: Combination of fire weather index, fire season length, fire severity index, burned area, including wildfire smoke
30	Permafrost thaw	Thawing of permafrost
31	Sea level rise	Mean sea level (when increasing)
32	Sea level fall	Mean sea level (when falling)
33	Sea Ice cover	Reduction in sea ice cover
34	Coastal erosion	Coastal erosion assessed by coastal sensitivity index
35	Hurricane	Number of hurricanes, intensity (i.e., wind speed), and precipitation
36	Thunderstorm	Convective storms that can include lightning, hail, downburst, derechos, tornadoes, and heavy precipitation
37	Biofouling	Cyanobacterial growth, algae bloom, and lake/ocean acidification
38	Invasive species	Climate-tracking plants and animals

All relevant climate indicators were reviewed in the context of the changing climate for two future time-horizons relative to the baseline (1981-2010). According to the *PIEVC High Level Screening Guide*, the historical climate is assigned a probability score of 3 (i.e., baseline). If a climate event becomes less frequent or less intense, the probability score decreases, and if an event becomes more frequent or more intense, the score increases (**Table 4-9**).

Table 4-9: Probability Scoring Matrix According to Public Infrastructure Engineering Vulnerability Committee High Level Screening Guide

Likelihood	Baseline	Method	Relative Change
1	↑	Likely to occur less frequently than current climate	50% to 100% reduction in frequency or intensity with reference to baseline mean
2			10% to 50% reduction in frequency or intensity with reference to baseline mean
3	Baseline	Likely to occur as frequently as current climate	Baseline mean conditions or a change in frequency or intensity of ±10% with reference to baseline mean
4	↓	Likely to occur more frequently than current climate	10% to 50% increase in frequency or intensity with reference to baseline mean
5			50% to 100%+ increase in frequency or intensity with reference to baseline mean

Source: *PIEVC High Level Screening Guide* (PIEVC Program, 2021)

Estimates of Consequences

The third step of the *PIEVC High Level Screening Guide* is to assess the climate change risk to the Project. The risk assessment is carried out after determining the project components, in this case the valued components, the climate parameters or climate indicators, and their likelihood scores. The interaction between each valued component and climate indicator is then assessed to determine if there is exposure and impact, or consequence, resulting from the interaction.

To estimate the level of consequences, five impact categories were identified based on the most relevant aspects regarding the risk management for the Project. These five impact categories are defined as:

- **Impact on health and safety**, including occupational illness and injury to workers or the road users because of incidents for which the owner may be liable;
- **Infrastructure integrity**, including damages or deterioration of essential components and materials;
- **Operational impact**, including operational delays, process slowdowns, road closure or interruption of services;
- **Financial impact to Marten Falls First Nation**, including losses due to road closure or failure to maintain operations; or

- **Financial impact to the road owner**, including losses due to additional cost/expense directly attributed to the event, damages to asset to be repaired immediately to maintain operations.

The severity rating (1 - very low to 5 - very high) and impact categories which were used to guide the risk analysis are detailed in **Table 4-10**.

Table 4-10: Impact Severity Rating and Impact Categories

		Impact Categories				
Impact Severity Rating	**Conse-quences**	**Health and Safety**	**Infrastructure Integrity**	**Operational Impact**	**Financial Impact to Marten Falls First Nation**	**Financial Impact to Road Owner**
1	Very low	First Aid Injury	Very low damage; repairable immediately. **Under $50k damage**.	Operation impacted for less than a day, but no full closure of the road.	Under $2.5k impact or claim.	Under $50k impact or claim.
2	Low	Medical treatment for a minor injury	Minor damage to component materials; Reduction of the service life of the material. **$50k - 250k damage**.	Operation impacted for less than a week but no full closure of the road. **Full closure of the road for up to 1 day.**	$2.5k - 5k impact or claim.	$50k - 250k impact or claim.
3	Moderate	Bodily injury / Illness with work restrictions	Moderate damage to component materials; Slow deterioration of the materials of certain essential components. **$250k - 1M damage**.	Operation impacted for less than a month but no full closure of the road. **Full closure of the road for up to 1 week.**	$5k - 10k impact or claim.	$250k - 1M impact or claim.
4	High	Permanent disabling injury or multiple people injured	Accelerated deterioration of the materials of certain essential components. **$1M - 5M damage**.	Operation impacted for less than 6 months but no full closure of the road. **Full closure of the road for up to 1 month.**	$10k - 15k impact or claim.	$1M - 5M impact or claim.
5	Very high	Fatality or significant irreversible disability	Deterioration of materials causing the failure of several elements essential to the functionality of the network. **Over $5M damage**.	Operation impacted for less than a year but no full closure of the road. **Full closure of the road for up to 6 months.**	Over $15k impact or claim.	Over $5M impact or claim.

Based on the impact severity rating in **Table 4-10**, the potential consequences of interactions of climate change and assets were evaluated. The consequence levels were established using expert judgement and relevant literature (Partington, et al., 2017; Ball, 2023; Beugin et al., 2023; Echt et al., 2020). A two-level risk analysis exercise was completed, with two risk evaluators and a discussion to review differences in opinion and come to a consensus. If a consensus could not be reached, or if there was a lack of information and knowledge, other experts were consulted to further refine the analysis.

Risk Evaluation

The risk score is obtained by multiplying the likelihood (of the weather/climate event) by the severity/consequence score and exposure where the binary exposure term is either 0 for no exposure or 1 if the asset is exposed to the weather/climate event (PIEVC Program, 2021).

Risk = Likelihood x Consequence x Exposure

The resulting risks are then classified into three risk levels (i.e., low, medium, and high risks; **Table 4-11**).

Table 4-11: Risk Evaluation Matrix Scoring and Risk Rating

Severity of Consequences	Very high	5	5	10	15	20	25
	High	4	4	8	12	16	20
	Moderate	3	3	6	9	12	15
	Low	2	2	4	6	8	10
	Very low	1	1	2	3	4	5
			1	2	3	4	5
			- 50-100%	-10-50%	Baseline (± 10 %)	+10-50%	+ 50-100%+
			Likelihood				

Risk (R) = Likelihood x Severity x Exposure	
Low Risk: R ≤ 9	Controls/Actions likely not required
Moderate Risk: 10 ≤ R ≤ 16	Some controls/actions required to reduce risks to lower levels
High Risk: R ≥ 20	High priority control measures required

Source: *PIEVC High Level Screening Guide* (PIEVC Program, 2021)

Climate Change Impacts on Ecosystems

Climate change has a direct impact on the integrity and stability of ecosystems by altering biodiversity, habitats, and ecosystem processes and services (U.S. Climate Resilience Toolkit, no date). It poses a threat to many species, mainly due to increased temperatures, changes in precipitation patterns, disturbances in inter-species relationships, increases in pests and pathogens, in addition to anthropogenic pressure on natural habitats (Applequist et al., 2020). Social, cultural, and economic activities that revolve around land, such as hunting, trapping, gathering, and fishing, are, therefore, deeply impacted by the changing climate. A brief review of these impacts was carried out using the scientific literature and is presented in **Attachment C**.

4.4.4 Mitigation and Enhancement Measures Methodology

Following the identification of potential effects, the effects assessment has explored technically and economically feasible mitigation measures to avoid or minimize the identified negative effects. The recommended enhancement measures are anticipated to increase positive effects beyond those that are already inherent to the design. These measures consist of industry-standard practices, federal and provincial standard specifications, regulator-mandated measures, best management practices, Indigenous and community recommendations and recommendations from environmental professionals based on expertise, scientific publications, experience, and judgement.

It is important that mitigation and enhancement measures are achievable, measurable and verifiable and monitored for compliance and effectiveness during all temporal phases as part of the Project follow-up monitoring plan. Recommended environmental monitoring will verify the potential environmental effects predicted, evaluate the effectiveness of mitigation and enhancement measures, and identify the process the Proponent will follow if mitigation and enhancement measures are not effective.

Climate Adaptation and Resiliency identified risk treatment and adaptation measures for reducing unacceptable risks to acceptable levels based on available literature and professional judgement. These measures are adapted to address the medium- and high-risk levels of the 2071-2100 time-horizon.

The adaptation measures are divided by the implementation stage:

- **Design**: Measures to be incorporated during the design/redesign phase of assets for these to be resilient to future climate risks and to prevent costly revamps.
- **Operations**: Measures to be incorporated over the lifespan of the assets during operation to improve resiliency.
- **Policy**: Measures to be executed to always provide and maintain safe and healthy working.

4.5 Data Management and Analysis Methodology

Data management including quality assurance / quality control will be employed to minimize potential for data entry and analysis errors, to prepare datasets for analysis, while limiting sensitive data distribution in accordance with established agreements. Climate scientists apply quality assurance / quality control routines and algorithms to identify potentially non-valid data points, and complete additional measures to confirm if outliers (i.e. data far outside the expected range) represent instrumentation errors or actual extreme values in the datasets. When data gaps require data supplementation from other sources, those sources will be identified, with the relevant methods and rationale described for their application in this study.

One 30-year baseline historical record and two 30-year periods centred on the 2050s (2041-2070) and the 2080s (2071-2100) are used to align the assessment of climate change impacts on the Project with the design life expectations for the Community Access Road.

Future climate projections relative to the assessment time-horizons are reviewed and historical and projected climate information are compiled for climate indicators relevant to the Community Access Road from locations in regional study area. AECOM's CLIMEX A tool was used to obtain credible, quality-checked (by Environment and Climate Change Canada and National Resource Canada) historical observations and local future climate projections. CLIMEX A develops climate profiles by utilizing

- Datasets of available Environment and Climate Change Canada observation stations (of various record lengths) dating back to 1900 for some stations (daily with major airport hourly);
- Datasets of observed historical gridded data for Canada developed by Environment and Climate Change Canada and Natural Resources Canada at 10 km resolution;
- For climate projections, a representative dataset 12 of statistically downscaled climate models based on global climate models using the Representative Concentration Pathway (RCP8.5);
- Dataset of available Environment and Climate Change Canada Intensity-Duration-Frequency datasets from across Canada; and
- Dataset of Environment and Climate Change Canada historical Canadian tornadoes.

Based on the combined historical and future climate information, CLIMEX A calculates climate indicators such as heat wave intensity and length, design temperatures, intensity frequency duration curve for short-duration rainfall events, drought probabilities, and wildfire risk. Due to the direct use of data from varied climate models, the inherent uncertainties of climate projection are estimated by CLIMEX A as well.

CLIMEX A results have been validated against similar products publicly available on, for example, climatedata.ca. These validations show very high agreement between those datasets and CLIMEX A results.

4.6 Deviations from Draft Study Plan

Deviations from the *Draft All Season Community Access Road: Climate Adaptation and Resiliency Study Plan* (**Attachment A**) were anticipated to be required as the Project evolved due to challenges encountered in the field, alternative methodologies being developed, comments from regulators, and as updated guidance became available. **Table 4-12** outlines these deviations. General changes such as changes to section headings, organization of sections and subsections and, changes to phrasing and tense have been made throughout. These administrative changes have not been documented in **Table 4-12**.

Table 4-12: Deviations from Study Plan

Section Reference	Description of Change	Rationale
■ **3.2.3 Spatial Boundaries**	■ The study plan previously used the term *'Local Study Area'* to define the 5km corridor, which is being studied in the Existing Conditions section, and within which the footprint of the project will be further refined. This area has been retitled as the "Project Study Area."	■ This change eliminates confusion between the Project Study Area and the discipline-specific Local Study Area.
■ **3.4 Data Management**	■ In Section 3.4.1, the study plan previously identified that data would be backed up on a 'daily basis'. This wording has been revised to state that data would be backed up on a 'regular basis'.	■ This change brings alignment with the Proponent's various data backup policies.
■ **3.4 Data Management**	■ In Section 3.4.2 wording was updated to note that datasets from all survey sites will be provided upon report finalization. No timeline had been previously identified.	■ The revision provides added clarity around when the data would be provided.
■ **4. Study Methods and Assessment Scope**	■ The methodology described throughout Section 4 was updated ○ To the more recent protocol (*PIEVC High Level Screening Guide*; PIEVC Program, no date) instead of Infrastructure Canada's *Climate Lens General Guidance*;	■ This change was due the release of the new guideline since the completion of the study plan and the transfer of the task to AECOM.

Section Reference	Description of Change	Rationale
	○ To reflect the shift from Dillon's Climate Analytics Data Engine to AECOM's CLIMEX A tool; and ○ To reflect the transition from the "Delta Method" for the development of the climate projections to the direct analysis of the statistically downscaled climate models.	
■ **4.3.2 Spatial Boundaries**	■ Instead of the assessment of two alternative options, only the preferred alternative was considered.	■ Existing gaps in historical observations and general uncertainty in the generation of climate projections limit the resolution of climate information. As such, there is no discernible difference for the alternatives from a Climate Adaptation and Resiliency perspective.
■ **4.3.3 Valued Components and Indicators**	■ The valued components and Indicators were reversed to reflect the understanding that ○ Valued components will experience impacts or are affected by changes; and ○ Indicators are markers of the expected changes. ■ In the study plan climate indices and events are defined as valued components. Valued components now encompass project components such as road, culverts, bridges, among others. Indicators and climate indicators are used synonymously and include heat wave, extreme daily rainfall, wildfire, among others.	■ This revision is due to the change in the Climate Adaptation and Resiliency team, as well as the new protocol used to carry out the study.

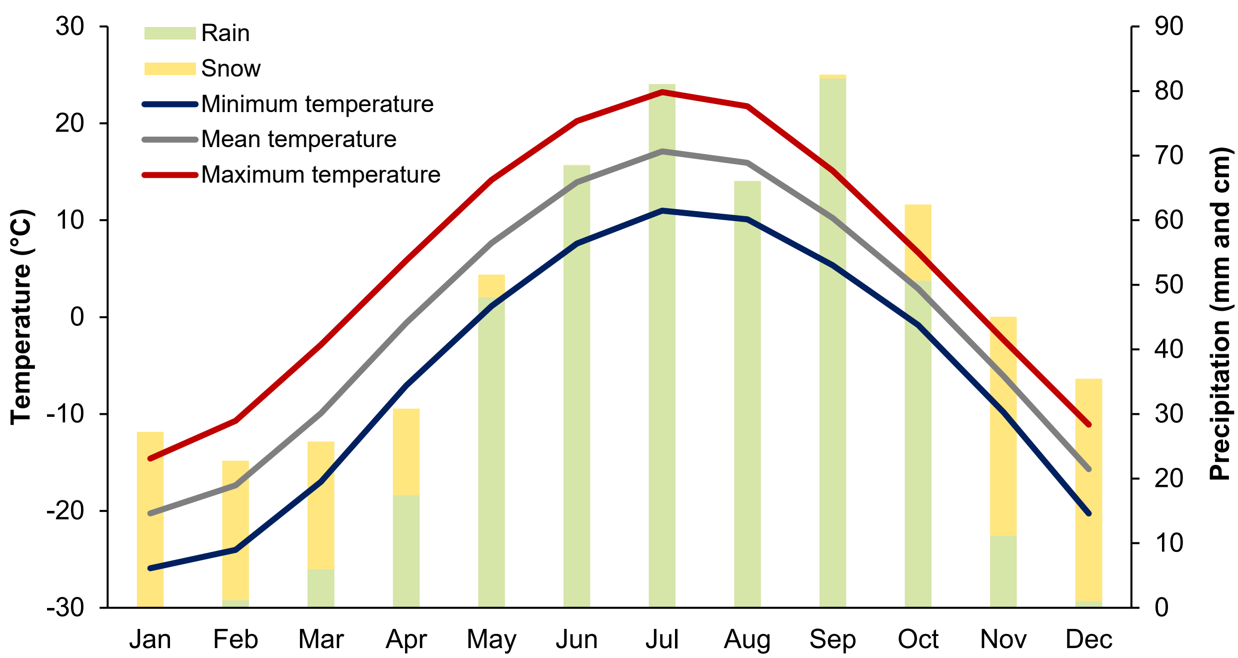
5. Existing and Future Climate Description

The existing conditions are described based on a combination of information obtained through engagement and consultation and desktop assessment.

5.1 Existing Climate Descriptions

The historical climate (1981-2010) along the Preferred Route of the access road is characterized by cold winters and mild summers, with a mean temperature of 5.5°C. The year-round precipitation of 600 mm falls predominantly during the summer months. The monthly maximum rainfall of 82 mm falls in September (**Figure 5-1**). For the historical climate period, the monthly averages of daily mean temperature indicate a range from -20.3°C in January to 17.1°C in July. The absolute minimum temperature for the reference period of -46.7°C occurred on December 19, 2008, and the maximum temperature of 39.8°C occurred on June 18, 1995. Rainfall amounts are highest in September (82 mm), while the driest month is February, when the region receives 22 cm of snow and 1 mm of rain. The maximum daily precipitation (i.e., rain- and snowfall together) over the time-horizon of 82 mm occurred on October 10, 1993.

Figure 5-1: Historical Annual Cycle of Temperature and Precipitation



Anecdotal observations from community members point towards decreasing snowfall in winter and an increase in thunderstorm activity in summer. These thunderstorms bring heavy rainfall and high wind speeds in the late afternoon and result in significant damages to buildings and trees. These observations also indicate an increase in the number of tornadoes in the greater region of Northwestern Ontario.

These observations by community members are inline with instrument measurements and expectation based on the current physical understanding. As the temperature has increased, the atmosphere contains more energy and provides ideal conditions for (severe) thunderstorms to develop. This means that the region over which tornadic thunderstorm can and will develop is shifting northward. Records of tornadoes within a 200 km radius surrounding Marten Falls First Nation show one tornado between 1981-2010 while the last 8 years (2017-2024) was on average one tornado per year.

5.2 Projected Climate Description

Using the historical observational record between 1950 and 2010, an overall good agreement between the observations and the climate simulations for the annual averages of the daily minimum, mean, and maximum temperature was established. The trend in minimum, mean, and maximum temperature since the early 1970s shows a steady temperature increase for the region (**Figure 5-2**). The annual mean temperature is projected to increase from -0.1°C for the historical reference period (1981-2010) to 3.4°C for 2041-2070 and 6.1°C for 2071-2100.

The trend in extreme temperatures is more pronounced than the change in annual averages, especially in terms of cold extremes. For example, extreme low temperatures with a return period of 10 years (i.e., events that will occur statistically every 10 years) are projected to become 10.4°C warmer in the 2071-2100 time-horizon. For high temperature extremes, hot days, with daily maximum temperatures greater than 30°C, will increase from 4 days per year to 35 days at the end of the century (2071-2100; **Figure 5-3**). Heatwaves, defined as three consecutive days above 28°C, have occurred on average 1.4 times per year over the historical period from 1981-2010. Climate change will lead to the increase of number heat waves as well as in increase in duration and intensity. For the 2071-2100 time-horizon, about six heat waves per year with an average length of 7.5 days are projected.

Figure 5-2: Annual Observed and Projected Temperatures

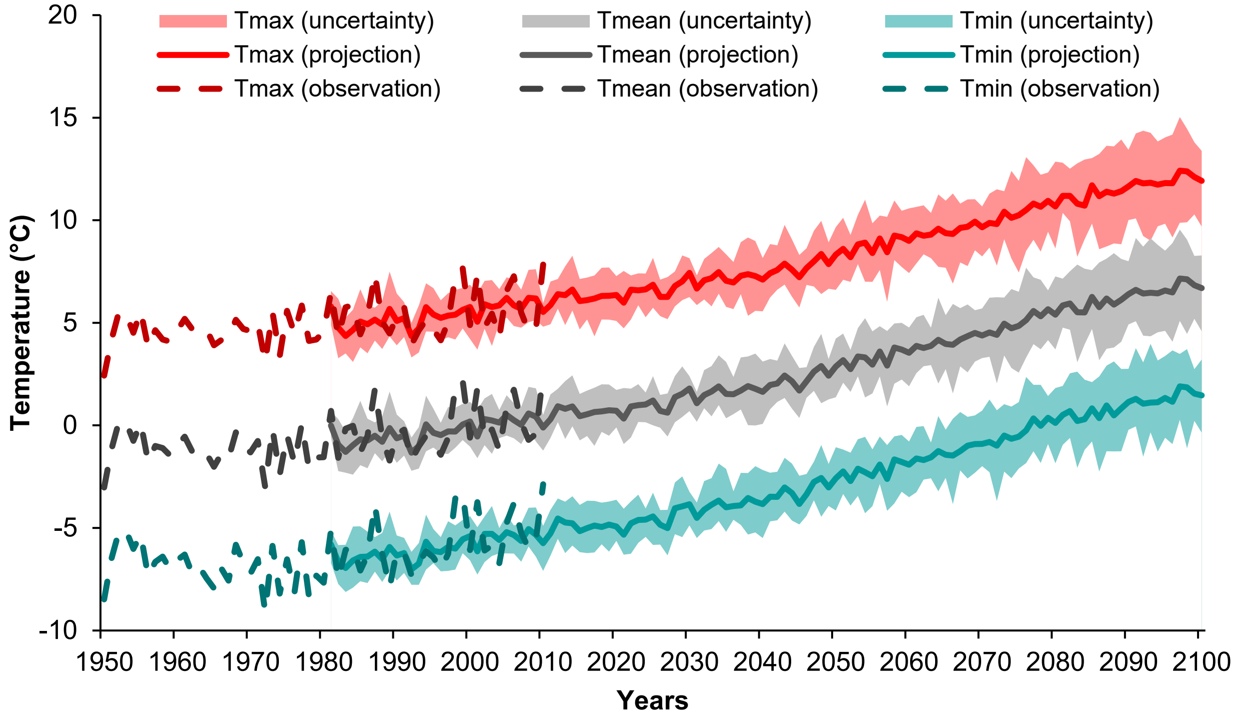
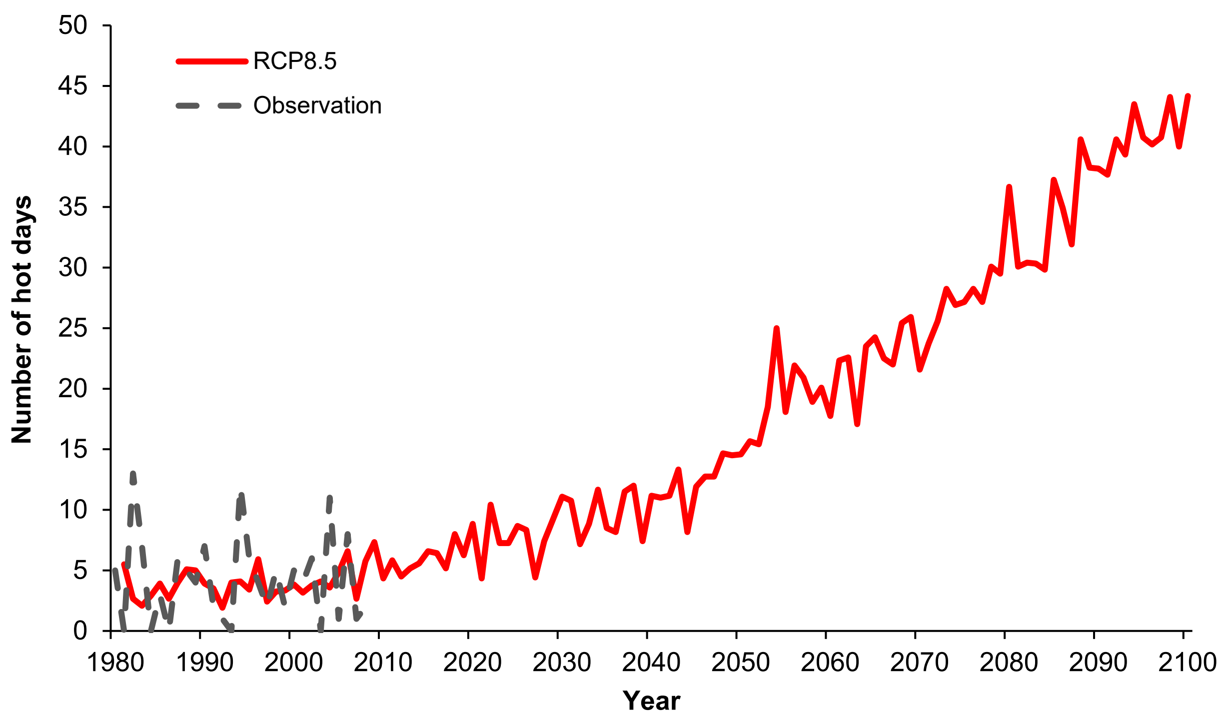


Figure 5-3: Annual Number of Hot Days



Note: Hot days are defined as days with daily maximum temperatures greater than 30°C.

Climate change will also lead to an increase of the annual precipitation sum. The total precipitation sum is projected to increase from 600 mm for the 1981-2010 historical reference period to 700 mm for the 2071-2100 time-horizon. While the annual rainfall amount will increase from 433 mm for the historical period to 544 mm (about 26 %), the annual snowfall amount is projected to decrease from 166 cm to 151 cm (about 10 %; **Figure 5-4**). At the same time the annual rainfall sum increases with climate change, the heavy precipitation events will become more intense. It is projected that by 2041-2071, a historical 50-year rainfall event that was associated with 102 mm will bring 129 mm rain in 24 hours. Viewed alternatively, a historical 50-year event is projected to happen every 5 years in the 2041-2070 time-horizon. The same event is projected to happen every 6 years at the end of the century (2071-2100; **Figure 5-5**).

Figure 5-4: Annual Observed and Projected Rain- and Snowfall

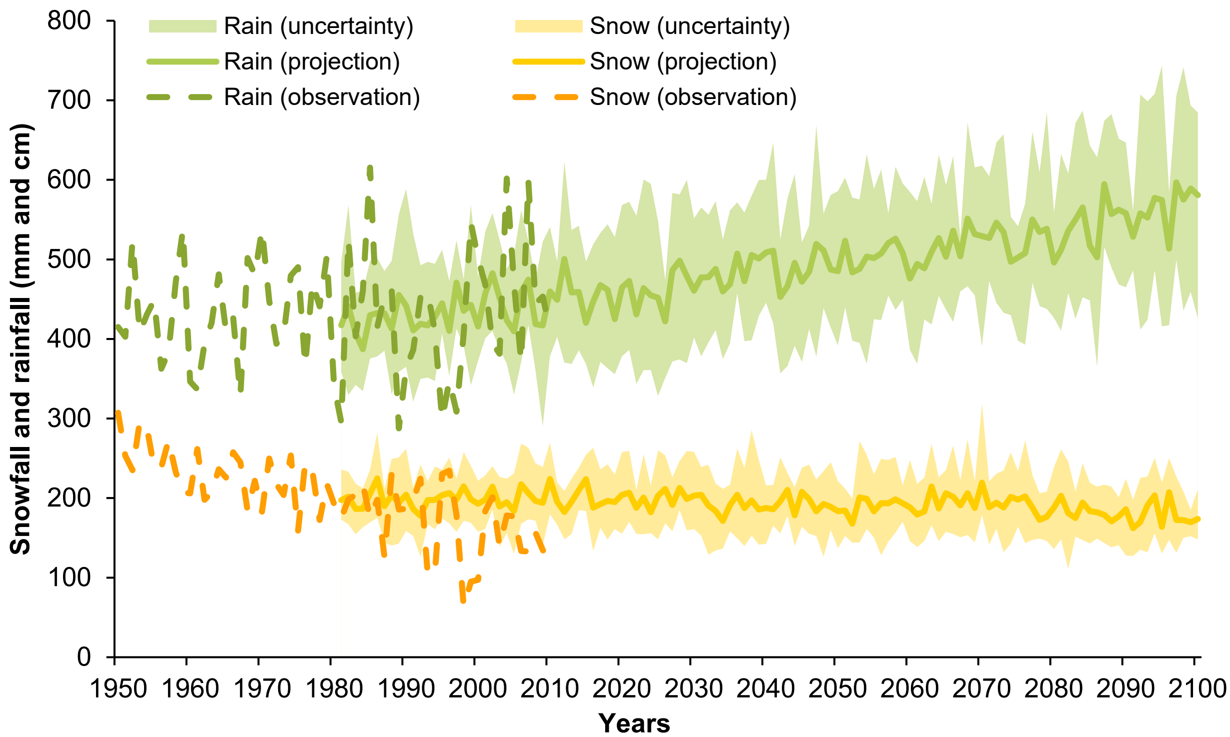
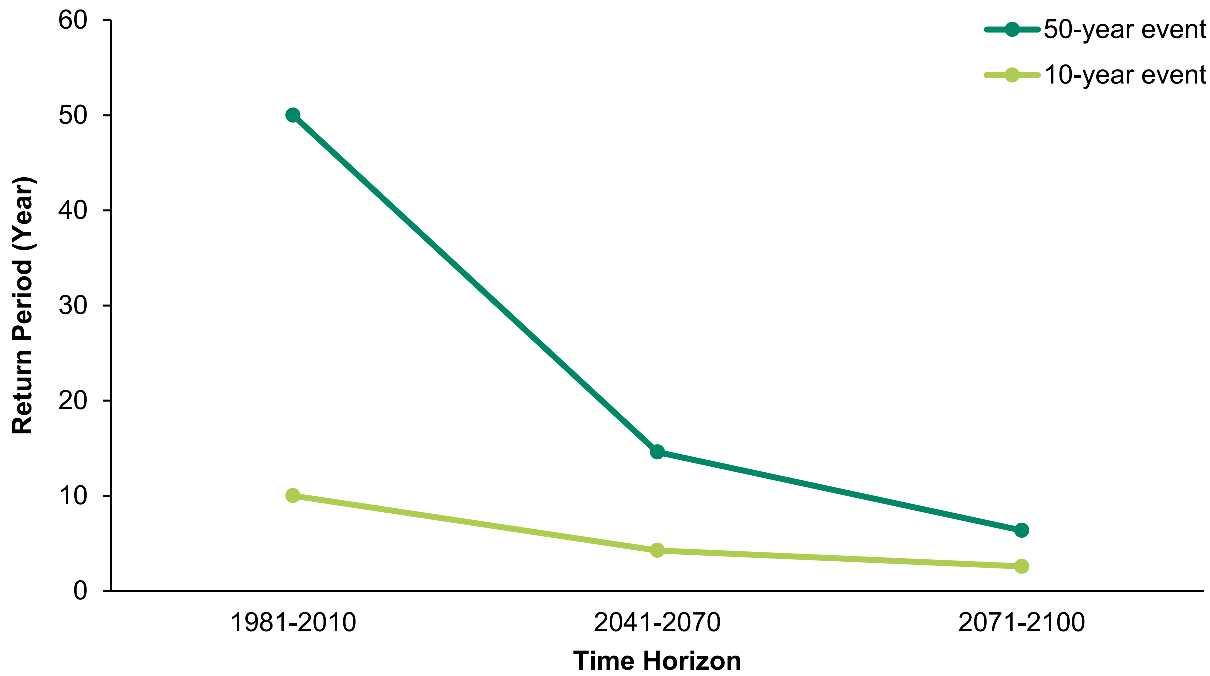


Figure 5-5: Return Period of Historical 50-Year and 10-Year Rainfall Events



5.2.1 Climate Likelihood

The relative change to the historical reference period has been calculated for all climate indicators as indicated in **Table 4-9**. Subsequently, the respective likelihood score was assigned. For example, the extreme (high) temperature is projected to have increased by 11% in 2041-2070 and by 17% in 2071-2100 compared to the historical reference periods of 1981-2010. Consequently, a likelihood score of 4 has been assigned for both time-horizons. Similarly, the frequency of heavy rainfall (i.e., 10-year return event of daily rainfall) is projected to increase by 57% in 2041-2070 and 74% in 2071-2100 with their likelihood scores becoming 5. The full list of all indicators, their relative change and likelihood score is provided in **Table 5-1**.

Table 5-1: Full List of Climate Indicators Analyzed for the Project

Climate Indicator		Historical	2041-2070		2071-2100	
		Score	Relative Change	Score	Relative Change	Score
1	Air temperature	**3**	1,991%	5	3,481%	5
2	Extreme (high) temperature	**3**	11%	4	17%	4
3	Extreme (low) temperature	**3**	-12%	2	-22%	2
4	Heat wave	**3**	192%	5	311%	5

Climate Indicator		Historical	2041-2070		2071-2100	
		Score	Relative Change	Score	Relative Change	Score
5	Cold spell	**3**	-74%	1	-100%	1
6	Freeze-thaw cycles	**3**	-9%	3	-12%	2
7	Heating Degree Days (HDD)	**3**	-17%	2	-29%	2
8	Cooling Degree Days (CDD)	**3**	219%	5	470%	5
9	Freezing Degree Days (FDD)	**3**	-29%	2	-49%	2
10	Melting Degree Days (MDD)	**3**	182%	5	544%	5
11	Frost-free season	**3**	28%	4	46%	4
12	Growing-degree days	**3**	36%	4	69%	5
13	Corn-heat units	**3**	36%	4	67%	5
14	Annual Rain	**3**	16%	4	26%	4
15	Annual Snow	**3**	-4%	3	-9%	3
16	Heavy daily rainfall (10-year event)	**3**	57%	5	74%	5
17	Extreme daily rainfall (100-year event)	**3**	77%	5	90%	5
18	Short-duration, high-intensity rainfall (50-year event)	**3**	69%	5	86%	5
19	Multi-day heavy precipitation	**3**	13%	4	18%	4
20	Daily Snowfall (50-year event)	**3**	2%	3	10%	3
21	Snow depth	**3**	-23%	2	-42%	2
22	Snow depth max	**3**	-4%	3	1%	3
23	Dry Period	**3**	2%	3	7%	3
24	Drought	**3**	-20%	2	-20%	2
25	Heavy Wind	**3**	2%	3	3%	3
26	Relative Humidity	**3**	-	3	-	3
27	Freezing Rain	**3**	-25%	2	-25%	2
28	Fog	**3**		2		2
29	Wildfire	**3**	15%	4	25%	4
36	Thunderstorm (e.g., rain, lightning, hail)	**3**	-	4	-	5
37	Biofouling	**3**	-	4	-	4
38	Permafrost thaw	**3**	-	3	-	3

These climate conditions or events that can cause, for example, loss of productivity, damage to the infrastructure, harm to the road users, were reviewed at a high level to assess the risk to the Project due to climate change. As a result of this initial review, some climate indicators were combined due to their comparable risk profile (e.g., 10 and 100-

year heavy rainfall events or dry periods and drought). Others were removed from the analysis as their impacts on the Project were deemed low or nonexistent (e.g., cooling degree days). Based on the preliminary analysis described in **Section 2.1.1**, permafrost thaw was not included in the analysis. If subsequent geotechnical investigations reveal permafrost along the road, a detailed analysis of the potential permafrost degradation must be conducted. A constant or decreasing likelihood also led to the removal of climate indicators such as cold spells or freezing rain as it is assumed that existing standards and measures are sufficient. The remaining nine indicators were selected as:

- The climate indicators identified past extreme weather conditions (past extreme weather events were researched as they provide insights into the potential relevance of certain climate indicators for the future infrastructure);
- Historical and future annual and seasonal variation of both temperature and precipitation provide insights on future trends;
- Applicable climate indicators show significant increases in probability during the project's timeframe;
- Climate indicators with decreasing likelihood are excluded from the analysis as existing design and work practices incorporate existing climate;
- The local reality mandates the inclusion of the climate indicator; and
- Potential interactions of a certain climate condition with a project component carries non-negligible.

The list includes temperature-related indicators such as heat wave and ambient air temperature, precipitation-related indicators such as daily rainfall and multi-day heavy precipitation, as well as wildfires and thunderstorms (**Table 5-2**).

Table 5-2: Selected Climate Indicators for the Project with their Respective Likelihood Scores

#	Climate Indicator	Likelihood Score		
		Historical	2041-2070	2071-2100
1	Extreme (high) temperature	3	4	4
2	Heat wave	3	5	5
3	Melting degree days	3	5	5
4	Extreme daily rainfall	3	5	5
5	Short-duration, high-intensity rainfall (50-year event)	3	5	5
6	Multiple-day heavy precipitation	3	4	4
7	Daily snowfall (50-year event)	3	3	3
8	Wildfire	3	4	4
9	Thunderstorm	3	4	5

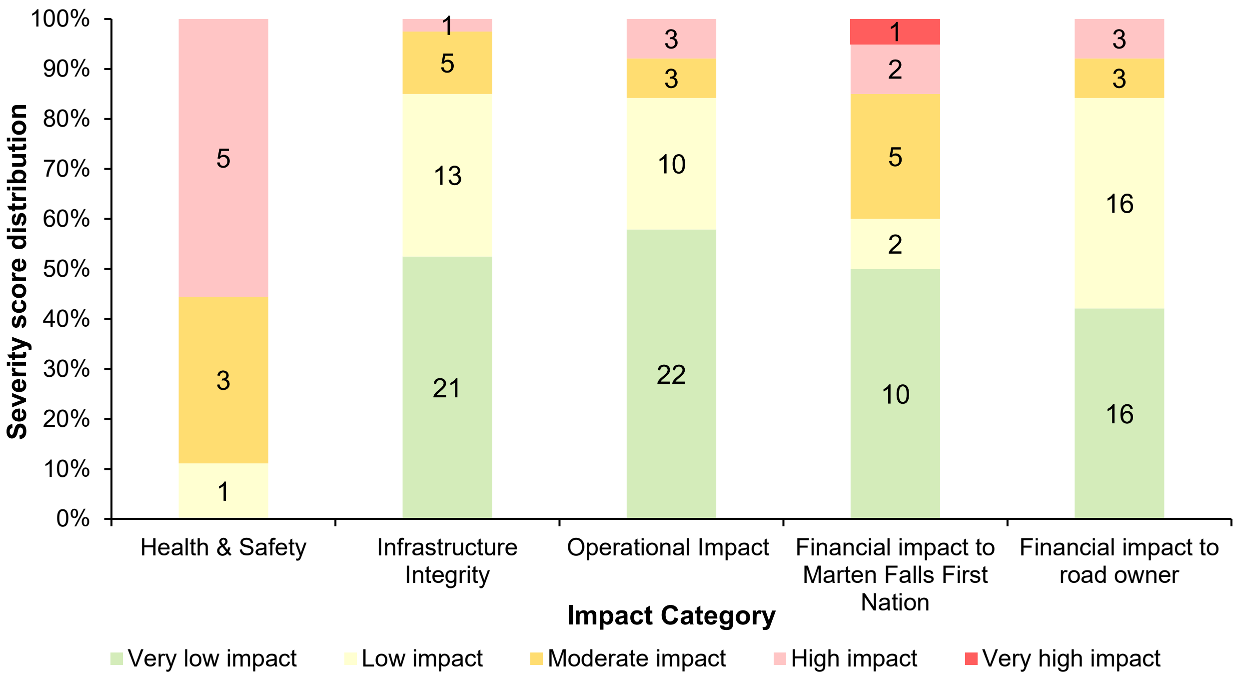
6. Climate Change Risk Assessment

6.1 Estimates of Consequences

The assessment revealed that, of 63 potential interactions between 9 climate indicators (**Table 5-2**) and 7 valued components (**Table 4-3**), 11 interactions resulted in a no-impact assessment due to no exposure of the valued components to weather/climate events and were, therefore, excluded from the subsequent analysis. These interactions mainly concern safety systems (with all indicators but wildfires), illumination (with melting degree days), and rest stops and road turnout (with extreme temperatures and heat). The full assessment is documented in the Climate Change Risk Analysis Excel Spreadsheet accompanying this report.

For the remaining interactions, the impact severity was assessed for each impact category (**Figure 6-1**). Most interactions received a very low or low severity assessment. The health and safety impact category is most severely impacted by climate and weather-related events with three moderate- and five high-severity assessments. A very high financial impact to Marten Falls First Nation consequence interaction was identified in the analysis as the result of the interaction between wildfires and the Community Access Road. This ranking can be used to help prioritize adaptation measures that will minimize impacts related to health and safety of road users, the infrastructure integrity, the operations, and the finances, of the Project.

Figure 6-1: Number of Interactions per Level of Severity for Each Impact Category



6.2 Risk Evaluation

Using the risk equation described in **Section 4.4.3**, the risk level for the 52 interactions between the 9 climate indicators and the 7 valued components that resulted in exposure, have been calculated. The risk levels vary from low- to high-risk, as shown on **Figure 6-2**.

Figure 6-2: Level of Risks of Historical and Projected Interactions Between Climate Indicators and Valued Components for Both Future Time-Horizons

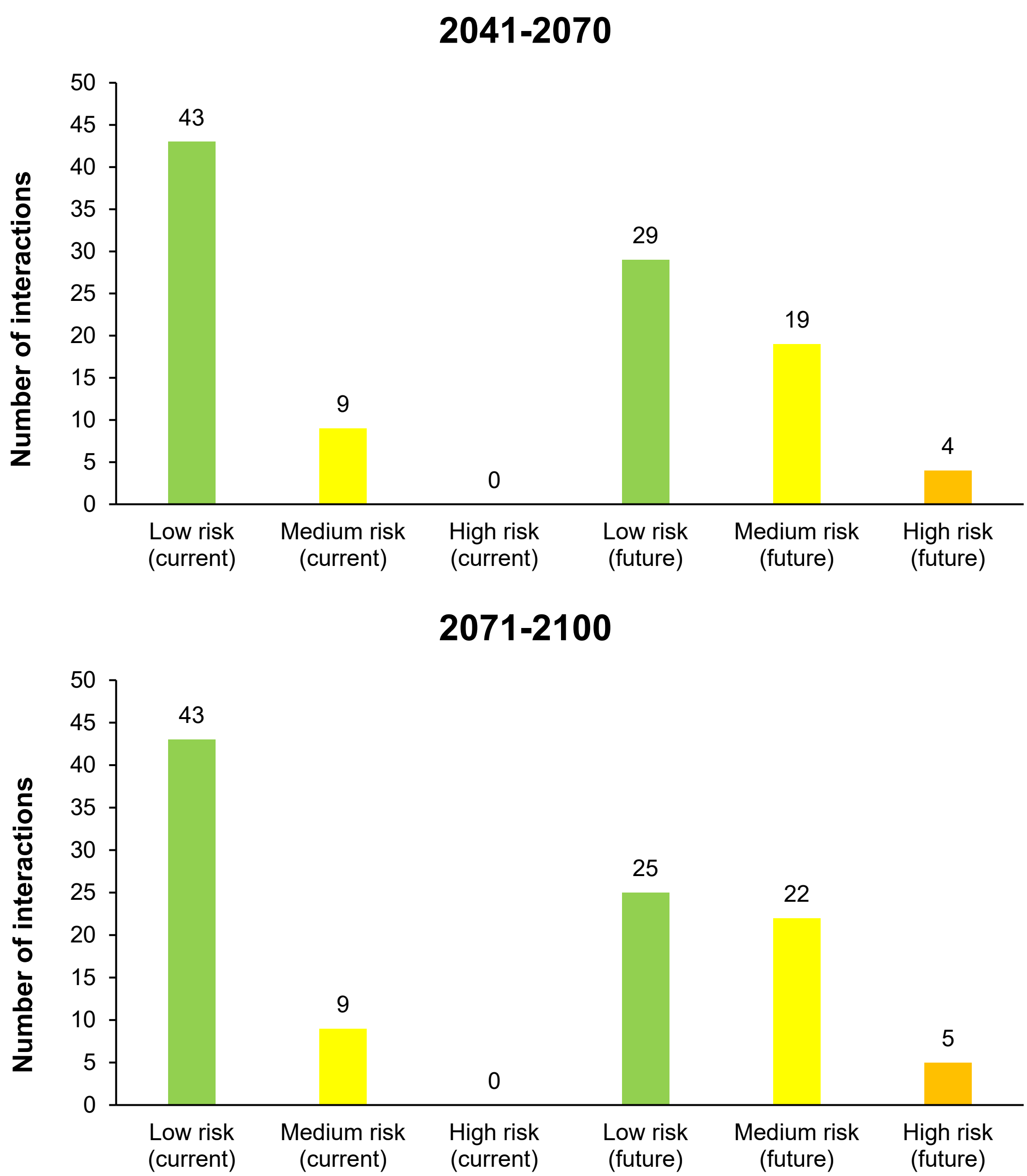


Table 6-1 presents the distribution of low, moderate, and high risks for the current and projected timeframes. The number of low risks should decrease over the century, while the

number of moderate and high risks should increase. Low risks will make up the majority of interactions until the period 2071-2100, where most interactions will result in moderate and high risks.

Table 6-1: Number of Interactions per Risk Level for Each Climate Reference Period

Level of Risk	Climate Reference Period		
	Current	2041-2070	2071-2100
Low Risk	43	29	24
Moderate Risk	9	19	23
High Risk	0	4	5

A breakdown of the risk scoring for the individual interactions of weather/climate events and assets is provided in **Table 6-2**. The risk assessment for both the climate references period (1981-2010) and the future time-horizons of 2041-2070 and 2071-2100 for the RCP8.5 highlights the increased risk due to heat waves, extreme rainfall, wildfires, and thunderstorms.

Of the 52 interactions that resulted in exposure, only 24 interactions of moderate-risk and high-risk were carried to the next part of the analysis, the *PIEVC High Level Screening Guide* Step 4. These selected interactions were further analyzed to recommend risk treatment and adaptation measures for the 2071-2100 timeframe (**Attachment B**). The full assessment is documented in the Climate Change Risk Assessment Excel Spreadsheet accompanying this report.

Table 6-2: Risk Evaluation Matrix

	Extreme (high) temperature			***Heat wave***			***Melting degree days***			***Extreme daily rainfall***			***Short-duration, high-intensity rainfall (50-year event)***			***Multi-day heavy precipitation***			***Daily snowfall (50-year event)***			***Wildfire***			***Thunderstorm***			***Total number of future special cases, moderate and high risks per infrastructure element***	***Total number of future special cases, moderate and high risks per infrastructure element***
Components	Hist	2050s	2080s	Hist	2050s	2080s	Hist	2050s	2080s	Hist	2050s	2080s	Hist	2050s	2080s	Hist	2050s	2080s	Hist	2050s	2080s	Hist	2050s	2080s	Hist	2050s	2080s		
Community Access Road	3	4	4	3	5	5	3	5	5	12	20	20	6	10	10	12	16	16	9	9	9	15	20	20	6	8	10	4	5
Culverts and bridges	3	4	4	3	5	5	6	10	10	9	15	15	6	10	10	9	12	12	9	9	9	9	12	12	6	8	10	5	6
Safety systems																						3	4	4				0	0
Illumination	3	4	4	3	5	5				3	5	5	3	5	5	3	4	4	3	3	3	6	8	8	6	8	10	0	1
Construction camps	3	4	4	6	10	10	3	5	5	6	10	10	3	5	5	6	8	8	6	6	6	12	16	16	6	8	10	3	4
Rest stops and road turnout							3	5	5	6	10	10	6	10	10	6	8	8	6	6	6	6	8	8	6	8	10	2	3
People	9	12	12	12	20	20	6	10	10	9	15	15	12	20	20	9	12	12	12	12	12	12	16	16	12	16	20	9	9
Total number of risks per climate parameter and horizon	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**7**	**7**	**7**	**6**	**6**	**6**		

Risk Rating

Risk (R) = Likelihood x Severity x Exposure		
Low Risk:	R ≤ 9	Controls/Actions likely not required
Moderate Risk:	10 ≤ R ≤ 16	Some controls/actions required to reduce risks to lower levels
High Risk:	R ≥ 20	High priority control measures required

Source: *PIEVC High Level Screening Guide* (PIEVC Program, 2021)

7. Effects Assessment on the Project

Effects assessment results are provided for the Preferred Route, by each temporal phase of the Project as described in **Section 4.3.1**. This includes the potential effects (positive and negative), mitigation measures, residual effects, and indirect effects. Where applicable Gender-Based Analysis Plus has been considered within the assessment for each valued component. Refer to **Section 3.5** for more information.

Only the medium and high effects or risks resulting from the Climate Change Risk Assessment are considered in the next sections, as stated in the *PIEVC High Level Screening Guide* (**Table 4-11**; PIEVC Program, 2021). Climate Adaptation and Resiliency does not consider residual and indirect effects, as the objective of this study is to assess the impacts of climate change on the Project instead of the Project's impact on the environment. The detailed results of the risk analysis as well as possible adaptation measures are presented in **Attachment B**. Table 7-1 and Table 7-2 summarize the proposed adaptation measures for the construction and operation of Marten Falls Community Access Road.

Table 7-1: Summary of Effects and Adaptation Recommendations - Construction

Climate Indicators	Valued Components	Justification	Adaptation Measure or Risk Treatment
Extreme (high) Temperature and Heat Wave	■ Construction camps	■ Extreme temperature and heat waves can reduce productivity and cause delays in construction and maintenance work. ■ Extreme temperature and heat waves can increase indoor air temperature in construction trailers and therefore the need for cooling/ventilation systems. ■ High temperature and heat waves will reduce the loading rate (maximum power rate) of above ground transformers and other electrical equipment like generators. The life expectancy for transformers (as for other electrical equipment) is reduced by 50% for every 10°C over their rated temperature limit. ■ The demand for water may increase during periods of high temperature and heat waves.	■ Enforce breaks for workers during the construction, provide protective equipment and air conditions in camps, and implement flexible work schedules during heat waves. ■ Increase thermal efficiency (e.g., insulation, ventilation, choice of materials, green or pale coloured/reflective roofs) of construction trailers to decrease indoor air temperature, as well as power demand from cooling during hot days. ■ Use white "cooling" boxes for outdoor electrical equipment (e.g., on the roof tops) to prevent overheating of power and heating equipment.
	■ People	■ Extreme temperature and heat waves can cause various health impacts, including skin rash, heatstroke, fainting, exhaustion, muscle cramps, dehydration, and edema. ■ Extreme temperatures and heat waves can affect vulnerable people in greater proportions and intensity.	■ Implement an alert protocol designed to identify and communicate hot weather and heat wave conditions that could impact the well-being of community members, visitors, and workers. ■ Communicate the health risks of extreme heat events with the public, as recommended by Health Canada (2011). For example, share heat wave warnings and health safety tips on display signs in construction camps and in community buildings. ■ Limit the exposure of workers to extreme temperatures and heat waves by modifying physically demanding work schedules during periods of increased temperature, humidity, or insulation. ■ Provide designated cool, shaded, or air-conditioned areas for workers in order to limit their exposure to extreme temperatures and heat.
Extreme Daily Rainfall, Short-duration, high-intensity rainfall (50-year event), and Multi-day heavy precipitation	■ Community Access Road	■ Extreme rainfall can cause the erosion of the road surface and can create rills and gullies. ■ Road washouts are possible in areas where runoff or surface water congregates (i.e., culvert or bridge). Washouts may render the road impassable for an extended period. ■ Extreme rainfall may cause flooding. Road segments with culverts and bridges may be more vulnerable to flooding.	■ Design drainage systems to cope with heavy rainfall with well defined overland flow routes. On larger fill sites with expansive grade slopes, confirm that erosion protection measures are employed (blanket to foster revegetated growth, synthetic ditch checks, straw wattle and others) to slow down erosive forces. ■ Use non-moisture susceptible building materials so that work can continue during rain events (ex quarried rock, granular fill materials)
	■ Culverts and bridges	■ Extreme precipitations can cause an accelerated deterioration of culverts by increasing the amount of runoff water that converges through them. ■ Extreme precipitations can increase the scour rate of bridge foundations. ■ High volumes of water can overwhelm culverts and lead to failure and flooding.	■ Choose oversized culverts to take into account the increase in the recurrence of floods and extreme rainfall of about 172 mm (i.e., a 100-year rainfall in 2071-2100). ■ Raising the bridge deck will increase the hydraulic capacity of bridges, limiting damages sustained during flooding event.

Climate Indicators	Valued Components	Justification	Adaptation Measure or Risk Treatment
	▪ Construction camps	▪ Extreme rainfall may result in premature deterioration of exterior building elements (e.g., windows, exterior doors) and the construction trailers due to water infiltration, resulting in increased inspections and maintenance costs. ▪ Extreme rainfall can lead to water accumulation on flat roofs (ensuing drainage difficulties). ▪ Extreme rainfall can cause delays in construction and maintenance work. ▪ Extreme rainfall can cause the erosion of the hard-surfaces and can cause flooding	▪ Increase inspections and maintenance of construction trailers and other installations to prevent the worsening of wear and tear during heavy rainfall and flooding events.
	▪ Rest stops and road turnout	▪ Extreme rainfall can cause the erosion of the road turnout surface and can create rills and gullies. ▪ Road washouts are possible in areas where runoff or surface water congregates (i.e., culvert or bridge). Washouts may render the road impassable for an extended period. ▪ Extreme rainfall may cause flooding. Road turnouts near culverts and bridges may be more vulnerable to flooding.	▪ Design drainage systems to cope with heavy rainfall with well defined overland flow routes.
	▪ People	▪ Extreme rainfall can cause dangerous driving conditions by reducing visibility and traction. Road conditions can deteriorate quickly. ▪ Extreme rainfall may cause flooding or flash floods. Floods can reduce road safety for users and may cause road closures. This can cause delays in the mobilization and arrival of first responders during emergency situations.	▪ Communicate the condition of the road with the public in order to encourage people to be careful when traveling. For example, share the location and status of floods or road washouts in construction camps and in community buildings. ▪ Develop and implement an Emergency Preparedness and Management Plan in the case of a heavy rainfall or flood event.
Daily Snowfall (50-year event)	▪ People	▪ Heavy snowfall can cause dangerous driving conditions which can lead to skidding and collisions. ▪ Heavy snowfall can increase frequency and effort needed during snow removal operations. This can cause delays in the mobilization and arrival of first responders during emergency situations	▪ Communicate the conditions of the roadway with the public in order to encourage people to be careful when traveling. For example, share the status of plowing operations in construction camps and in community buildings. ▪ Develop and implement an Emergency Preparedness and Management Plan in the case of a heavy snowfall event.
Wildfire	▪ Construction camps	▪ Wildfires can cause major damages to construction camps and decrease air quality, resulting in operational impact. ▪ Evacuation may be necessary. ▪ If wildfires reach explosives storages, large explosions may occur.	▪ Implement early warning systems to prepare for wildfire events and make informed decisions about construction camp closures. ▪ Remove ground litter and high ignition vegetation (e.g., dead, dying, dried and overmature trees) on a regular basis to limit the presence of fire fuel around construction camp infrastructure, especially near explosives storage. ▪ Keep grasses near the construction camp infrastructure cut at less than 10 cm in height during the fire season. ▪ Install an external unmanned sprinkler system and have sources of water available (especially near storage of explosive materials).

Climate Indicators	Valued Components	Justification	Adaptation Measure or Risk Treatment
	■ Culverts and bridges	■ The flames and heat generated by forest fires can damage Marten Falls Access Road components, including bridges and culverts. ■ Wildfires can cause accelerated deterioration of bridge materials, especially fire-vulnerable materials such as timber. Such damage may affect the structural integrity of a concrete structure.	■ The use of timber in bridge structures is discouraged and steel/concrete shall be incorporated.
	■ People	■ The intense heat caused by nearby wildfires can affect the integrity of vehicles. ■ Wildfires can cause the closure of the road, causing delays in the mobilization and arrival of first responders. ■ Wildfire smoke can decrease air quality by increasing the amount of Particular Matter (PM) 2.5. Wildfire smoke can be carried for considerable distances and for an extended period of time, depending on wind intensity and direction. ■ Decreased visibility due to wildfire smoke and debris on the road can cause dangerous driving conditions which can lead to accidents.	■ Monitor air quality and limit the exposure of workers to smoke by modifying work schedules during wildfire season. Keep monitoring the following website for smoke intensity and forecasts (https://firesmoke.ca/forecasts/current/) ■ Communicate the health risks of wildfires and wildfire smoke with the public. For example, share wildfire, road, and evacuation status on display signs in construction camps and in community buildings. ■ Develop and implement an Emergency Preparedness and Management Plan in the case of a wildfire event.
Thunderstorm	■ Community Access Road	■ Thunderstorms, combined with heavy winds and/or precipitations, may cause flooding and soil erosion.	■ Design drainage systems to cope with heavy rainfall with well defined overland flow routes.
	■ Construction camps	■ Thunderstorms, combined with heavy winds, heavy precipitations, lightning, and/or hail, can cause damage to construction site equipment. ■ Thunderstorms can cause delays in construction and maintenance work.	■ Secure construction equipment and material in preparation of thunderstorms (heavy wind). ■ Communicate the health risks of thunderstorms with the public. For example, track and share status of thunderstorms on display signs in construction camps and in community buildings. ■ Use the following website to confirm threat (https://weather.gc.ca/lightning/index_e.html). ■ Develop and implement an Emergency Preparedness and Management Plan in the case of a thunderstorm.
	■ Rest stops and road turnout	■ Thunderstorms, combined with heavy winds and/or precipitations, may cause flooding and soil erosion.	■ Design drainage systems to cope with heavy rainfall with well defined overland flow routes.
	■ People	■ Thunderstorms, including heavy winds, heavy rain and lightning, can cause dangerous driving conditions which can lead to accidents.	■ Establish a storm warning system that alerts road users in advance so that they can plan their travel. ■ Establish and communicate guidelines on what to do in case of a thunderstorm to road users.

Table 7-2: Summary of Effects and Adaptation Recommendations - Operations

Climate Indicators	Valued Components	Justification	Adaptation Measure or Risk Treatment
Extreme (high) temperature and Heat wave	■ People	■ Extreme temperature and heat waves can cause various health impacts, including skin rash, heatstroke, fainting, exhaustion, muscle cramps, dehydration, and edema. ■ Extreme temperatures and heat waves can affect vulnerable people in greater proportions and intensity.	■ Implement an alert protocol designed to identify and communicate hot weather and heat wave conditions that could impact the well-being of community members, visitors, and workers.
			■ Communicate the health risks of extreme heat events with the public, as recommended by Health Canada (2011). For example, share heat wave warnings and health safety tips on display signs in construction camps and in community buildings.
Melting degree days	■ Culverts and bridges	■ The increase in melting degree days can increase the amount of runoff water that converges in culverts.	■ Schedule inspections and maintenance of culverts to prevent the worsening of wear and tear following the winter season.
	■ People	■ The increase in melting degree days can lead to an increase in snow and ice melt, which in turn can lead to the deterioration of road conditions and accidents.	■ Communicate the condition of the roadway with the public in order to encourage people to be careful when traveling. For example, sharing the location of the greatest damage in construction camps and in community buildings.
Extreme daily rainfall, Short-duration, high-intensity rainfall (50-year event), and Multi-day heavy precipitation	■ Community Access Road	■ Extreme rainfall can cause the erosion of the road surface and can create rills and gullies. ■ Road washouts are possible in areas where runoff or surface water congregates (i.e., culvert or bridge). Washouts may render the road impassable for an extended period. ■ Extreme rainfall may cause flooding. Road segments with culverts and bridges may be more vulnerable to flooding.	■ On larger fill sites with expansive grade slopes, confirm that erosion protection measures are employed (blanket to foster revegetated growth, synthetic ditch checks, straw wattle, and others) to slow down erosive forces.
			■ Increase inspections and maintenance after extreme rainfall event to prevent the worsening of wear and tear of the road during heavy rainfall and flooding events.
			■ Conduct frequent grading and maintenance of the road to fill potholes and maintain a crowned (4%) surface that can handle heavy rainfall more effectively.
	■ Culverts and bridges	■ Extreme precipitations can cause an accelerated deterioration of culverts by increasing the amount of runoff water that converges through them. ■ Extreme precipitations can increase the scour rate of bridge foundations. ■ High volumes of water can overwhelm culverts and lead to failure and flooding.	■ Proceed to scour monitoring to limit the extent of the damaged to bridges during a flood.
			■ Increase inspections and maintenance of culverts to prevent the worsening of wear and tear during heavy rainfall and flooding events.
	■ Rest stops and road turnout	■ Extreme rainfall can cause the erosion of the road turnout surface and can create rills and gullies. ■ Road washouts are possible in areas where runoff or surface water congregates (i.e., culvert or bridge). Washouts may render the road impassable for an extended period. ■ Extreme rainfall may cause flooding. Road turnouts near culverts and bridges may be more vulnerable to flooding.	■ Increase inspections and maintenance to prevent the worsening of wear and tear of the rest stops and road turnouts after heavy rainfall and flooding events.

Climate Indicators	Valued Components	Justification	Adaptation Measure or Risk Treatment
	■ People	■ Extreme rainfall can cause dangerous driving conditions by reducing visibility and traction. Road conditions can deteriorate quickly. ■ Extreme rainfall may cause flooding or flash floods. Floods can reduce road safety for users and may cause road closures. This can cause delays in the mobilization and arrival of first responders during emergency situations.	■ Communicate the condition of the road with the public in order to encourage people to be careful when traveling. For example, share the location and status of floods or road washouts in construction camps and in community buildings. Include the road in the internet feed for road conditions reporting. ■ Develop and implement an Emergency Preparedness and Management Plan in the case of a heavy rainfall or flood event.
Daily snowfall (50-year event)	■ People	■ Heavy snowfall can cause dangerous driving conditions which can lead to skidding and collisions. ■ Heavy snowfall can increase frequency and effort needed during snow removal operations. This can cause delays in the mobilization and arrival of first responders during emergency situations	■ Communicate the conditions of the roadway with the public in order to encourage people to be careful when traveling. For example, share the status of plowing operations in construction camps and in community buildings. ■ Develop and implement an Emergency Preparedness and Management Plan in the case of a heavy snowfall event.
Wildfire	■ Community Access Road	■ Wildfires can cause the closure of the road for safety reasons, preventing the road users from using it, causing delays in the mobilization and arrival of first responders, and disrupting supply chains. ■ Wildfires in surrounding areas can create dangerous driving conditions, such as reduced visibility from smoke and ash. Heat from wildfires can damage vehicles. ■ The road should not be damaged directly from wildfire flames and heat.	■ Conduct regular maintenance and inspection of the road and its cleared 60m right-of-way to prevent the accumulation of flammable debris and improve safe travel. ■ Implement early warning systems to prepare for wildfire events and make informed decisions about road closures.
	■ Culverts and bridges	■ The flames and heat generated by forest fires can damage Marten Falls Community Access Road components, including bridges and culverts. ■ Wildfires can cause accelerated deterioration of bridge materials, especially fire-vulnerable materials such as timber. Such damage may affect the structural integrity of a concrete structure.	■ Conduct regular maintenance and inspection of bridges to prevent the accumulation of flammable debris and improve safe travel. ■ Increase inspections and maintenance after wildfire events to prevent the worsening of wear and tear of bridges and culverts.
	■ People	■ The intense heat caused by nearby wildfires can affect the integrity of vehicles. ■ Wildfires can cause the closure of the road, causing delays in the mobilization and arrival of first responders. ■ Wildfire smoke can decrease air quality by increasing the amount of Particular Matter (PM) 2.5. Wildfire smoke can be carried for considerable distances and for an extended period of time, depending on wind intensity and direction. ■ Decreased visibility due to wildfire smoke and debris on the road can cause dangerous driving conditions which can lead to accidents.	■ Communicate the health risks of wildfires and wildfire smoke with the public. For example, share wildfire, road, and evacuation status on display signs in construction camps and in community buildings. ■ Keep monitoring the following website for smoke intensity and forecasts (https://firesmoke.ca/forecasts/current/). ■ Develop and implement an Emergency Preparedness and Management Plan in the case of a wildfire event.

Climate Indicators	Valued Components	Justification	Adaptation Measure or Risk Treatment
Thunderstorm	■ Community Access Road	■ Thunderstorms, combined with heavy winds and/or precipitations, may cause flooding and soil erosion.	■ Increase inspections and maintenance after extreme rainfall event to prevent the worsening of wear and tear of the road during heavy rainfall and flooding events.
			■ Conduct frequent grading and maintenance of the road to fill potholes and maintain a smooth surface that can handle heavy rainfall more effectively.
	■ Culverts and bridges	■ Thunderstorms, combined with heavy winds and/or heavy precipitations, can cause an accelerated deterioration of bridges. ■ High volumes of water can overwhelm culverts and lead to failure and flooding.	■ Increase inspections and maintenance of culverts to prevent the worsening of wear and tear during heavy rainfall and flooding events.
	■ Illumination	■ Dense clouds associated with thunderstorms can extend the duration of illumination of the roadway and therefore use up the battery charge. ■ Thunderstorms, including heavy precipitations, strong winds, lightning and/or hail, can damage solar streetlights.	■ Keep backup solar streetlights in stock in order to be able to replace quickly any damaged equipment after a thunderstorm.
	■ Rest stops and road turnout	■ Thunderstorms, combined with heavy winds and/or precipitations, may cause flooding and soil erosion.	■ Increase inspections and maintenance after a thunderstorm to prevent the worsening of wear and tear of the rest stops and road turnouts.
	■ People	■ Thunderstorms, including heavy winds, heavy rain and lightning, can cause dangerous driving conditions which can lead to accidents.	■ Establish a storm warning system that alerts road users in advance so that they can plan their travel.
			■ Establish and communicate guidelines on what to do in case of a thunderstorm to road users.

8. Cumulative Effects of the Project

When analyzing climate change, a large variety of climate change aspect were investigated. The underlying assumption for this assessment was singularity – the events occur independently, successively, and without impacting one another. This simplification entails the exclusion of compound events where compound events are events that are:

- **Preconditioned:** One climate event leads or amplifies a second event (e.g., a drought leading to an exacerbation of a wildfire).
- **Temporally co-occurring:** Two or more climate events occur at the same time or in quick succession (e.g., two heat waves occur in sequence).
- **Spatially co-occurring:** Two or more climate events occur at different sites at the same time (e.g., derecho passing over multiple sites).

Some preconditioned compound events have been indirectly considered (e.g., increased air temperature and more frequent heat waves will increase the likelihood and intensity of biofouling events). Other compound events include the exacerbation of drought events by temporally co-occurring heat waves or the intensification of thunderstorms due to preconditioning heat wave. Spatially co-occurring events can limit the resources available to address these events, for example in the instance of two more wildfires occurring simultaneously along the road or in multiple communities. However, no systematic analysis of preconditioned compound events was conducted for this Climate Change Risk Assessment. Moreover, temporally and spatially compound events have not been considered at all. Therefore, no cumulative effects with respect to climate change were considered in this Project.

9. Monitoring Programs and Future Commitments

Limitations arise from the underlying climatological dataset. Climate projections and the underlying assumptions about human behaviour (i.e., population and economic growth which ranges from slow and progressively reliant on alternative fuel for the intermediate-emission scenario to fast and heavily reliant on fossil fuel without systematic climate change mitigation efforts for the high-emission scenario) introduce uncertainties into the risk assessment process. The results of this risk assessment must be reviewed once new scientific findings regarding the climate change trajectory become available, human behaviour leads to significantly changed conditions, or site characteristics are altered.

As human behaviour and the associated greenhouse gas emissions are unpredictable and alterations to the site characteristics might occur currently unforeseen, it is difficult to predetermine an update schedule. However, from the perspective of new climate projections, it is recommended that results of updated climate simulations expected towards the end of this decade (i.e., 2028-2030) are compared to this Climate Change Risk Assessment. Scientific findings and new insights of the short term (i.e., next 3 to 5 years) will likely have a marginal impact on risk profile development in this Climate Change Risk Assessment. Nonetheless, reviewing relevant scientific findings and revisiting climate projections and associated potential impacts from climate change is recommended. Furthermore, the ongoing inclusion of Indigenous observations regarding the experienced effects of climate change is advised.

Hence, no monitoring programs and future commitments are considered in this study.

10. Summary and Recommendations

Risk treatment and adaptation measures for reducing medium and high risks to lower, more acceptable levels, were identified. For future timeframes, these measures are summarized in **Table 10-1**. Climate Indicators that resulted in similar risk assessments and adaptation measure are combined (i.e., extreme (high) temperature and heat wave, or extreme daily rainfall, Short-duration, high-intensity rainfall (50-year event) and multi-day heavy precipitation) by using the higher risk scoring in case they differ. A detailed version of **Table 10-1** is available in **Attachment B**, with additional information on the effectiveness of the adaptation measures as well as the recommended timeframe for their implementing.

Table 10-1: Summary of Adaptation Measures

Climate Indicator	Adaptation Measures	Implementation Timeframe	Project Phase
Extreme Temperature and Heat Wave	■ Implement an alert protocol designed to identify and communicate hot weather and heat wave conditions that could impact the well-being of community members, visitors, and workers.	■ Policy	■ Construction / Operations
	■ Enforce breaks for workers during construction, provide protective equipment and air conditioning in camps, and implement flexible work schedules during heat waves.	■ Operations	■ Construction
	■ Communicate the health risks of extreme heat events to the public, as recommended by Health Canada (2011). For example, share heat wave warnings and health safety tips on display signs in construction camps and in community buildings.	■ Policy	■ Construction / Operations
	■ Provide designated cool, shaded, or air-conditioned areas for workers in order to limit their exposure to extreme temperatures and heat.	■ Design	■ Construction

Climate Indicator	Adaptation Measures	Implementation Timeframe	Project Phase
Extreme Rainfall	■ Design drainage systems to handle heavy rainfall, with well defined overland flow routes.	■ Design	■ Construction
	■ Choose oversized culverts to account for the increase in the recurrence of floods and extreme rainfall of about 172 mm (i.e., a 100-year rainfall in 2071-2100).	■ Design	■ Construction
	■ Conduct frequent grading and maintenance of the road to fill potholes and maintain a smooth surface that can handle heavy rainfall more effectively.	■ Operations	■ Operations
	■ Communicate the condition of the road to the public to encourage people to be careful when traveling. For example, share the location and status of floods or road washouts in construction camps and in community buildings. Include the road in the internet feed for road conditions reporting.	■ Policy	■ Construction / Operations
Wildfire	■ Conduct regular maintenance and inspection of the road to prevent the accumulation of flammable debris and improve safe travel.	■ Operations	■ Operations
	■ Implement early warning systems to prepare for wildfire events and make informed decisions about road closures.	■ Policy	■ Operations
	■ Develop and implement an Emergency Preparedness and Management Plan in the case of a wildfire event.	■ Policy	■ Operations
Thunderstorm	■ Establish a storm warning system that alerts road users in advance so that they can plan their travel.	■ Policy	■ Operations
	■ Establish guidelines on what to do in case of a thunderstorm and communicate to road users.	■ Policy	■ Operations

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Attachment A - Study Plan, Workplan and Regulator Comments

MARTEN FALLS FIRST NATION
ALL SEASON COMMUNITY ACCESS ROAD

FINAL

Climate Adaptation and Resiliency Study Plan

May 2021

Distribution List

# Hard Copies	PDF Required	Association / Company Name
	✓	Marten Falls First Nation
	✓	AECOM Canada Ltd.

Revision History

Rev #	Date	Revision Description
Draft	May 2020	Submitted “Study Plan- Climate Change DRAFT FOR DISCUSSION” to the Agency.
Final	May 2021	Revised to address federal and provincial agency comments.

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Appendices

Appendix A. Preliminary List of Data Sources

Appendix B. Agency Comments on the Draft Study Plan

Acronyms

Agency, the ... Impact Assessment Agency of Canada (IAAC)
AR5 .... Fifth Assessment Report, IPCC
BAU .... Business as Usual
CADE .... Dillon's Climate Analytics Data Engine
CAR............... Community Access Road
CCRA .... Climate Change Resilience Assessment
CCHIP .... Risk Sciences International's Climate Change Hazards Information Portal
EA.................. Environmental Assessment
ECCC .... Environment and Climate Change Canada
GCM .... Global Climate Model
IA .... Impact Assessment
IAA................. *Impact Assessment Act*
IAAC .... Impact Assessment Agency of Canada
IPCC.............. Intergovernmental Panel on Climate Change
IS .... Impact Statement
ISO .... International Standards Organisation
km.................. kilometre
LSA................ Local Study Area
MECP .... Ontario Ministry of the Environment, Conservation and Parks
MFFN .... Marten Falls First Nation
NBCC .... National Building Code of Canada
NRCan........... Natural Resources of Canada
PIEVC……….. Public Infrastructure Engineering Vulnerability Committee Protocol
PDA .... Project Development Area
RSA .... Regional Study Area
SAR .... Species at Risk
TISG .... Tailored Impact Statement Guidelines
ToR................ Terms of Reference
VC .... Valued Component

1. Introduction

The Proponent of the Community Access Road (CAR or the Project) is Marten Falls First Nation (MFFN), a remote First Nation community in northern Ontario located at the junction of the Albany and Ogoki rivers, approximately 430 kilometres (km) from Thunder Bay, Ontario. The MFFN community is proposing an all-season Community Access Road that will connect the MFFN community to the Ontario's provincial highway network (Highway 643) to the south via the existing Painter Lake Road. MFFN, as the Proponent of the Project, has formed a MFFN CAR Project Team that includes MFFN CAR Community Member Advisors and MFFN CAR Project Consultants who act with input, guidance and direction from the MFFN Chief and Council.

This document outlines the Study Plan for the Climate Adaptation and Resiliency Assessment. Note that this effects assessment focuses on climate impacts on the CAR. Assessment of impacts of the project on climate change are described in the Atmospheric Environment and Greenhouses Gases Study Plan. The study plan supports a co-ordinated Impact Assessment (IA) required for Project review by the Impact Assessment Agency of Canada (the Agency) under the federal *Impact Assessment Act* (IAA) and Environmental Assessment (EA) required for Project review by the Ontario Ministry of the Environment, Conservation and Parks (MECP) under the Ontario *Environmental Assessment Act*.

1.1 Federal and Provincial Terminology

The study plans have been prepared using federal terminology, however, the respective provincial terminology has been provided in **Table 1-1** for reference. The terms can be used interchangeably.

Table 1-1: Equivalent Federal and Provincial Terms

Provincial Term	Federal Term
Criteria	Valued Component
Impact Management Measure	Mitigation Measure
Net Effects	Residual Effects
Record of Consultation	Record of Engagement

1.2 Project Study Plans

This Study Plan is one of a group of study plans created for the Project. **Table 1-2** includes the study plans for each environmental[1] discipline currently planned for the Project and the valued components (VCs) covered by the study plans where applicable.

Table 1-2: Project Study Plans and Valued Components

Environmental Discipline	Study Plan Name	Valued Component(s)
Aboriginal and Treaty Rights and Interests	■ Aboriginal and Treaty Rights and Interests Study Plan	■ Indigenous Current Use of Lands and Resources for Traditional Purposes ■ Cultural Continuity (ability to practice and transmit cultural traditions)
Atmospheric Environment	■ Atmospheric Environment and Greenhouse Gases Study Plan	■ Air Quality ■ Greenhouse Gas Emissions
Climate Change	■ Climate Adaptation and Resiliency Study Plan	■ Climate Change
Acoustic and Vibration Environment	■ Acoustic and Vibration Environment Study Plan	■ Noise ■ Vibration
Physiography, Geology, Terrain and Soils	■ Physiography, Terrain and Soils Study Plan	■ Physiography, Terrain and Soils
Surface Water	■ Surface Water Study Plan	■ Surface Water
Groundwater and Geochemistry	■ Groundwater and Geochemistry Study Plan	■ Groundwater
Vegetation	■ Vegetation Study Plan	■ Wetland and Riparian Ecosystems ■ Upland Ecosystems ■ Designated Areas (Areas of Natural and Scientific Interest, Environmentally Significant Areas, Significant Woodlands, Critical Landform / Vegetation Associations) ■ Traditional Use Plants and SAR Plant Populations (including species with special conservation status or rarity in the province)
	■ Peatlands Study Plan	■ Peatland Ecosystems (bogs and fens)
Wildlife	■ Wildlife Study Plan	■ Bats (including SAR-bats such as: Little Brown Myotis [*Myotis lucifugus*], Northern Myotis [*Myotis septentrionalis*] and Tricolored Bat [*Perimyotis subflavus*])

1. *The use of the term environment in this document is inclusive of the components of the environment that are included in the Ontario Environmental Assessment Act definition, which includes a general description of the social, cultural, built and natural environments.*

Environmental Discipline	Study Plan Name	Valued Component(s)
		■ Fur Bearers (proxy VC[2] American Marten [*Martes americana*], Beaver [*Castor canadensis*] and Wolverine [*Gulo gulo*]) ■ Amphibians and Reptiles ■ Pollinating Insects
	■ Ungulates (Moose and Caribou) Study Plan	■ Moose (*Alces alces*) ■ Caribou, boreal population (*Rangifer tarandus*)
	■ Bird Study Plan	■ Forest Birds (proxy VC of Red-eyed Vireo [*Vireo olivaceus*] for deciduous forest, Ovenbird [*Seirus aurocapilla*] for mixedwood forest, Dark-eyed Junco [*Junco hyemalis*] for coniferous forest and disturbed forest ■ Raptors (proxy VC of Osprey [*Pandion haliaetus*] for diurnal raptors and Boreal Owl [*Aegolius funereus*] for nocturnal raptors ■ Shorebirds (proxy VC of Wilson's Snipe [*Gallingo delicata*]) ■ Waterfowl (proxy VC of Mallard [*Anas platyrhynchos*]) ■ Bog / Fen Birds and Other Wetland Birds (proxy VC of Palm Warbler [*Setophaga palmarum*] for bogs, Common Yellowthroat [*Geothlypis trichas*] for fens; and Northern Waterthrush [*Parkesia noveboracensis*] for swamps. ■ SAR birds: Canada Warbler (*Cardellina canadensis*), Chimney Swift (*Chaetura pelagica*), Common Nighthawk (*Chordeiles minor*), Eastern Whip-poor-will (*Antrostomus vociferous*), Eastern Wood-Pewee (*Contopus virens*), Evening Grosbeak (*Coccothraustes vespertinus*), Olive-sided Flycatcher (*Contopus cooperi*), Bald Eagle (*Haliaeetus leucocephalus)*, Peregrine Falcon (*Falco peregrinus*), Short-eared Owl (*Asio flammeus)*, Bank Swallow (*Riparia riparia*), Barn Swallow (*Hirundo rustica*), Black Tern (*Childonias niger*), Rusty Blackbird (*Euphagus carolinus*), Yellow Rail (*Coturnicops noveboracensis*).
Fish and Fish Habitat	■ Fish and Fish Habitat Study Plan	■ Lake Sturgeon (*Acipenser fulvescens*) ■ Walleye (*Sander vitreus*) ■ Brook Trout (*Salvelinus fontinalis*) ■ Northern Pike (*Esox lucius*) ■ Lake Whitefish (*Coregonus clupeaformis*) ■ Chain Pickerel (*Esox niger*) ■ Yellow Perch (*Perca flavescens*) ■ Cisco (*Coregonus artedii*)

2. *A proxy VC is used when looking at the effects of one species that represents many others.*

Environmental Discipline	Study Plan Name	Valued Component(s)
		■ Burbot (*Lota lota*) ■ Longnose Sucker (*Catostomus catostomus*) ■ White Sucker (*Catostomus commersonii*) ■ Forage / Prey Species (including species such as Lake Chub [*Couesius plumbeus*]) ■ Lower Trophic Organisms (e.g., benthic invertebrates)
Social	■ Social Study Plan	■ Housing and Accommodation ■ Community Service and Infrastructure ■ Transportation ■ Community Well-being ■ Populations and Demographics
Economy	■ Economic Study Plan	■ Regional Economy ■ Labour Force and Employment ■ Government Finances
Land and Resource Use	■ Land and Resource Use Study Plan	■ Land Use Compatibility ■ Parks and Protected Areas ■ Extractive Industry ■ Forestry Industry ■ Energy and Linear Infrastructure ■ Recreation and Tourism
Human Health and Community Safety	■ Human Health and Community Safety Study Plan	■ Public Safety ■ Public Health ■ Diet ■ Environmental Factors Influencing Health
Visual Aesthetics	■ Visual Aesthetics Study Plan	■ Visual Contrast / Character ■ Visibility ■ Visual Sensitivity
Archaeological and Cultural Heritage	■ Cultural Heritage Study Plan	■ Archaeological Sites and Resources ■ Built Heritage Resources and Cultural Heritage Landscapes

It should be noted that while there is not a consultation study plan, the Project has developed the *Consultation and Engagement Plan to Support the Environmental Assessment / Impact Statement* (AECOM 2020) (referred to as the Impact Statement [IS] / EA Consultation Plan).

2. Purpose and Objectives

The key objectives of conducting an IA / EA are to describe the existing environment, gather sufficient information to predict Project-related effects (positive and negative, direct and indirect) of the Project and alternatives on the environment, determine measures needed to avoid or minimize adverse Project effects, and enhance beneficial Project effects where feasible, and to undertake consultation and engagement throughout. The purpose of this Study Plan is to explain:

- A baseline[3] study methodology that will result in a comprehensive description of the existing environment potentially impacted by the Project;
- How efficient and transparent data management and analysis will be undertaken;
- Effects assessment scoping specific to the Climate Adaptation and Resiliency discipline that will identify potential impacts of climate change on the Project and assess the risks they represent for the Project. Note, impacts of the Project on climate change (i.e., project contribution to GHG emissions) are addressed in the Atmospheric Environment and Greenhouse Gasses Study Plan; and,
- How the Study Plan aligns with federal and provincial requirements and guidance, including the Agency's Tailored Impact Statement Guidelines (TISG), dated February 24, 2020 (the Agency 2020c), for this Project and applicable provincial agency comments on the Draft Terms of Reference (ToR)[4].

As required by the IAA and referenced in TISG Section 7.3, work plans will also be developed for disciplines as required. It is anticipated the work plans will include further details on how to action the study plans; for example they would contain such information as location of sampling sites, scheduling, and sequencing.

For the purposes of establishing appropriate context, the study plan begins with background and relevant information on:

- Study plan related discussions with the Agency, the MECP and applicable agencies to date (**Section 3**);
- The approach to Project consultation and engagement (**Section 4**);
- How Indigenous Knowledge will be collected and used in the IA / EA (**Section 5**); and
- The spatial and temporal boundaries that will be used for the IA / EA (**Section 6**).

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3. *Baseline refers to the current conditions of the environment potentially impacted by the Project. Baseline conditions serve as a reference against which changes due the Project are measured.*
4. *If necessary, the Study Plan will be updated to reflect the approved ToR if approval is obtained.*

2.1 Approach to Handling Confidential Information

2.1.1 Indigenous Knowledge

Permission from the Indigenous community will be sought before including Indigenous Knowledge in the IS / EA Report, regardless of the source of the Indigenous Knowledge. Sensitive and / or confidential information will be specifically collected through the Indigenous Knowledge Program to inform the IS / EA Report, and its use and publication will be governed by Indigenous community-specific Indigenous Knowledge Sharing Agreements. Sensitive and / or confidential information collected through Indigenous Knowledge Sharing Agreements will be protected from public or third-party disclosure and will be established between the Proponent and Indigenous communities participating in the Indigenous Knowledge Program prior to the sharing and use of any sensitive information. Instances where Indigenous Knowledge sharing has taken place during consultation activities (e.g., meetings) will be recorded in the Record of Engagement, including where Indigenous Knowledge was incorporated into Project decisions and into the IS / EA Report (i.e., specifics will not be included in the Record of Engagement given the potential sensitivity and / or confidentiality of the information shared).

3. Study Plan Technical Discussions

To facilitate the development of satisfactory study plans and eventually a satisfactory IS / EA Report, MFFN previously submitted draft study plans in an effort to hold technical discussions with the Agency, the MECP and applicable agencies. To date, no technical discussions have taken place regarding the Climate Adaptation and Resiliency Study Plan. The MFFN CAR Project Consultants commit to including the results from any future technical discussions related to the Study Plan in the IS / EA Report.

4. IS / EA Report Consultation and Engagement Process

4.1 Interested Persons and Government Agencies

The Proponent will provide Project notices and advise of opportunities for consultation and engagement with interested persons[5] which includes, at a minimum, members of the public outlined in the *Public Participation Plan for the Marten Falls Community Access Road Project Impact Assessment* (IAAC 2020) (referred to as the Public Participation Plan). This will include the opportunity to provide input on the existing environment, VCs, effects assessment methods, effects assessment results, and mitigation and follow-up program measures as applicable. A variety of activities will be offered so that members of the public are informed of the IS / EA Report as it progresses and are aware of the opportunities and means to provide their input. The study plans have recognized public and agency input received on the Project to date. Government agencies and interested persons will have the opportunity to comment on components of the study plans throughout the IS / EA Report consultation and engagement process. The Project's approach to handling confidential and sensitive information is outlined in **Section 2.1**.

4.2 Indigenous Communities

The Proponent will provide Project notices and opportunities for consultation and engagement with Indigenous communities identified in **Table 4-1**, which is inclusive of all Indigenous communities identified in the *Indigenous Partnership and Engagement Plan for the Marten Falls Community Access Road Project Impact Assessment* (The Agency 2020a) (referred to as the Indigenous Engagement and Partnership Plan).

Indigenous communities will be provided the opportunity to be involved at critical decision-making points throughout the IS / EA Report so that the Proponent can consider and incorporate, where appropriate, Indigenous Knowledge and Indigenous land and resource use information into the Project as it pertains to the existing environment, VCs, effects assessment methods, effects assessment results, and mitigation and follow-up program measures. A variety of activities will be offered so that Indigenous communities are informed of the IS / EA Report as it progresses and are aware of the opportunities, means and timelines to

5. *Interested persons, as defined in the IS / EA Consultation Plan, are individuals and groups (e.g., associations, non-governmental organizations, industry and academia) who could have an interest in the Project, including but not limited to communities in the region, those with commercial interests (e.g., forestry, trappers, outfitters, other mineral tenure holders in the area) and recreational users or those with recreational interest (e.g., campers, hunters and environmental groups).*

provide their input. The study plans have recognized Indigenous community input received on the Project to date. Indigenous communities will have the opportunity to comment on components of the study plans throughout the IS / EA Report consultation and engagement process.

Table 4-1: Identified Neighbouring Indigenous Communities, including their Provincial Territorial Organizations and / or Tribal Council Affiliations

Tribal Council Affiliation	Indigenous Community or Organization
Matawa First Nations Management (Nishnawbe Aski Nation)	■ **Marten Falls First Nation** (Proponent and potentially affected Indigenous community) ■ Aroland First Nation ■ Constance Lake First Nation ■ Eabametoong First Nation ■ Ginoogaming First Nation ■ Neskantaga First Nation ■ Nibinamik First Nation ■ Webequie First Nation
Matawa First Nations Management and the Union of Ontario Indians / Nishnawbe Aski Nation	■ Long Lake #58 First Nation**
Mushkegowuk Council (Nishnawbe Aski Nation)	■ Attawapiskat First Nation ■ Fort Albany First Nation ■ Kashechewan First Nation
Shibogama First Nations Council (Nishnawbe Aski Nation)	■ Kasabonika Lake First Nation ■ Kingfisher Lake First Nation ■ Wapekeka First Nation ■ Wawakapewin First Nation ■ Wunnumin Lake First Nation
Independent First Nations Alliance (Nishnawbe Aski Nation)	■ Kitchenuhmaykoosib Inninuwug First Nation
Independent First Nations (Nishnawbe Aski Nation)	■ Mishkeegogamang First Nation ■ Weenusk First Nation
Nokiiwin Tribal Council	■ Animbiigoo Zaagi'igan Anishinaabek First Nation*
Métis Nation of Ontario	■ Métis Nation of Ontario; Region 2*
Independent Métis Nation	■ Red Sky Independent Métis Nation*

*Notes: * Indigenous communities or organizations identified by MECP who should be consulted on the basis that they may be interested in the Community Access Road.*
*** MECP indicated in a letter to MFFN that Long Lake #58 First Nation was moved from interest-based to rights-based.*

4.3 Consideration of Identity and Gender-Based Analysis Plus in Engagement

To fulfill requirements of the IAA, the Consultation and Engagement Program will consider a diverse range of perspectives from interested persons and interested Indigenous communities and their members identified in the Agency's Indigenous Engagement and Partnership Plan and the Public Participation Plan. This will include at a minimum providing ongoing opportunities for engagement to:

- **Neighbouring Indigenous communities, including relevant subpopulations:**
  - Women;
  - Youth; and
  - Elders.
- **Non-Indigenous communities including:**
  - Women;
  - Youth; and
  - Activity-based subgroups (e.g., recreationalists, snowmobilers, tourism establishment operators).

The Proponent will also consult and engage with other subpopulations identified by communities during consultation and engagement. The information from these activities and any additional identity groups identified by communities through consultation and engagement will be considered by applicable environmental disciplines for the purposes of data collection and considering disproportionate effects.

During consultation and engagement, these aforementioned groups will be consulted and engaged with on targeted input. Specialized knowledge will be gathered through other disciplines such as Social, Economic, Land and Resource Use and Aboriginal and Treaty Rights and Interests. The Socio-economic Data Collection Program is expected to include targeted interviews, focus groups, questionnaires and other niche tools to gather information from diverse populations to resolve gaps in socio-economic secondary data. These diverse populations include the identity groups referenced in the IS / EA Consultation Plan and those identified by communities during consultation and engagement. Subject to interest, community-led primary data collection and secondary data sharing for Indigenous Knowledge and Indigenous land and resource use will be completed through the Indigenous Knowledge Program.

When feedback is received from interested persons and Indigenous communities, issues, comments and questions will be tracked, which is consistent with the process described in the IS / EA Consultation Plan. Specific to Gender-Based Analysis Plus objectives, this will include efforts to engage with diverse populations. It is expected this will include activities specific to subgroups and tabulation of consultation and engagement participation with respect to identity factors. This will provide summary statistics to demonstrate the diversity achieved in consultation and engagement.

5. Consideration of Indigenous Knowledge in the IS / EA Report

The following provides a general description of how Indigenous Knowledge will be considered in the IA / EA process. The extent to which Indigenous Knowledge is considered by each specific VC will vary depending on the nature of the VC, the potential for Project effects on the VC and whether Indigenous knowledge that relates to a VC is provided / obtained. As such, not all aspects of the general approach described below may apply to all VCs / study plans.

There are two concurrent and complementary avenues for Indigenous communities and groups to be engaged with and provide input on the Project: the Indigenous Knowledge Program and the Consultation and Engagement Program. Both programs serve to support the collection of Indigenous perspectives, values, and input on the Project, including Aboriginal and Treaty Rights and how they may be impacted by the Project, to be integrated throughout the IA / EA process. However, the Indigenous Knowledge Program specifically aims to solicit and incorporate information that is considered sensitive and may have confidentiality requirements, including Indigenous Knowledge and information on Indigenous land and resource use . Indigenous Knowledge Sharing Agreements will be established between the Proponent and Indigenous communities participating in the Indigenous Knowledge Program prior to the sharing and use of any sensitive information.

All Indigenous communities and groups identified by MECP and the Agency through the Indigenous Engagement and Partnership Plan have the opportunity to participate in the Indigenous Knowledge Program. The Indigenous Knowledge Program provides interested Indigenous communities an opportunity to: share existing Indigenous Knowledge and information on Indigenous land and resource use and cultural values that may be relevant to the Project, and / or complete Project-specific studies to collect and share Indigenous Knowledge and information on Indigenous land and resource use and cultural values. The Indigenous Knowledge Program includes opportunities for Indigenous communities and groups to meet with the Proponent to discuss the program, ask questions, and share concerns and interests. In support of this, the Proponent has created an Indigenous Knowledge Program Guidance Document (the Guidance Document) that provides:

- An overview of the Indigenous Knowledge Program and information on how Indigenous Knowledge and Indigenous land and resource use and cultural values and practices can be collected and / or shared;

- Information on how Indigenous Knowledge and information on Indigenous land and resource use and cultural values and practices may be used in the planning and design processes; and
- A suite of guidance materials that were developed based on the information requirements of both the federal and provincial assessment processes, including question guides to support the collection of information on historical and current community context, Indigenous Knowledge that may be relevant to the various technical disciplines , information on Indigenous land and resource use, cultural values and practices and associated spatial data, and perspective on potential Project-related effects and associated mitigation and / or enhancement measures.

The Guidance Document will also support participating Indigenous communities in providing Project-specific information in a manner that facilitates meaningful incorporation into the IS / EA Report.

The IS / EA Consultation Plan outlines the process for obtaining information and feedback about the Project from Indigenous communities (i.e., the Consultation and Engagement Program). All Indigenous communities identified by the MECP and the Agency have the opportunity to participate in the Consultation and Engagement Program through community-specific meetings, Public Information Centres, web conferences, and other formats. All Indigenous communities identified by MECP and the Agency will be provided information related to the Project and invited to participate at various points throughout the IA / EA process.

There are also opportunities for technical teams to engage with Indigenous communities to solicit perspectives and information relevant to the Project, including information related to collection of existing information and the development of the IS / EA Report. The Proponent also invites feedback and inputs throughout the Project via the Project website and ongoing communications with the Proponent.

The Indigenous Knowledge and Consultation and Engagement programs are designed to be complementary and provide multiple opportunities for communities to offer feedback and information, including perspectives on Aboriginal and Treaty Rights and interests and how these may be impacted by the proposed Project. Relevant information collected through both the Indigenous Knowledge and Consultation and Engagement programs, including potential effect pathways on Aboriginal and Treaty Rights and interests, will be shared with each of the relevant disciplines throughout the IA / EA to: guide and inform VCs; support characterization of the existing environment; identify the potential effects of the Project on VCs; help identify mitigation measures and potential monitoring programs; and ultimately guide Project planning. The nature of how the Indigenous Knowledge becomes integrated into the IS / EA Report will be dictated by the specific information provided by each Indigenous community and the parameters set out in the Indigenous Knowledge Sharing Agreements. A description of how Indigenous Knowledge was considered in the IA / EA and in each of the technical discipline areas will be included in the IS / EA Report.

It is also important to note that information collected through the various activities (e.g., field studies and programs, effects assessments) of each discipline area (e.g., wildlife, vegetation, cultural heritage) will be shared with the Indigenous Knowledge Program leads. This will support the establishment of the existing environment and the effects assessment for the Aboriginal and Treaty Rights and Interests environmental discipline, as well as the identification of potential mitigation measures and monitoring programs, given the interrelated nature of Indigenous peoples and other environmental disciplines.

The Proponent will strive to respectfully collaborate with Indigenous communities on how Indigenous Knowledge and information on Indigenous land and resource use and cultural values will become part of the IS / EA Report, and how potential effects to Aboriginal and Treaty Rights and interests will be assessed. It is expected that measures to support this may include but are not limited to: engaging Indigenous communities to solicit information on Indigenous Knowledge and Indigenous land and resource use and cultural values to inform baseline conditions, providing Indigenous communities with draft sections of the IS / EA Report to illustrate how Indigenous Knowledge and information on Indigenous land and resource use and cultural values has been integrated and to confirm it has been presented appropriately, and completing collaborative working sessions with Indigenous communities for the effects assessment on Aboriginal and Treaty Rights and Interests. Further information on how potential effects on Indigenous rights will be assessed is provided in the Aboriginal and Treaty Rights and Interests Study Plan.

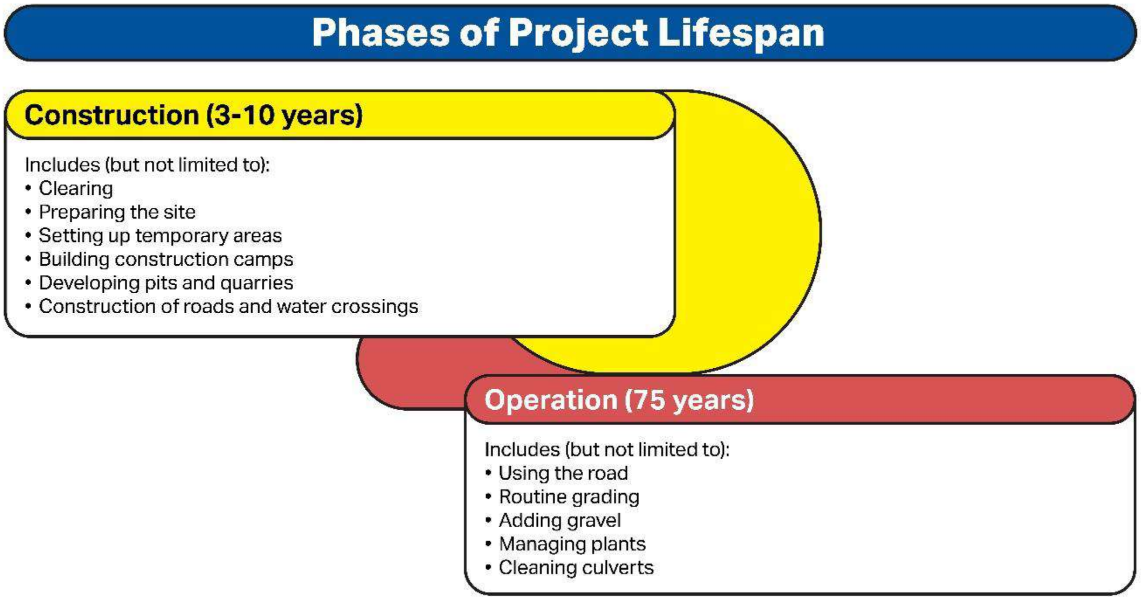
6. Assessment Boundaries

6.1 Temporal Boundaries: Project Phases

Project phases, which are temporal boundaries, are developed to establish the timeframes within which potential effects of the Project will be considered in the IS / EA Report. The Project is planned to occur in two phases, which are briefly described below and shown in **Figure 6-1**.

- **Construction Phase:**
  The time from start of construction, including site preparation activities, to the start of operations and maintenance of the CAR. Decommissioning of construction works is included in the construction phase. The construction phase is anticipated to take approximately 3 to 10 years to complete.
- **Operations and Maintenance Phase:**
  The operations and maintenance phase starts once construction activities are complete and lasts for the life of the Project. The operations and maintenance phase of the Project is considered to be 75 years based on the expected timeline for when major refurbishment of road components (e.g., bridges), is anticipated.

Figure 6-1: Project Schedule



There are currently no plans to decommission the CAR as there is no expected / known end date for its need. Therefore, future suspension, decommissioning and eventual abandonment of the CAR will not be considered in the IS / EA Report. It will be considered if and when a decommissioning or abandonment application is made for the road.

In determining the temporal boundaries, in particular the long operations and maintenance phase, consideration was given to the long-term effects on the well-being of present and future generations (Sustainability Principle #2[6]). The final temporal boundaries to be used in the IS / EA Report will be based on regulatory agency guidance, professional judgement and input received through the Project consultation process.

6.1.1 Climate Adaptation and Resiliency Assessment Temporal Boundary

Specific to the climate change impact assessment of the CAR and supporting infrastructure, two 30-year periods were defined as future time horizons to represent future climate conditions in the region for climate impact assessment during the operation phase of the CAR. One 30-year baseline historical record will be applied to the construction phase of the project and two 30-year periods centred on the 2050s (2041 – 2070) and the 2080s (2071 – 2100) will be used to assess anticipated future climate change impacts on operation and maintenance phases for the CAR.

Thirty-year periods are most often selected for climate change investigations since they represent a length of time which has been shown to adequately ‘average’ day to day weather conditions.(WMO, 2019). The 30-year period represents a balance between a long enough period to average short-term climate fluctuations, while not so long so as to include very different climate at the beginning of the period versus the end. As climate change modelling typically extends to the end of the century (year 2100), this dictates application of 30-year projection periods of 2041-2070 (aka 2050s) and 2071-2100 (aka 2080s).

6. *Sustainability Principles #2 is one of four sustainability principles included in Section 25 of the Project’s TISG as further elaborated on Section 9.7.*

6.2 Spatial Boundaries: Study Areas

6.2.1 General Information

Study areas identify the geographic extents within which potential effects of the Project are likely to occur and will be considered in the IS / EA Report. The existing conditions and potential effects are documented for three study areas selected for the Project:

- **Project Development Area (PDA):** area of direct disturbance;
- **Local Study Area (LSA):** the area where most of the direct effects of the Project are likely to occur; and
- **Regional Study Area (RSA):** the area where indirect effects of the Project are likely to occur.

The PDA encompasses the 100 metre wide CAR right-of-way (ROW), temporary construction access roads, work areas, worker camps, and pits, quarries and associated access roads. The preliminary LSA currently being considered within the scope of the ongoing provincial regulatory review process generally includes the area within 2.5 km of the centreline of Alternative 1 and Alternative 4. The preliminary study area generally allows for the documentation of existing conditions and prediction of potential environmental effects for the Project. A 5 km wide study area also allows for route refinements during development of Project design (e.g., adjustment of the alignment to avoid sensitive features).

The specific location of Project components, including the roadway, quarries, pits and temporary infrastructure, are not yet known and will be included in the IS / EA Report. While most of the Project components are expected to be located within the preliminary 5 km wide study area, benefits (e.g., reduced environmental disturbance, avoidance of sensitive features, technical considerations, concerns received through consultation) for locating Project components on lands outside of the 5 km wide study area may become known during the IA / EA process. If the need to locate Project components outside the 5 km wide study area is determined to be required or of benefit to the Project, the study area would be adjusted.

The study area for each environmental discipline may vary from the above-described general study area based on the potential for the Project to directly or indirectly affect each environmental discipline; therefore, discipline-specific LSAs and RSAs have been defined for the Project. In defining the final LSAs and RSAs, each environmental discipline will consider:

- Location and other characteristics of the environmental discipline relative to the Project;
- The anticipated extent of the potential Project effects;

- Federal, provincial, regional, and local government administrative boundaries;
- Indigenous groups listed in **Table 4-1**;
- Community knowledge and Indigenous Knowledge;
- Current or traditional land and resource use by Indigenous communities;
- Exercise of Aboriginal and Treaty Rights of Indigenous peoples, including cultural and spiritual practices; and
- Physical, ecological, technical, social, health, economic and cultural considerations.

The study areas included in this document are preliminary, covering the extent to which readily available information suggests the Project may have noticeable effects on the environment. The size, nature and location of past, present and reasonably foreseeable projects will be taken into consideration in the development of the cumulative effects assessment study area(s). The appropriate study area(s) to assess cumulative effects are dependent on the VCs predicted to have direct residual adverse effects as a result of the Project, and therefore, cannot to defined until the IS / EA Report has sufficiently advanced.

As further detailed in **Section 4**, the Proponent will continue to provide opportunities for neighbouring Indigenous communities and interested persons to provide input and inform the effects assessment, including the LSAs and RSAs.

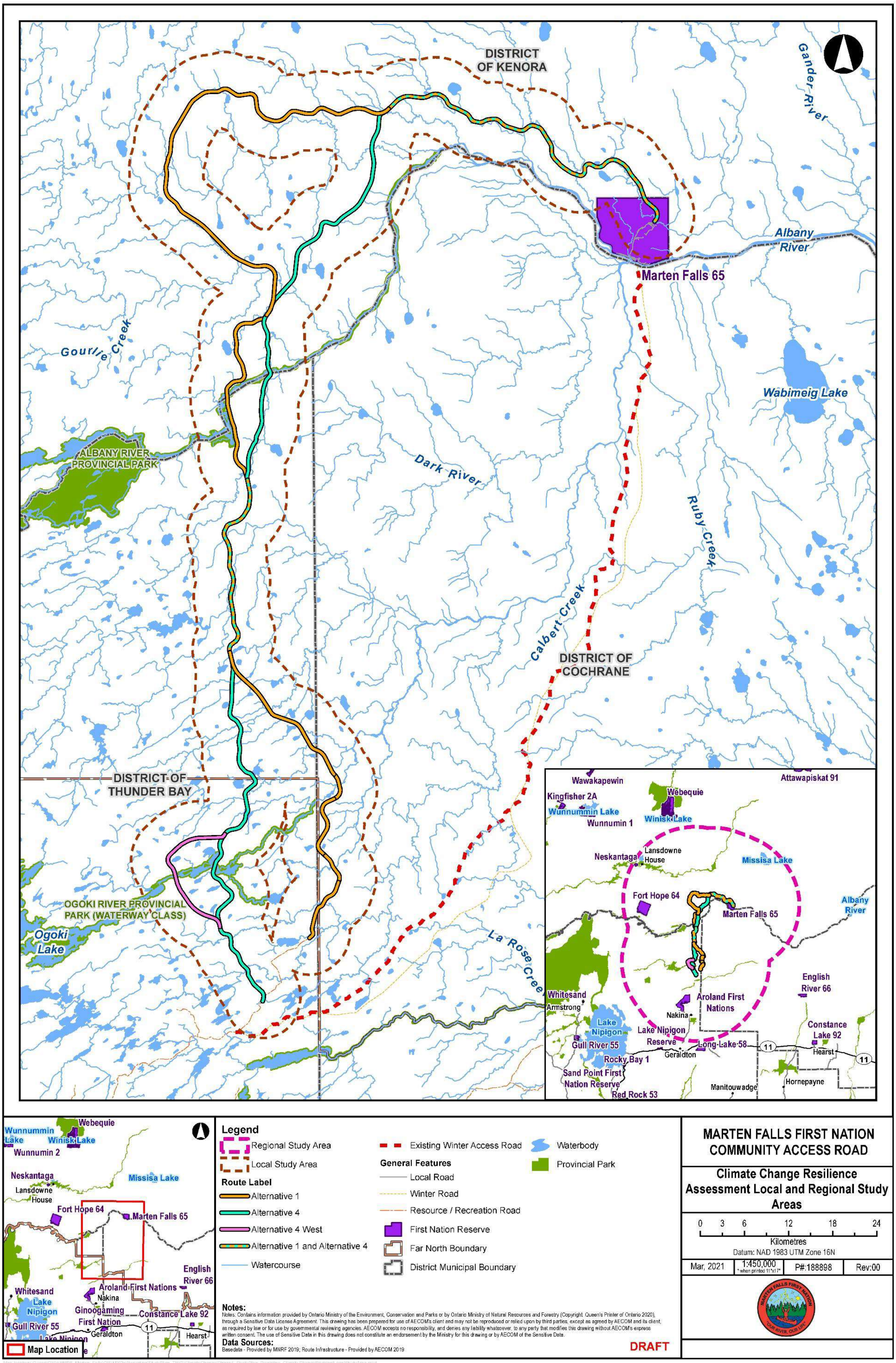
6.2.2 Climate Adaptation and Resiliency Study Areas

The LSA and RSA boundaries for the Climate Adaptation and Resiliency discipline are detailed in **Table 6-1** and shown on **Figure 6-2**.

Table 6-1: Climate Adaptation and Resiliency Impact Assessment Study Areas

Study Area	Geographic Extent	Rationale
Local Study Area	■ PDA plus a 5.0 km buffer on either side of the centreline of Alternative 1 and Alternative 4.	■ Area in which climate change effects on the Project are expected.
Regional Study Area	■ 100 km northwest of the northernmost extent of the PDA to 100 km south of southernmost point of the PDA, as shown in Figure 6-2.	■ Climate change effects on the Project are constrained to the LSA, therefore the RSA is defined based on the geographic extents from available regional climate data.

Figure 6-2: Climate Change Impacts Local and Regional Study Areas



7. Baseline Study Design

A desktop review of existing information sources will be completed to identify information gaps that will need to be addressed by further study through application of supplementary datasets. A preliminary list of applicable information sources has been included in **Appendix A** and reflects federal and provincial guidance received to date. This Study Plan focuses on the additional studies that are anticipated to be required to gather information beyond what is currently available through existing information sources, including those as described in Section 7.2 'Sources of baseline information' in the Agency's TISG for this Project.

The baseline climate conditions study will characterize the historical climate conditions resulting from analysis of the 30-year period of record from 1981 to 2010 which is the most recently vetted climate normals period. Data sufficiency will be reviewed for this period and supplementary data (described below) will be required to address identified gaps in Environment and Climate Change Canada (ECCC) weather station records. Baseline climate conditions will be defined through desktop analyses conducted on regional weather station datasets from ECCC, supplemented with CANGRD data from NRCan / ECCC.

The most recently vetted climate normals period remains defined as 1981-2010. Data for the next climate normals period beyond 1981 to 2010 (i.e. 1991 to 2020) has not yet been computed by ECCC, nor has an updated gridded dataset for Canada been initiated yet which allows for full spatial coverage between stations. Although this period is 10 years out of date, climate conditions averaged between a 30-year block of 1981 to 2010 versus 1991 to 2020 would not be expected to be significantly different. Twenty of the 30 years in the 1981 to 2010 period would be included in the newer 1991 to 2020 normals period. Depending upon the timing of the Project, it may be possible to use the new normals period for baseline conditions.

As is the case with many remote locations in Canada, the available historical record for ECCC station meteorological observations is not complete at all regional ECCC stations, with some station locations providing longer periods of data record than others. For the Climate Adaptation and Resiliency Study Area, meteorological station coverage is available from the OGOKI POST Airport station (with data from 2014 to present), the Lansdowne House station (with data record from 1942 to 1989, and 1992 to current) and the GERALDTON A station (with data record 1981 to current). The locations of these ECCC meteorological stations s are shown in **Figure 7-1**.

The climate data record at the OGOKI POST Airport station, extending from 2014 to present, is not sufficient for assessing long-term climatology. Several criteria are considered when evaluating a meteorological station for application in a regional assessment, including: completeness of data record, quality of data record, extents of missing data periods within a met station, analysis to determine if extreme values were captured in the record.

These data will require supplementation using the GERALDTON A or LANSDOWNE HOUSE station data after determining sufficient correlation between the locations.

Dillon’s climate analytics tool will be applied, which is an updated and enhanced analytics engine developed to leverage ECCC climate data and the Intergovernmental Panel on Climate Change (IPCC) AR5 datasets (IPCC 2013), by the same personnel who developed the Climate Change Hazards Information Portal (CCHIP) at Risk Sciences International. Dillon’s Climate Analytics Data Engine (CADE) is an engineering and climate data analytics processing engine tailored to specific sectors, infrastructure considerations and their climate impact thresholds. The CADE tools also obtain historical data from ECCC and Natural Resources Canada (gridded data). Daily data are available for analysis within Dillon’s CADE system, but full availability varies among stations depending on what data was originally collected at station locations.

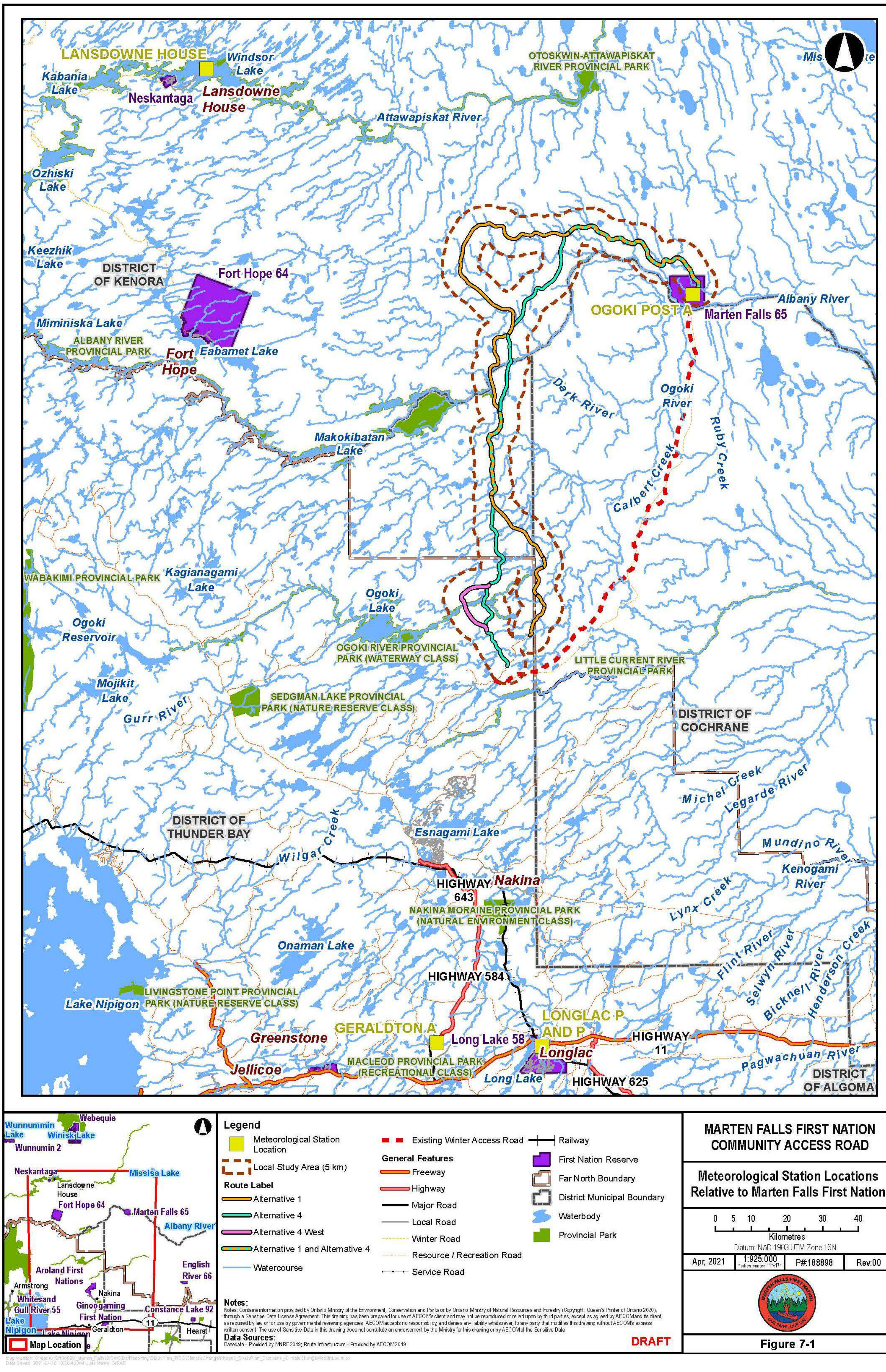
CADE currently contains daily historical data up to the end of 2018. Its analytics engine relies on the ECCC Climate Data Archive for its historical dataset, consisting of hundreds of stations over various periods of record. For regions with poor ECCC station coverage or incomplete data periods of record, data from CADE based on high-resolution (10 km by 10 km) peer-reviewed and vetted gridded observed data will be used that covers the entire Canadian landmass. This gridded dataset, known as CANGRD, was developed in a collaboration between Natural Resources Canada and ECCC. In locations where datasets are constrained, such as remote locations, CANGRD can provide an acceptable data source for climate change assessments.

Interpolated daily ECCC weather station observations and CANGRD data can be used to obtain data at 10 km x 10 km resolution and will provide historical average and climate normal conditions for the Climate Adaptation and Resiliency study area. Data collected in the ECCC archive includes variables such as:

- Temperature max / min / mean;
- Dewpoint;
- Relative Humidity;
- Humidex;
- Windchill;
- Visibility;
- Precipitation (total);
- Atmospheric Pressure;
- Wind Direction;
- Wind Speed; and,
- Wind Gusts (daily).

The results of the baseline climate assessment will be documented in a summary chapter in the Baseline Study Report which will support the development of the IS / EA Report. Within this chapter, historical climate variable values and statistical trends will be provided for the 30-year baseline record (1981-2010) specific to the RSA. Note that the effects assessment of the Marten Falls Community Access Road focuses on climate impacts on the CAR and its supporting infrastructure which are constrained to the LSA.

Figure 7-1: Meteorological Station Locations Relative to Marten Falls First Nation



8. Data Management and Analysis

Data management including quality assurance / quality control (QA / QC) will be employed to minimize potential for data entry and analysis errors, to prepare data sets for analysis, while limiting sensitive data distribution in accordance to established agreements. Climate scientists apply QA / QC routines and algorithms to identify potentially non-valid data points, and complete additional measures to confirm if outliers (i.e. data far outside the expected range) represent instrumentation errors or actual extreme values in the data sets. When data gaps require data supplementation from other sources, those sources will be identified, with the relevant methods and rationale described for their application in this study.

One 30-year baseline historical record and two 30-year periods centred on the 2050s (2041 – 2070) and the 2080s (2071 – 2100) will be used to align the assessment of climate change impacts on the Project with the design life expectations for the CAR.

Future climate projections relative to the assessment time horizons will be reviewed and historical and projected climate information will be compiled for climate factors relevant to the CAR from locations in proximity to the preferred CAR route. We will apply Dillon's Climate Analytics Data Engine (CADE) to efficiently and rapidly access credible, quality-checked (by ECCC) historical and projected climate data on relevant climate factors. The Dillon CADE Tool develops climate analytics through leveraging a large collection of datasets, including:

- Dataset of available ECCC observation stations (of various record lengths) dating back to 1900 for some stations (daily with major airport hourly);
- Dataset of observed historical gridded data for Canada (CANGRD) developed by ECCC and Natural Resources Canada (NRCan) at 10 km resolution;
- For climate projections, the full dataset of officially available IPCC AR5 (IPCC 2013) Global Climate Models (GCMs), this includes simulations from almost 40 IPCC GCMs;
- Dataset of available ECCC Intensity-Duration-Frequency (IDF) datasets from across Canada;
- Dataset of ECCC historical Canadian tornadoes; and,
- Dataset of National Building Code of Canada (NBCC) meteorological code standards from across Canada.

Descriptions of specific data sources, data collection, sampling, survey and research protocols and methods followed for each baseline environmental condition will be provided in the IS / EA Report.

9. Effects Assessment

The following sections provide discipline-specific input and considerations as they pertain to the methodology for effects assessment. The Project is in the early stage of the IS / EA Report preparation and it is expected that the effects assessment methodology will be refined iteratively based on regulatory agency guidance, professional judgment and input received through the Project consultation and engagement process.

The Climate Adaptation and Resiliency Effects Assessment will be conducted in accordance with Version 1.2 of Infrastructure Canada's *Climate Lens General Guidance* (September, 2019). For consistency with *Annex G - Methodologies and Resilience Assessment Steps* from the *Climate Lens General Guidance*, the effects assessment will assess climate change resilience of the Project using methodologies accepted by the *Climate Lens Guidance* and consistent with ISO 31000 (ISO, 2018). The *Climate Lens General Guidance* lists the Public Infrastructure Engineering Vulnerability Committee (PIEVC) Protocol (pievc.ca) as the first of several methodologies accepted as consistent with ISO 31000.

In accordance with the *Climate Lens General Guidance* we will apply a methodology that is aligned with the principles of Engineers Canada's PIEVC Protocol, ISO 31000 and Ontario's Guide for Considering Climate Change in the Environmental Assessment Process (MOECC 2017). With the proposed approach, we will conduct a Climate Change Resilience Assessment (CCRA) adhering to the *Climate Lens General Guidance* Requirements to deliver a high-level assessment that will fit with the Project impact assessment requirements. Our reporting for this assessment will include coverage of the steps typically included in Risk Assessment (Annex G: *Methodologies and Resilience Assessment Steps*, *Climate Lens General Guidance*), including: establishing context, identification of risk, analysis of identified risks, risk evaluation, and identification of recommended feasible risk treatment options. The IS / EA Report will include a description of the methodology of the effects assessment, some of which is also summarized in this Study Plan.

9.1 Valued Components and Indicators

VCs are the environmental, health, social, economic or additional elements or conditions of the natural and human environment that may be impacted by a proposed project and are of concern or value to the public, Indigenous peoples, federal authorities and interested parties (the Agency 2020b). Indicators represent the resource, feature, or issue related to the VC that, if changed, may demonstrate an effect on the environment. The indicators and rationale for selection and measurement of potential effects, to be used to assess and evaluate the alternative routes in the IS / EA Report are provided in **Table 9-1**. The table includes both quantitative and qualitative indicators. The final list of VCs and indicators to be used in the IS / EA Report will be based on regulatory agency guidance, professional judgement and input received through the Project consultation and engagement process.

The indicators were determined for this assessment of climate change effects on the Project through consideration of the CAR development's major infrastructure components, specific sub-components, environmental features and operations / maintenance considerations. The CAR Project elements and characteristics with potential sensitivity to shifts in climate and extreme weather events include:

- Road surface, shoulders, subgrade for preferred route and temporary access roads;
- Barriers, poles and signage;
- Road embankments and / or cuts;
- Slopes and natural hillsides;
- Drainage: ditches, sub-drains and culverts;
- Structures crossing streams;
- Erosion controls and river training works;
- In stream or off-channel habitat works;
- Worker camps and supporting infrastructure / services;
- Pits and quarries;
- Vegetation management;
- Invasive species: pests and plants;
- Maintenance programs;
- Works and maintenance yards;
- Communications;
- Emergency response; and,
- Staff serviceability, administration and engineering.

A final list of indicators for application in the assessment will be confirmed through:

- Consultations with government agencies, Indigenous communities and interested persons;
- Preliminary design data;
- Best Practice in climate risk assessment of road and supporting infrastructure designs; and
- Databases and climate risk assessment reporting on climate hazards, extreme weather events and impacts on transport system infrastructure.

Inputs received to date from Indigenous communities, agencies and interested persons through the Consultation and Engagement Program, including inputs received on the Draft ToR, have also been used to inform the selection of the VCs and indicators for the climate adaptation and resiliency assessment.

Table 9-1: Climate Adaptation and Resiliency Indicators

Valued Components	Indicators	Rationale for Selection
Climate Indices	■ High Temperature events: Number of days with max. temperature exceeding 30°C ■ Low Temperature events: Number of days with min. temperature below -30°C ■ Temperature Variability: Daily temperature variation exceeding a set maximum value ■ Freeze / Thaw: # days where max. temp >0°C and min. temp. <0°C ■ Frost Penetration: empirical analysis of climate conditions ■ Frost: X days where min. temperature <0°C ■ Extreme 24-hour Rainfall Intensity ■ Magnitude of severe storm-driven peak flows: determined empirically through consideration of wind speed, temp, precipitation. ■ Rain on snow events: X days or more where rain falls on snowpack ■ Freezing Rain: 1 or more days where precipitation falls as rain and freezes on contact. ■ Snowstorms / Blizzards ■ Snow frequency ■ Snow Accumulations ■ High Wind events ■ Visibility due to Fog	■ Parameters selected are variables and indices for assessment of changes to climate that are relevant to road infrastructure design and corridor routing considerations. Additional guidance: *Adapting to Climate Change – Canada's First National Engineering Vulnerability Assessment of Public Infrastructure,* (Canadian Council of Professional Engineers , 2008).
Climate Events	■ Flooding events ■ Drought ■ Wildfire ■ Pests, Invasive Species, Vegetation and Vegetation Control ■ Shifts in seasonal extents and timing	■ Climate change-driven events with potential to induce impacts to the Project and surrounding environment. Additional guidance: *Adapting to Climate Change – Canada's First National Engineering Vulnerability Assessment of Public Infrastructure"; (*Canadian Council of Professional Engineers , 2008)

9.2 Methods for Predicting Future Conditions

With respect to quantitative models and predictions, the IS / EA Report must detail the model assumptions, parameters, the quality of the data and the degree of certainty of the predictions obtained.

Climate indicators were selected on the basis of design code considerations applicable to climate conditions, supplemented by anticipated climate impact interactions for road and supporting infrastructure components in their operating environment for the Project.

Not all projected climate variables have the same certainty or reliability. One of the largest low confidence variables is extreme precipitation which is both spatially and temporally challenging even for the highest resolution regional climate models (RCMs). Some suggestions for addressing this issue are described below in the discussion on Intensity Duration Frequency (IDF). For other variables (e.g., temperature and temperature-based), there is sufficient certainty directly from modelled output, provided adequate ~~enough~~ bias-removal processes are applied. The delta approach employed using a large ensemble of model projections effectively removes any such individual model bias and provides a pure climate change signal. This signal, when applied to a reliable baseline period climate is a proven efficient and straightforward technique which requires no advanced statistical manipulation of the model output data. The key to this technique is the use of a large ensemble of model outcomes which can provide information on model sensitivities and ranges of possible projection outcomes that a single or few higher resolution models cannot. Although higher resolution RCMs are available, they are much fewer in number limiting any possible ensemble, and would carry forward any inherent bias from their driving GCM. The MFFN CAR Consultant team acknowledges that the restrictions of future climate projections are dependent on the variable being considered.

On IDF considerations, the confidence in projections for different parameters is not uniform, with greater veracity in temperature than precipitation. As a result, different approaches may be required depending upon the parameter in question. For example, a regional large-scale approach can be adequate for a climate change 'signal', whereas for short-durations, high intensity rainfall point measurements from representative locations can be more appropriate. In fact, the future projection of extremes of rainfall is an active research area with previous demonstrations of very disparate results depending upon the selection of models and methodologies. Current practice should involve the consideration of historical trends, projected 'extreme indicators' such as changes in ninety-ninth percentile precipitation, the 'Clausius-Clapeyron[7]'

7. *The Clausius-Clapeyron equation pertains to the relationship between vapor pressure and temperature of a substance (e.g., the atmosphere). By applying the equation, it can be determined that the atmosphere will hold about 7% of additional atmospheric moisture for every degree Celsius of increased temperature,*

temperature correlation which has been applied successfully, and the possible development of extreme precipitation station combinations into 'superstations'. ECCC has demonstrated in their own analyses that there are no clear trends in historical IDF station amounts even within close proximity due to the nature of these extreme events (infrequent and falling between measurement locations, short station record lengths). The MFFN CAR Project Consultant team is aware of the limitations of extreme precipitation projections in such an actively changing research field and staff have participated in writing CSA guidance on this issue. Multiple approaches for the identification of extreme precipitation and their careful interpretation versus the acceptance of a single methodology is required.

Climate change projections of temperature and precipitation for this Project will be derived from an ensemble of 40 GCMs from the most recent IPCC fifth assessment report (i.e. AR5; IPCC 2013) for the RSA. These values will be calculated from the AR5 datasets (IPCC 2013) using Dillon's Climate Analytics Data Engine (CADE) tools. Within the CADE system, projected values are generated using the "Delta Method" (IPCC-TGICA 2007), which consists of applying the average projected difference (the "delta") for a given climate parameter to the historical average or baseline value. Projections will be developed for two 30-year periods (time horizons), centred on the 2050s (2041–2070) and the 2080s (2071–2100).

An initial investigation of available point-source meteorological stations was performed for this project. In the north, station densities are quite low. Therefore, we propose to use a gridded historical temperature and precipitation dataset for continuous spatial coverage. In this case 'CANGRD' will be used which is computed by ECCC and NRCAN scientists. These datasets are available at 10 km resolution and available for all of Canada for the period of 1981 to 2010 normals period discussed above.

The ensemble of models from the most recent IPCC assessment (AR5; IPCC 2013) was downloaded directly from one of the IPCC official data warehouse websites, the US Lawrence Livermore National Laboratory (https://esgf-node.llnl.gov/search/cmip5/), which is a member of the World Climate Research Program. For the computation process, raw data are required (unprocessed) which is not the case at the Ontario Climate Data Portal (OCDP) where different baseline periods and different model assemblages were used. Therefore, the MFFN CAR Project Consultant's independent calculations using raw data will provide consistency for the Project's projected climate output.

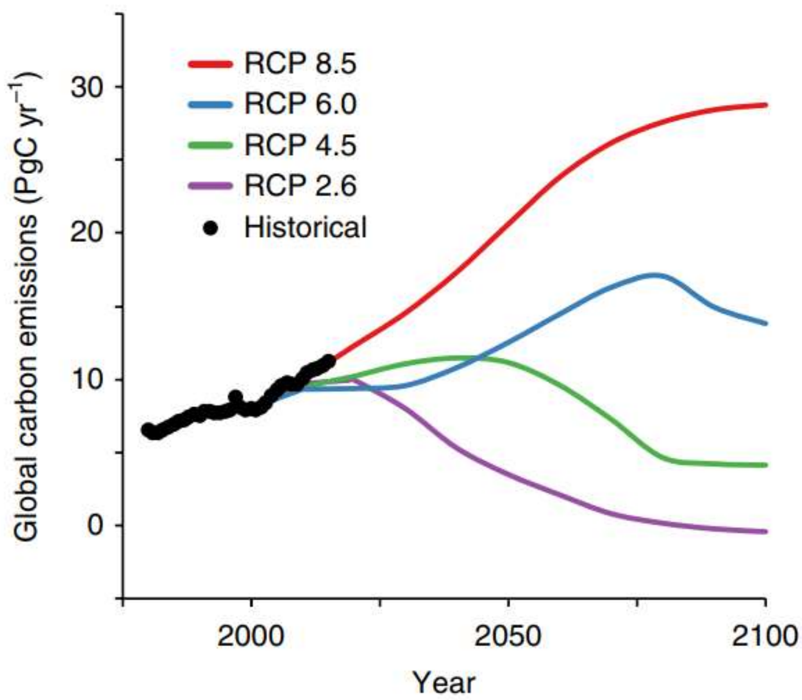
Four future global GHG concentration scenarios have been established by the IPCC (American Meteorological Society, 2012). Each of these scenarios is defined by different Representative Concentration Pathways (RCPs). The RCPs are:

1. RCP 8.5: considered the global "Business As Usual" (BAU) GHG global emissions regime. This is the current global trajectory based on current global GHG emissions;

2. RCP 6.0: GHG emissions double by 2060 and then decrease dramatically but remain above current GHG levels;
3. RCP 4.5: a medium GHG scenario derived from assumptions that global GHG emission reduction efforts result in approximately half of the emissions observed under RCP 8.5; and,
4. RCP 2.6: a scenario that aligns with global GHG emission reductions that maintain global warming below 2°C above pre-industrial global temperatures.

The IPCC's Special Report on Global Warming (IPCC 2018) confirms that global GHG emissions continue to track along the RCP 8.5 pathway. For infrastructure impact assessment, a precautionary approach is required to manage climate risks. The current trajectory of global GHG emissions corresponds with RCP 8.5. Using other RCPs would represent a scenario indicating higher reductions of global GHG emissions that current trends indicate. This assessment will accordingly apply the RCP 8.5 scenario for the projections used to anticipate future conditions. **Figure 9-1** shows a plot comparing the scenario categories and how current global GHG emissions track in comparison to the four concentration pathways.

Figure 9-1: Comparison of Historical GHG Emissions to the Four Representative Concentration Pathways (Smith and Meyers 2018)



9.2.1 Route Option Assessment for Anticipated Climate Change Impacts

Climate change impacts (construction and operations) anticipated for each of the two project alternative routes will be qualitatively assessed and compared through the application of design, routing and operational setting-based criteria.

This qualitative assessment will look at the characteristics for each of the two proposed routing alternatives and will assign a rating between 1 (poor) and 5 (excellent) to indicate the extent to which each routing option satisfies the routing option criteria.

The route evaluation criteria will be based on considerations focusing on climate-induced hazard potential along each route option. The qualitative assessment will evaluate each route and assign scored ratings for specific route criteria, as follows:

- Historical evidence of natural hazards and extreme weather events (e.g., flash flooding, prolonged flooding, ice breakup / jamming, wildfires, and drought);
- Geotechnical indicators (e.g., extent of geological hazards, problematic soil conditions, slumps and slope stabilities, collapsible silts);
- Routing characteristics and potentials for accidents and malfunctions in route construction, operation, maintenance; and
- Routing and access to lands and resources.

9.2.2 Climate Change Assessment of Two Alternative Routes

Following the route option assessment for the two alternative routes, the impact of climate change on the Project's two alternative routes will be assessed through a Climate Change Resilience Assessment (CCRA) in accordance with Infrastructure Canada's Climate Lens General Guidance v1.2 (Infrastructure Canada 2019). This CCRA will apply a blended methodology that is aligned with Engineers Canada's PIEVC assessment protocol and ISO 31000. In this CCRA methodology, a detailed, quantitative analyses will not be undertaken within this scope. The methodology proposed for this scope will be a blended, higher level, ISO 31000-consistent climate change assessment, in alignment with the principles of a PIEVC process and conforming to the guidance for proponents provided in Section 5.3.1 of Environment and Climate Change Canada's (ECCC) *DRAFT Strategic Assessment of Climate Change* (ECCC, 2019) and Ontario's Guide for Considering Climate Change in the Environmental Assessment Process (MOECC 2017). In the *Strategic*

Assessment of Climate Change document, Infrastructure Canada's Climate Lens - General Guidance (a.k.a. the *Climate Lens*; Infrastructure Canada 2019) is referenced for requirements of climate change resilience assessments. The *Climate Lens* document contains guidance indicating PIEVC as an appropriate approach in climate resilience assessment of public infrastructure. Applying this approach means the assessment will entail a blend of quantitative and qualitative methods.

PIEVC-based approaches are consistent with Infrastructure Canada's *Climate Lens Requirements for Climate Change Resilience Assessments* ()*,* which requires consistency with the principles of the ISO 31000 Risk Management Standard and consideration of future climate conditions and impacts in the process. ISO 31000 provides a generic risk management model and is an internationally recognized standard designed to accommodate any kind of risk to an organization but has been effectively customised to reflect climate risks for infrastructure developments.

This general approach will be deployed, guided by Infrastructure Canada's *Climate Lens Requirements for Climate Change Resilience Assessments* (Infrastructure Canada 2019), ISO 31000 and Ontario's Guide for Considering Climate Change in the Environmental Assessment Process (MOECC, 2017).

Indigenous Knowledge compiled through the Project Indigenous Knowledge program (**Section 5**) will be used to guide and inform the climate analytics development and the selection of project elements / considerations for the climate change risk assessment.

9.2.2.1 Component Identification

Selection and definition of preferred road route components will be guided by their importance in the CAR route design, construction, management, operation and maintenance. A CAR infrastructure component listing will be developed for the CAR corridor and its major systems including:

- Above-ground road infrastructure (road surface, bridge crossings, erosion controls, engineered stabilization works, shoulders, embankments / slopes, road signage, guardrails);
- Water crossings;
- Culverts, drainage infrastructure;
- Bridge crossing piers and abutments;
- Environmental elements (valued or designated habitats / ecosystems, vegetation management, wildlife management, in-stream habitat protection works, off-channel habitat works, sensitive species habitat and migrations) within the Climate Adaptation and Resiliency LSA; and,
- Miscellaneous Operations (seasonal maintenance, maintenance crew access, support facilities / works yards, weight restriction considerations, emergency response).

9.2.2.2 Design Code Review

A review of applicable codes, standards, criteria, including best practices and procedures for each of the identified components as available through design and operational specifications, and technical preliminary design drawings where such information is available will be undertaken. Site-specific operation requirements will also be indicated. The focus of design code review will be restricted to relevant climate parameters for the components selected for risk assessment.

9.2.2.3 Climate Data Review and Selection of Relevant Climate Parameters

Baseline historical climate (1980 to 2010) and future climate projections will be reviewed and assessed for two future time horizons. The future time horizons are selected to align with design life expectations for the CAR development and are centred on the 2050s (2041 to 2070) and the 2080s (2071 to 2100).

The Climate Analytics Data Engine (CADE) will be applied to develop historical and projected climate analytics for climate parameters relevant to the CAR and its supporting infrastructure.

Upon completion of the climate data review and assessment, a list of selected climate parameters and infrastructure indicators will be developed, and probability scores will be established for each climate change event anticipated to affect the infrastructure and its related components through adverse impacts to the functionality of the CAR system. Probability scoring will be determined in accordance with the guidance documented within the PIEVC Protocol and will be informed by output from the Dillon CADE Tools. (Dillon Climate Analytics Data Engine Tools, 2020, leveraging datasets from IPCC AR5, AR6 datasets and Environment Climate Change Canada's Observational Meteorological Station network.)

9.2.2.4 Climate Impacts Assessment

Climate impacts on the CAR system will be determined by application of climate analytics datasets, information describing the environmental setting from the biophysical assessment teams, preliminary design information and applied professional judgment and experience, informed by climate vulnerability characteristics developed for infrastructure assessments related to transportation infrastructure, drainage infrastructure, and road system operational / maintenance requirements. This information will be applied to identify interactions between climate conditions and key infrastructure components of the CAR development. Climate impacts will be determined using ISO 31000-compatible processes in alignment with the principles of PIEVC Version 10.

Climate change vulnerability assessment will be conducted using a developed set of climate analytics describing meteorological trends anticipated to result from climate change. Methods and selection of relevant climate change analytics will be documented for application in the climate vulnerability assessment and included in the climate vulnerability assessment reporting. Discussion of mitigation measures to reduce frequency, severity and consequences of projected effects will be included in the Climate change vulnerability assessment.

9.2.2.5 Risk Assessment Workshop

A one-day facilitated technical workshop will be convened to assess the magnitude of potential climate change impacts to the CAR infrastructure and key subcomponents. The workshop will include participants from teams including engineering design, biophysical specialists as well as outreach to Indigenous communities to seek their participation. The MFFN CAR Project Team will work with Indigenous communities to determine community members who would participate in this facilitated workshop.

The workshop structure will align with the principles of Step 3 (Risk Assessment) of PIEVC and will be guided by materials prepared in advance detailing climate factors and infrastructure systems with key subcomponents for the CAR development.

The workshop will start with a review and confirmation of likely climate / infrastructure component interactions as informed by the MFFN CAR Project Team. Information will be presented to workshop participants using a structured Risk Assessment Worksheet. Once potential climate interactions are verified, the workshop participants will be asked to consider and assign a Consequence Severity rating, using rating severity scales developed prior to the workshop with input from MFFN CAR Project Team specialists, for each confirmed climate / project component interaction. A Likelihood Score Rating will also be assigned using a probability (i.e. likelihood) scale defined and confirmed prior to the workshop. The default PIEVC probability / likelihood scale factor scoring is provided below in **Figure 9-2**. PIEVC allows for the use of either of these scale factor scoring methods, and PIEVC also allow for flexibility that permits assessors to develop scale factors across custom scales (e.g., 5-point scale) on the condition that such custom scales are applied consistently across the assessment.

Figure 9-2: Default PIEVC Probability / Likelihood Scale Factor Scoring

Score	Probability	
	Method A	Method B
0	Negligible Not Applicable	< 0.1 % < 1 in 1,000
1	Highly Unlikely Improbable	1 % 1 in 100
2	Remotely Possible	5 % 1 in 20
3	Possible Occasional	10 % 1 in 10
4	Somewhat Likely Normal	20 % 1 in 5
5	Likely Frequent	40 % 1 in 2.5
6	Probable Often	70 % 1 in 1.4
7	Highly Probable Approaching Certainty	> 99 % > 1 in 1.01

Score	Severity of Consequences and Effects	
	Method D	Method E
0	No Effect	Negligible Not Applicable
1	Measurable	Very Low Some Measurable Change
2	Minor	Low Slight Loss of Serviceability
3	Moderate	Moderate Loss of Serviceability
4	Major	Major Loss of Serviceability Some Loss of Capacity
5	Serious	Loss of Capacity Some Loss of Function
6	Hazardous	Major Loss of Function
7	Catastrophic	Extreme Loss of Asset

Probability X Severity = Risk

Risk Range	Threshold	Response
< 12	Low Risk	▪ No action necessary
12 – 36	Medium Risk	▪ Action may be required ▪ Engineering analysis may be required
> 36	High Risk	▪ Action required

Source: PIEVC © Engineers Canada

Risk Levels will be established for each climate / infrastructure interaction, based on the Likelihood and Severity scores confirmed by workshop participants. Identified risks will then be prioritised for development of climate change risk reduction actions.

At the conclusion of the workshop session, the MFFN CAR Project Team will have developed a full listing of climate / infrastructure interactions for the CAR development and will develop a prioritized list of risks to be included in the final reporting and recommendations resulting from the assessment.

9.2.2.6 Final Reporting: Conclusions and Recommendations

Final reporting of the climate change assessment will be prepared. The final reporting will include the development of recommendations to reduce climate vulnerabilities identified from the Risk Assessment Workshop. Risk reduction measures will be prioritized to correspond with the risk levels determined through the work completed prior to and through the completion of the Risk Assessment Workshop.

Results will be summarised in worksheets developed from the Risk Assessment Workshop. Documented discussion points on climate impact severities and potential risk reduction measures (adaptation options) will be gathered from the Workshop for processing, with details provided within a CCRA Final Report for the assessment of the CAR.

The format of the final reporting will adhere to the requirements stated in Climate Lens General Guidance Document Annex D. (Infrastructure Canada, 2019) The final reporting will also include: sections documenting the engineering vulnerabilities identified from the CCRA; recommended remedial measures to reduce these risks; and a climate overview section for the study region. Reporting will align with the suggested guidance stated in Annex D for "Table of Contents for Resilience Assessments" from the Climate Lens Guidance document issued September, 2019 (Infrastructure Canada, 2019).

9.3 Mitigation and Enhancement Measures

Residual effects, which are the effects remaining after the application of mitigation measures, will be assessed in the EA / IA process. Once potential effects have been identified, the effects assessment will explore technically and economically feasible mitigation measures to avoid or minimize the identified negative effects and enhancement measures to increase positive effects beyond those that are already inherent to the design. These measures will consist of industry-standard practices, federal and provincial standard specifications, regulator-mandated measures, best management practices, Indigenous and community recommendations and recommendations from industry and environmental professionals based on expertise, scientific publications, experience and judgement. The identification of and the assessment of the effectiveness of mitigation measures will be done as a discipline or VC-specific exercise, and will be done as part of the EA / IA.

It is important that mitigation and enhancement measures are achievable, measurable and verifiable, and monitored for compliance and effectiveness during all temporal phases as part of the Project monitoring plan. Required environmental monitoring will verify the potential environmental effects predicted in the IS /

EA Report, evaluate the effectiveness of mitigation and enhancement measures, and identify the process the Proponent will follow if mitigation and enhancement measures are not effective.

9.4 Consideration of Sustainability Principles

The sustainability assessment for the Project will be undertaken on the preferred alternative and will characterize the Project's contribution to sustainability incorporating the requirements set out in Section 25 of the TISG.

One aspect of the sustainability assessment is describing the process in selecting the preferred alternative to the Project and how the sustainability principles were considered. The effects assessment approach for the Project has included the consideration of the sustainability principles outlined in the Project TISG and the Agency's guidance on sustainability. The sustainability principles that have been considered include:

1. Consider the interconnectedness and interdependence of human-ecological systems;
2. Consider the well-being of present and future generations;
3. Consider positive effects and reduce adverse effects of the Project; and
4. Apply the precautionary principle by considering uncertainty and risk of irreversible harm.

The interconnectedness and interdependence of human-ecological systems will be considered through the assessment of potential indirect effects of each alternative. An indirect effect occurs when a change to one environmental discipline resulting from a Project activity causes a change to another environmental discipline (e.g., changes in vegetation could indirectly affect wildlife).

The well-being of present and future generations will be considered in the effects assessment through the application of the long-term operations phase temporal boundary of 75 years (**Section 7.1.1**) and through the effects characteristics description of duration and reversibility for each residual effect predicted.

The consideration of positive effects and reducing adverse effects of the Project is fundamental to the effects assessment methodology through the identification of mitigation measures to reduce potential adverse effects and the identification of the preferred alternative through the evaluation of advantages (e.g., positive effects) and disadvantages (e.g., adverse effects).

The effects assessment will apply the precautionary principle by clearly describing and documenting all uncertainties and assumptions underpinning the analysis and identifying information sources. The effects assessment will consider risk of irreversible harm through the effects characteristics description of reversibility for each residual effect predicted and will describe any uncertainty in the assessment of residual effects.

The scope of the sustainability assessment will be defined by issues of importance identified by Indigenous communities and interested persons through consultation and engagement activities, while also ensuring to be inclusive of the diversity of views expressed. The selection of VCs that will be the focus of the sustainability assessment will be aligned with the issues of importance identified by Indigenous communities and interested persons, as well as residual effects identified through the effects assessment process. The sustainability assessment will describe how the planning and design of the Project, in all phases including follow-up monitoring, considered the sustainability principles.

9.5 Consideration of Identity and Gender-Based Analysis Plus in Effects Assessment

The Proponent recognizes that communities and sub-populations within those communities may be impacted differently by the Project with respect to VCs and indicators. As such, the Project aims to collect baseline information for the purpose of assessing differential effects and establishing relevant mitigation measures, as further elaborated on in **Section 4.3**. Gender-Based Analysis Plus will not be limited to community feedback, when offered or discussed in secondary texts, additional sub-population information as is applicable to the relevant assessment will be incorporated.

9.6 Follow-up Programs

A follow-up program verifies the accuracy of the effects assessment and evaluates the effectiveness of mitigation measures. Identification of follow-up programs for the Project are not described in this study plan as the information needed to determine environmental monitoring requirements is dependent on the outcome of the effects assessment and consultation with Indigenous communities, agencies and interested persons. Therefore, the Proponent will include information on follow-up programs, that address the requirements outlined in Section 26 of the TISG, in the IS / EA Report and will identify the compliance and effects monitoring activities to be undertaken during all phases of the Project, as required.

10. Assumptions

Any assumption used in the effects assessment, for example the assumed average daily traffic on the CAR, will be clearly identified and a rationale provided in the IS / EA Report.

Assumptions used in the effects assessment are summarized below:

- Traffic counts and other data will be derived from preliminary design data and the Project's formal project description document.
- Indigenous knowledge collected through the engagement with traditional territories in the vicinity of the Project will be available for consideration alongside background data collected and used to inform the effects assessment, where available.
- Construction Phase of the CAR project, including decommissioning of construction works will be conducted over a period of 3-10 years.
- Operations and Maintenance Phase of the CAR project begins once construction activities are complete and lasts for the life of the Project. The operations and maintenance phase of this project is assumed to be 75 years, based on the expected timeline for when major refurbishment of road components is anticipated.
- Assumption that no decommissioning is planned for the constructed CAR, therefore decommissioning is not considered in the IS / EA report.
- 30-year periods are selected for climate change investigations and this assessment will apply the 30-year "climate normal" period established by the World Meteorological Association. This dictates application of 30-year projection periods of 2041 to 2070 ("the 2050s") and 2017 to 2100 ("the 2080s"). Historical 30-year baseline will be defined by the most recently vetted climate normals period remains defined as 1981 to 2010. Data for the next climate normals period of 1991 to 2020 has not yet been computed by ECCC, nor has an updated gridded dataset for Canada been initiated yet which allows for full spatial coverage between stations.
- Development of climate analytics will be based upon ECCC climate data archive and the Intergovernmental Panel on Climate Change (IPCC 2013) AR5 datasets (IPCC 2013). For regions with poor ECCC station coverage or incomplete data periods of record, data from CADE based on high-resolution (10 km by 10 km) peer-reviewed and vetted gridded observed data that covers the entire Canadian landmass will be used. This gridded dataset, known as CANGRD, was developed in a collaboration between Natural Resources Canada and ECCC. In locations

where datasets are constrained, such as remote locations, CANGRD can provide an acceptable data source for climate change assessments.

- Historical climate variable values and statistical trends will be provided for the 30-year baseline record (1981-2010) specific to the RSA.
- Quantitative and qualitative indicators have been established for the resilience assessment of the Project, these indicators were established through consideration of the CAR's major infrastructure components and sub-components, environmental features and operations/maintenance considerations. A final list of indicators for application in the climate risk assessment will be confirmed through consultation with government agencies, and indigenous community stakeholders.
- Climate indicators were selected through assumption of design code considerations applicable to climate conditions, supplemented by anticipated climate impact interactions for road and supporting infrastructure components in their operating environment for the Project.
- Climate change projections of temperature and precipitation for this project will be derived from an ensemble of 40 GCMs from the most recent IPCC Fifth assessment report (AR5; IPCC 2013).
- RCP selection assumptions: For infrastructure impact assessment, a precautionary approach is required to manage climate risks. The current trajectory of global GHG emissions corresponds with RCP 8.5 and accordingly, this assessment considers impacts anticipated from selecting an RCP in alignment with current global GHG global trends. Using other RCPs would represent a scenario indicating higher reductions of global GHG emissions that current trends indicate.
- Climate data assumptions: baseline historical climate (1980-2010) and future climate projections will be reviewed and assessed for two future time horizons. The future time horizons are selected to align with design life expectations for the CAR development and are centred on the 2050s (2041-2070) and the 2080s (2071-2100).

11. Concordance with Federal and Provincial Guidance

This section provides the best information currently available on how federal and provincial requirements identified for the Project to date will be addressed. The final concordance with federal and provincial requirements will be included in the IS / EA Report, and will be based on regulatory agency guidance, professional judgement and input received through the Project consultation and engagement process.

Table 11-1: Study Plan Federal Concordance – Conformance with Requirements

ID #	Federal TISG Reference[8]	Requirement / Comment / Concern	Response	Study Plan Reference
1	TISG Section 1.1, page 4	■ The Guidelines correspond to factors to be considered in the impact assessment. These factors are listed in subsection 22(1) of IAAC and prescribe that the impact assessment of a designated project must take into account any change to the designated project that may be caused by the environment;	■ The potential effects of the project on the Climate and the potential effects of the environment on the project will be assessed in accordance with applicable standards and guidance.	■ Section 9 ■ Atmospheric Environment and Greenhouse Gasses Study Plan
2	TISG Section 13, pages 80-83	■ This section of the TISG describes the methodology for the effects assessment, including definitions of scope, severity, and irreversibility.	■ The IS / EA Report will include a description of the methodology of the effects assessment, some of which is also summarized in this Study Plan.	■ Section 9
3	TISG Section 15.4, page 96	■ Use population-level modelling to assess the effects of proposed disturbance on caribou at the scale of federal range boundaries and provincial range boundaries. Increases in predation caused mortality rates need to be considered as do the anticipated exacerbating effects of climate change	■ Climate analytics will be used in the assessment of impacts to caribou populations, including impacts on caribou resulting from climate change.	■ Ungulates Study Plan
4	TISG Section 2.3, pages 6-7	■ The description should focus on aspects of the Project and its setting that are important in order to understand the potential environmental, health, social and economic effects and impacts of the Project. The following information must be included and, where appropriate, located on map(s): – geographic co-ordinates (i.e., longitude/latitude using international standard representation in degrees, minutes, seconds) for the beginning and end points of the proposed road; – current land and/or aquatic uses within the study areas; – distance of the project components to any federal lands and the location of any federal lands within the study areas; – all waterbodies and their location on a map; – navigable waterways; – the environmental significance and value of the geographical setting in which the Project will take place and the study areas; – environmentally sensitive areas, such as national, provincial, territorial and regional parks, UNESCO World Heritage Sites, geological heritage sites, ecological reserves, ecologically and biologically sensitive areas, wetlands, and habitats of federally or provincially listed species at risk and other sensitive areas; – Dedicated Protected Areas3 and any other areas of ecological and social significance identified by the community during the community-based land use planning processes with the Province of Ontario (e.g., Enhanced Management Areas; see Section 6.1 for requirements related to confidentiality); – lands subject to conservation agreements; – current mineral development proposals, and areas of early and advanced mineral exploration in the study areas; – current areas of aggregate extraction; – description and locations of all potable drinking water sources (i.e., municipal or private), including spring water sources ; – description of local communities and Indigenous groups that is culturally relevant and gender sensitive; – if the information is not confidential, provide a description and location of Indigenous traditional territories and/or consultation areas, Treaty and/or Title lands, Indian Reserve lands, Indigenous harvesting regions (with permission of Indigenous groups), Métis settlements; and – culturally important features of the landscape.	■ The information related to landscape features, sensitive or protected areas and select others listed in the TISG will be illustrated on maps and / or described within the IS / EA Report, where appropriate.	■ Section 6.2.1
5	TISG Section 20, page 119-128	■ Section 20 of the TISG describes the requirements around mitigation and enhancement measures that must be considered in the Impact Statement.	■ Identification of and assessment of effectiveness of impact management measures will be done as a discipline or VC-specific exercise, and will be done as part of the IA / EA.	■ Section 9.4

8. Federal TISG Reference should be the Section or subsection, page etc. that clearly identifies where comment/issue we are addressing can be found (ex. Section 8.1 of TISG)

ID #	Federal TISG Reference[8]	Requirement / Comment / Concern	Response	Study Plan Reference
6	TISG Section 21, pages 129-130	■ Section 21 of the TISG describes the requirements and guidance associated with determining residual effects.	■ Residual effects will be assessed in the IA / EA.	■ Section 9.4
7	TISG Section 22, pages 131-133	■ Section 22 of the TISG describes the guidance around conducting cumulative effects assessment for the project.	■ Cumulative effects assessment will be conducted as part of the IA / EA.	■ Section 6.2.1
8	TISG Section 23.2, page 136	■ Identify the Project's sensitivities/vulnerabilities to change in climate (both in mean conditions and extremes such as short-duration heavy precipitation events), describe climate resilience of the Project and how climate change effects have been incorporated into the Project design (e.g., water crossings) and planning over the lifetime of the Project and describe the climate data, projections used, and related information used to evaluate these sensitivities (i.e., risks) over the full project lifetime;	■ A climate vulnerability assessment will be conducted on the Project using climate analytics describing historical (baseline) and projected (future) climate. Analytics will include consideration of means and extremes. Assessment of climate change will include descriptions of how climate change effects have been incorporated into Project design and planning over the life cycle of the Project. Descriptions of the climate data, projections used and methods to evaluate risks will be documented.	■ Section 9.2.2.4
9	TISG Section 23.2, page 136	■ Describe any identified trends in meteorological events, weather patterns, or physical changes to the environment that are anticipated to result from climate change (for example, changes to annual freeze-thaw cycles, water levels, break-up season and spring freshet), and incorporate this information in a risk assessment as contributing and complicating factors for possible accidents and malfunctions. Provide mitigation measures (both passive and active) that the proponent is prepared to undertake in order to minimize the frequency, severity and consequences of such projected effects;	■ A climate change vulnerability assessment will be conducted using a developed set of climate analytics describing meteorological trends anticipated to result from climate change. Methods and selection of relevant climate change analytics will be documented for application in the climate vulnerability assessment and included in the climate vulnerability assessment reporting of findings. Discussion of mitigation measures to reduce frequency, severity and consequences of projected effects will be included in the climate change vulnerability assessment.	■ Section 9.2.2.4
10	TISG Section 23.2, page 136	■ When describing possible effects from climate change on the Project, describe how considerations from Indigenous peoples on climate change may impact the Project were considered	■ Indigenous knowledge collected through engagement with traditional territories in the vicinity of the Project will be considered alongside background data collected and used to inform the effects assessment where applicable.	■ Section 2.1.1
11	TISG Section 26, Page 141	■ Section 26 of the TISG includes a description of the considerations for developing a follow-up program for environmental, health, social or economic effects, as applicable.	■ The IS / EA Report will include descriptions of follow-up programs, as required by VC.	■ Section 9.5
12	TISG Section 5.1, page 22	■ Any proposed mitigation measures are to be clearly linked, to the extent possible, to valued components in the Impact Statement as well as to specific project components or activities, as well as comments raised during engagement activities	■ Measures to reduce climate impact (adaptations) in design will be assessed for potential impacts to valued components and linkages to VCs will be documented in the IS / EA Report. Mitigation measures related to GHG emissions will be addressed in the Atmospherics Environment and Greenhouse Gasses Study Plan.	■ Atmospherics Environment and Greenhouse Gasses Study Plan
13	TISG Section 7.1, page 30	■ If the baseline data have been extrapolated or otherwise manipulated to depict environmental, health, social and/or economic conditions within the study area, modelling methods must be described and must include assumptions, calculations of margins of error and other relevant statistical information. Models that are developed should be validated using field data from the appropriate local and regional study areas. Ensure baseline data are representative of project site conditions. If surrogate data from reference sites are used rather than site-specific surveys, the proponent should demonstrate that the data are representative of project site conditions.	■ Methods for collecting, validating and analyzing data are described in this Study Plan.	■ Section 8
14	TISG Section 7.2, page 32	■ The Impact Statement must provide detailed descriptions of specific data sources, data collection, sampling, survey and research protocols and methods followed for each baseline environmental, health, social and economic condition that is described, in order to corroborate the validity and accuracy of the baseline information collected.	■ Descriptions of specific data sources, data collection, sampling, survey and research protocols and methods followed for each baseline environmental condition will be provided in the IS / EA Report and are summarized in this Study Plan.	■ Section 8

ID #	Federal TISG Reference[8]	Requirement / Comment / Concern	Response	Study Plan Reference
15	TISG Section 7.2, page 33	■ Baseline data must be collected in a manner that enables reliable analysis, extrapolations and predictions. Resulting data should be suitable for analyses to estimate pre-project baseline conditions, derive predictions of impacts, and evaluate and compare post-project conditions and at scales of within and across the Project, Local and Regional Assessment areas. Modelling methods, error estimates and assumptions should be reported (as per section 7.1). Modelling and simulations should be used early in the planning phase to estimate the necessary sampling intensity and to quantitatively evaluate the effectiveness of design options. Ethical guidelines and relevant cultural protocols governing research, data collection and confidentiality must be adhered to.	■ Descriptions of specific data sources, data collection, sampling, survey and research protocols and methods followed for each baseline environmental condition will be provided in the IS / EA Report and are summarized in this Study Plan.	■ Section 8
16	TISG Section 7.2, page 33	■ If using existing data sources, the Impact Statement must provide justification to show that the data sources are relevant in spatial and temporal coverage to the Project. Some data sources may have good coverage in Southern Ontario or existing road networks but be unsuitable as a baseline for these northern areas where there are not roads.	■ Justification for using existing data sources will be provided in the IS / EA Report.	■ Section 8
17	TISG Section 7.2, pages 31-33	■ Information sources and data collection methods used for describing the baseline environmental, health, social and economic setting may consist of the following sources of information. For specific sources of baseline information, see Appendix 1. – Federal government (e.g., Environment and Climate Change Canada, Health Canada, Indigenous Services Canada, Statistics Canada, Women and Gender Equality Canada); – Ontario provincial government (e.g., Ministry of Environment, Conservation, and Parks, Ministry of Natural Resources and Forestry; – Bird Conservation Region plans21; – academic institutions; – field studies, including site-specific survey methods; – database searches, including: – federal, provincial, territorial, municipal and local data banks; – Breeding Bird Atlas - Ontario (2001-2005) – monitoring program databases protected areas, watershed or coastal management plans; – natural resource management plans; – species recovery and restoration plans; – field measurements to gather data on ambient or background levels for air, water, soil and sediment quality, light levels or acoustic environment (soundscape); – land cover data, including: • terrestrial ecosystem mapping products; • forest cover maps; • remote sensing resources; • important habitats and features to include: ▪ water bodies, wetlands, watercourses; ▪ riparian habitat; ▪ river banks or other eroded habitats; ▪ artificial water sources; ▪ forest, tree patches, solitary trees (especially old decaying trees); ▪ forest edges and tree rows; ▪ ridges, including eskers; ▪ caves and mines; ▪ cliffs, rock outcrops, exposed bedrock, talus, and other karst topography; ▪ buildings, bridges, and other anthropogenic features, including linear features; ▪ sources of artificial lighting attracting insects; ▪ critical habitat; and ▪ any other habitat features known to be important in the area.	■ Information sources, relevant to the Project and area, will be examined as part of the desktop review, as summarized in the Study Plan.	■ Section 7.1

ID #	Federal TISG Reference[8]	Requirement / Comment / Concern	Response	Study Plan Reference
		– Published literature, such as peer reviewed journals, reports by think tanks, non-government organizations and government reports; – environmental assessment documentation, including monitoring reports, from prior projects in the area and similar projects outside the area; – regional studies, project assessments and strategic assessments; – renewable harvest data; – Indigenous knowledge, including oral histories and knowledge gathered by spending time on the land with knowledge holders; – community based monitoring and studies conducted by Indigenous communities; – expert, community, public and Indigenous engagement and consultation activities, including workshops, meetings, open houses, surveys; – qualitative information gathered from interviews, focus groups or observation; – census data; – baseline human health risk assessments; – community and regional economic profiles; – community well-being studies; and – statistical surveys, as applicable.		
18	TISG Section 7.4.1, page 36	■ For valued components establish three study area spatial boundaries to assess impacts to each valued component: 1) Project Study Area: defined as the project footprint for each alternative route; 2) Local Study Area: defined for each valued component – see below; 3) Regional Study Area: defined for each valued component – see below ■ Provide a rationale for boundaries of the project study area, local study area, and regional study area for each valued component and indicate how the above objectives were met in establishing the boundaries.	■ Geographic extent, and the extent rationale, of the Project, Local, and Regional Study Areas for this VC are provided in this Study Plan.	■ Section 6.2.1
19	TISG Section 7.4.1, pages 35-36	■ The Impact Statement must describe the spatial boundaries, including project, local and regional study areas, for each valued component included in assessing the potential adverse and positive environmental, health, social and economic effects of the Project and provide a rationale for each boundary. Spatial boundaries are defined taking into account the appropriate scale and spatial extent of potential effects and impacts of the Project; community knowledge and Indigenous knowledge; current or traditional land and resource use by Indigenous groups; exercise of Aboriginal and Treaty rights of Indigenous peoples, including cultural and spiritual practices; and physical, ecological, technical, social, health, economic and cultural considerations. The size, nature and location of past, present and foreseeable future projects and activities are factors that should be included in the definition of spatial boundaries. It should be noted that in some cases, spatial boundaries might extend to areas outside of Canada. These transboundary spatial boundaries should be identified where transboundary effects are expected.	■ Geographic extent, and the extent rationale, of the Project, Local, and Regional Study Areas for this VC are provided in this Study Plan.	■ Section 6.2.1
20	TISG Section 7.4.2, page 37	■ The temporal boundaries of the impact assessment span all phases of the Project determined to be within the impact assessment. If potential effects are predicted after project decommissioning or abandonment, this should be taken into consideration in defining specific boundaries. In order to assess a project's contribution to sustainability, consideration should be given to the long-term effects on the well-being of present and future generations. When defining temporal boundaries, the proponent should consider how elements of environmental, health, social and economic well-being that local communities, including municipalities, and Indigenous groups identify as being valuable could change over time.	■ Temporal boundaries for the climate adaptation and resiliency assessment for the CAR infrastructure will be used to align the assessment of climate change impacts on the project with the design life expectations for the CAR route.	■ Section 8

Table 11-2: Study Plan Provincial Concordance – Conformance with Requirements

ID	Comment From Regulatory Agency	Comment Type	Requirement / Comment / Concern	Response	Study Plan Reference
1	MECP	■ Email from Agni Papageorgiou & Sasha McLeod, Special Project Officer Environmental Assessment Services Section, Ministry of the Environment, Conservation and Parks with comments of the Draft ToR	■ Ontario has a Guide for Consideration of Climate Change in EA, 2017, which should be used in the proponent's climate change-related assessment. Please add to these sections (of the Draft TOR) that the climate change guide will be used in the preparation of climate change-related assessments for the EA, including both climate change risk assessment and mitigation of climate change.	■ Climate change risk assessment of impacts on the project will be based on ISO 31000 principles and consistent with Infrastructure Canada's Climate Lens Requirements Guidance (2019) and Ontario Provincial Guidance on Climate Change (2017).	■ Section 9
2	MECP	■ Email from Agni Papageorgiou & Sasha McLeod, Special Project Officer Environmental Assessment Services Section, Ministry of the Environment, Conservation and Parks with comments of the Draft ToR	■ #17 Section 8 Page 54 – Consultation on Assessment Methodology - MFFN acknowledges that the proposed methodology will be open to input during the draft ToR review, but also says a more detailed method will be presented in the EA. Page 47 indicates the effects assessment criteria will be developed during the EA. While it is appropriate to defer some detailed work planning to the EA phase, the ToR should include commitments for how technical reviewers, and other interested persons, will be consulted during the development of specific evaluation methodologies or technical work plans. It is strongly recommended that those opportunities for review occur prior to the completion of studies (e.g., prior to the submission of a draft or final EA document).It is not clear whether MFFN plans to consult on the more detailed methodology and criteria during the EA phase or if the ToR phase is the main opportunity to provide input. – Please indicate how consultation on the ToR has informed the preliminary criteria and indicators. Please clarify when MFFN will consult and provide opportunity for input on the detailed assessment method, including criteria and indicators (and work plans as MECP has proposed), with agencies, communities and stakeholders during the EA phase in order to finalize the methodologies before EA studies get advanced.	■ This Study Plan will be reviewed by relevant federal and provincial agencies. Engagement will occur to confirm criteria applied in the climate impacts assessment, and will take place prior to execution of the climate vulnerability assessment methodology.	■ Section 4.4
3	MECP	■ Email from Agni Papageorgiou & Sasha McLeod, Special Project Officer Environmental, MECP Assessment Services Section, Ministry of the Environment, Conservation and Parks with comments of the Draft ToR	■ Assessment Methods – For the most part, section 7.2 provides a description of potential environmental effects for each discipline. However this section also includes assessment methodologies for some subsections (7.2.1 and 7.2.2 AERMOD modelling, quantitative noise assessment) while the majority do not (7.2.3 – 12). The level of detail in the ToR about assessment methods should be consistent for all environmental components. It is strongly recommended to include commitments to develop work plans at the outset of the EA phase, including opportunities for technical review by agencies and others. The work plans should include assessment methodology appropriate for each environmental component. The ToR could include a high level summary table for each environmental discipline listing data collection and assessment methods, with a commitment to develop the work plans at the outset of the EA phase to provide more details. Consider where the information about air and noise modelling is best placed.	■ Methodology concerning data collection (including desktop and field-based, where appropriate) are summarized in this Study Plan.	■ Section 7, Section 8
4	MECP	■ Email from Agni Papageorgiou & Sasha McLeod, Special Project Officer Environmental, MECP Assessment Services Section, Ministry of the Environment, Conservation and Parks with comments of the Draft ToR	■ #16 Section 8 Page 54 – Work Plans - Section 8 describes the approach that will be taken to evaluate alternative methods during the EA, including proposed criteria and indicators (presented in Appendix A). The information presented is high level and does not provide an opportunity for technical review of the methodologies that will be applied to evaluate those specific criteria and indicators. – It is strongly recommended to include commitments to develop work plans at the outset of the EA phase, including opportunities for technical review by agencies and others.	■ The Study Plan meets this requirement	■ Section 9

ID	Comment From Regulatory Agency	Comment Type	Requirement / Comment / Concern	Response	Study Plan Reference
5	MNRF	■ Letter received from Dave Barker, Resources Management Supervisor, Nipigon District, MNRF on the Draft Terms of Reference	■ Sec. 14 - References 85+ Additional resources from: – Catalogue of natural resource scientific and technical publications. Search a list of the scientific and technical publications issued since 2004 see Catalogue-natural-resource-scientific-and-technical-publications – To request a publication issued by the Ministry of Natural Resources and Forestry, or if you have a question related to MNRF scientific and technical publications, please contact us by email with the title of the publication. For journal articles, please contact the journal publisher directly. – For MNRF climate change publications see MNRF_Climate_Change_Publications – Information about Ontario's species of conservation concern, plant communities, wildlife concentration areas and natural areas see https://www.ontario.ca/page/get-natural-heritage-information – Ontario Geohub https://geohub.lio.gov.on.ca/ provides spatial data and mapping applications such as OFAT (Ontario Flow Assessment Tool) that is used to better understand water flow in Ontario. https://www.ontario.ca/page/watershed-flow-assessment-tool – Some selected publications that may be of interest: • Wester, M.C. et al. 2018. The Ecosystems of Ontario, Part 2: Ecodistricts. Ontario Ministry of Natural Resources and Forestry, Science and Research Branch, Peterborough, ON. Science and Research Technical Report TR-26. 474 p. + appendices Catalogue-natural-resource-scientific-and-technical-publications • Ontario Ministry of Natural Resources and Forestry. 2019. Far North Information Knowledge Management Plan Progress Report 2008-2018. Ontario Ministry of Natural Resources and Forestry, Far North Branch, Peterborough, ON. 80p. contact: farnorthfeedback@ontario.ca • Riley, J. 2011. Wetlands of the Hudson Bay Lowland: An Ontario Overview. Nature Conservancy of Canada, Toronto ON 156 pp. ISBN 978-1-897386-27-9 link • Marshall, T.R. and Jones, N.E. 2011. Aquatic ecosystems of the Far North of Ontario state of knowledge. Ontario Ministry of Natural Resources.43 p.+ appends. ISBN 978-1-4435-6512-7 Catalogue-natural-resource-scientific-and-technical-publications • Metcalfe, R.A. et al., 2013. Aquatic Ecosystem Assessments for Rivers. Science and Research Branch, Ministry of Natural Resources, Peterborough, Ontario. 210 pp.link	■ Descriptions of specific data sources, data collection, sampling, survey and research protocols and methods followed for each baseline environmental condition will be provided in the IS / EA Report and are summarized in this Study Plan.	■ Section 7 ■ Section 8 ■ Appendix A
6	MNRF	■ Letter received from Dave Barker, Resources Management Supervisor, Nipigon District, MNRF on the Draft Terms of Reference	■ Draft Criteria and Indicators for Alternatives Evaluation Appendix A – Available resources to help inform the draft criteria and indicators include research publications and expert knowledge on topics such as stressor-effects pathways, cumulative effects, and associated environmental components and indicators. – Contacting researchers such as Rob Mackereth (MNRF) who has published research on these topics and related subjects is encouraged. – Rempel, R.S., et al. 2016. Support for development of a long term environmental monitoring strategy for the Ring of Fire area. Ontario Ministry of Natural Resources and Forestry, Science and Research Branch, Peterborough, ON. Science and Research Information Report IR-08. 34 p. + append. Catalogue-natural-resource-scientific-and-technical-publications – While no specifics are provided in this submission, MNRF welcomes a discussion with MECP and ENDM to explore what (if any) role this project could play in advancing baseline information and long-term environmental monitoring for the Ring of Fire in partnership with First Nations communities.	■ Data sources are being reviewed for their appropriateness and will be included in Study Plans where applicable. Information on specific data sources and their relevance to the Project will be included in the IS / EA Report.	■ Section 7 ■ Appendix A
7	MNRF	■ Letter received from Dave Barker, Resources Management Supervisor, Nipigon District, MNRF on the Draft Terms of Reference	■ A climate change risk assessment is proposed along with estimating greenhouse gas emissions and sampling peatlands. Referencing available literature and contacting researchers such as Jim McLaughlin and Maara Packalen (MNRF) who have published research on these topics and related subjects is encouraged. Suggest contacting researchers such as Jim McLaughlin (MNRF) and Maara Packalen (MNRF) who have published research on climate change - vulnerability assessment, peatland carbon modelling and hydrology.	■ This information will be incorporated into the climate change assessment component for the Project. There is limited soil investigation, which includes peat probing, as part of our field investigations described in the Peatlands Study Plan to support the baseline characterization of the Project area.	■ Section 9.2

ID	Comment From Regulatory Agency	Comment Type	Requirement / Comment / Concern	Response	Study Plan Reference
8	MECP	■ Completeness Review Memorandum compiled from MECP emails and August 2019 meetings with MECP and ENDM	■ Study areas are missing and lack clarity – maps show study area for 4 routes even though only 2 (or 1?) routes are proposed to be assessed; no indication of local and regional study areas for each environmental component (e.g., groundwater, surface water, caribou, etc.).	■ A preliminary study area for the IA / EA is identified in Section 7.1.1 of the Draft ToR. The study area maps have been revised to include the area within 2.5 km of the centre line of Alternative 1 and Alternative 4 only. Although the Draft ToR identifies one preliminary study area for the IA / EA, it is understood that the study area for each environmental component may vary to capture the area within which environmental effects are anticipated to occur. Therefore, the ToR indicates that the study area will be refined in the IA / EA through identification of discipline-specific local and regional study areas. The local and regional study areas will be consulted on with MFFN community members, neighbouring Indigenous communities and other interested persons. Study areas are included in the EA Consultation Plan under the key milestone “Evaluation Criteria and Development of Alternatives”. ■ Section 9.2.1 describes the detailed climate vulnerability assessment for two proposed route options.	■ Section 9.2.1

12. References

AECOM Canada Ltd., 2020:

Marten Falls First Nation Proposed Terms of Reference Marten Falls Community Access Road – Environmental Assessment, Appendix B: Consultation & Engagement Plan to Support the Environmental Assessment / Impact Statement.

Bulletin of the American Meteorological Society, 2012:

An Overview of CMIP5 and the Experiment Design, Bulletin of the American Meteorological Society, 93, 485-498. Taylor, K.E., Stouffer, R.J., Meehl, G.A. (2012).

Canadian Council of Professional Engineers, 2008:

Adapting to Climate Change – Canada's First National Engineering Vulnerability Assessment of Public Infrastructure. https://pievc.ca/wp-content/uploads/2020/12/adapting_to_climate_change_report_final.pdf

Environment and Climate Change Canada (ECCC), 2019:

DRAFT Strategic Assessment of Climate Change. https://www.strategicassessmentclimatechange.ca/9529/documents/17911

Impact Assessment Agency of Canada (The Agency), 2019:

Impact Assessment Act. https://laws-lois.justice.gc.ca/eng/acts/I-2.75/

Impact Assessment Agency of Canada (The Agency), 2020:

Public Participation Plan for the Marten Falls Community Access Road Project Impact Assessment. https://iaac-aeic.gc.ca/050/documents/p80184/133934E.pdf

Impact Assessment Agency of Canada (The Agency), 2020a:

Indigenous Partnership and Engagement Plan for the Marten Falls Community Access Road Project Impact Assessment. https://iaac-aeic.gc.ca/050/documents/p80184/133936E.pdf

Impact Assessment Agency of Canada (They Agency), 2020b:

Glossary of Terms for the impact assessment of designated projects under the IAA. https://www.canada.ca/en/impact-assessment-agency/services/policy-guidance/glossary-of-terms.html

Impact Assessment Agency of Canada (The Agency), 2020c:
Tailored Impact Statement Guidelines for the Marten Falls Community Access Road Project. https://iaac-aeic.gc.ca/050/documents/p80184/133937E.pdf

Infrastructure Canada, 2019:
Climate Lens General Guidance, Version 1.2. https://www.infrastructure.gc.ca/pub/other-autre/cl-occ-eng.htmln

Intergovernmental Panel on Climate Change (IPCC), 2013:
IPCC Fifth Assessment Report (AR5). https://www.ipcc.ch/report/ar5/syr/

International Standards Association, 2018:
ISO 31000 – Risk Management Guidelines

IPCC-TGCIA, 2007:
General Guidelines on the use of scenario data for climate impact and adaptation assessment. Version 2. Prepared by T.R. Carter on behalf of the Intergovernmental Panel on Climate Change, Task Group on Data and Scenario Support for Impact and Climate Assessment.

IPCC, 2018:
Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland, 32 pp.

McKenney, D.W. et al., 2011:
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Ontario Guide for Considering Climate Change in the Environmental Assessment Process. https://www.ontario.ca/page/considering-climate-change-environmental-assessment-process

Smith, M. and. Myers, S, 2018:
Impact Of Anthropogenic CO2 Emissions On Global Human Nutrition. Nature Climate Change. Vol. 8. pp 834-839. https://doi.org/10.1038/s41558-018-0253-3

Taylor, K.E., R.J. Stouffer and G.A. Meehl, 2012:
An Overview of CMIP5 and the experiment design." Bull. Amer. Meteor. Soc., 93, 485-498, doi:10.1175/BAMS-D-11-00094.1.

World Meteorological Association, 2019:
https://www.wmo.int/pages/prog/wcp/wcdmp/GCDS_1.php

Appendix A

Preliminary List of Data Sources

- Environment and Climate Change Canada, Draft Strategic Assessment of Climate Change, 2019
- Dillon Climate Analytics Data Engine, 2020, leveraging datasets from IPCC AR5 and AR6.
- Taylor, K.E., R.J. Stouffer, G.A. Meehl: An Overview of CMIP5 and the experiment design." Bull. Amer. Meteor. Soc., 93, 485-498, doi:10.1175/BAMS-D-11-00094.1, 2012.
- Environment and Climate Change Canada (online). Historical Data Access. https://climate.weather.gc.ca/historical_data/search_historic_data_e.html
- McKenney, D. W. et al. 2011. Customized Spatial Climate Models for North America. Bull. American Meteorological Soc. V 92 (12). Pp 1611-1622.
- IPCC Fifth Assessment Report (AR5; IPCC 2013).
- Climate Lens General Guidance Version 1.2, Infrastructure Canada, 2019
- PIEVC Protocol, Version PG-10.1, Engineers Canada, 2016
- ISO 31 000 Risk Management, 2018
- Dillon Climate Analytics Data Engine (Software tools), 2020

Appendix B

Agency Comments on Draft Study Plan

Draft Study Plan Comments – Federal

Comment # / Ref #	Study Plan Section	TISG Section	Comment / Context	Action Item	Response	Study Plan Reference
CC-01	▪ **General Comment**	▪ Sections 5, 6, 7, 13, 19.2 and 25	▪ In addition to the required actions detailed below, other required actions to be addressed in the update to this study plan are detailed in a separate table titled "2020-07-02 - IAAC to MFFN-General Comments on MFCAR Draft Study Plans". The Agency has provided these other required actions to highlight common sections of the Guidelines where requirements were not met in the draft study plans submitted to the Agency. These additional actions must be addressed in the updated study plans.	▪ Please see Comment / Context	▪ We have reviewed the relevant comments and incorporated where appropriate. Please refer to the General Comments Table Response submitted separately to the Agency for specific responses.	▪ Various Sections
CC-02	▪ **Section 3: Spatial Boundaries** – "The LSA and RSA boundaries for climate change are detailed in Error! Reference source not found. and the LSA is shown in Error! Reference source not found." ▪ **Section 6.1: Indicators and Expression of Change** – "The indicators and rationale for selection and measurement of potential effects proposed to assess and evaluate the selected preferred route option in the IA/EA are provided in Error! Reference source not found."	▪ Editorial Comment	▪ Error messages are shown in the study plan rather then the correct reference	▪ Revise the study plan to eliminate any error messages and provide the correct reference.	▪ Changes Made.	▪ No Reference
CC-03	▪ **Section 6.2: Methods for Predicting Future Conditions** – "With respect to quantitative models and predictions, the EA/IA will detail the model assumptions, parameters, the quality of the data and the degree of certainty of the predictions obtained. – Climate change projections of temperature and precipitation for this project will be derived from an ensemble of 40 GCMs from the most recent IPCC 5th assessment report (AR5), published in 2013. These values will be calculated from the AR5 datasets using the Dillon CADE	▪ **Section 23.2** – "…The Impact Statement must: … - Identify the Project's sensitivities/ vulnerabilities to change in climate (both in mean conditions and extremes such as short-duration heavy precipitation events), describe climate resilience of the Project and how climate change effects have been incorporated into the Project design (e.g., water crossings) and planning over the lifetime of the Project and describe the climate data, projections used, and related information used to evaluate these sensitivities (i.e., risks) over the full project lifetime;…"	▪ Additional details are required to ensure the study plan meets the requirements of the Guidelines with respect to the climate change projections, indicators and variables. ▪ In Section 6.2, the study plan indicates that "climate change projections of temperature and precipitation for this project will be derived from an ensemble of 40 GCMs from the most recent IPCC 5th assessment report (AR5), published in 2013." The delta method will be used to evaluate projected changes from baseline conditions for a number of climate variables over two future time periods for the RCP 8.5 scenario. A	▪ Provide details to demonstrate the rationale for the selected climate indicators. ▪ Describe more robust alternative approaches to assessing future climate projections that are being considered and how they inform the project design, as per the guidance provided in the context column.	▪ Climate Indicators: Climate indicators were selected on the basis of design code considerations applicable to climate conditions, supplemented by anticipated climate impact interactions for road and supporting infrastructure components in their operating environment for the Project. ▪ Alternative Approaches to Assessing Future Climate Projections: Not all projected climate variables have the same certainty or reliability. One of the largest 'low confidence' variables is extreme precipitation which is both spatially and temporally challenging even for the highest resolution regional	▪ Section 9.1

Comment # / Ref #	Study Plan Section	TISG Section	Comment / Context	Action Item	Response	Study Plan Reference
	tools. Within the CADE system, projected values are generated using the "Delta Method" (IPCC-TGICA, 2007), which consists of applying the average projected difference (the "delta") for a given climate parameter to the historical average or baseline value. Projections will be developed for two 30-year periods (time horizons), centred on the 2050s (2041–2070) and the 2080s (2071–2100). Four future global GHG concentration scenarios have been established by the IPCC. Each of these scenarios is defined by different Representative Concentration Pathways (RCPs). The RCPs are: 1. RCP 8.5: considered the global "Business As Usual" (BAU) GHG global emissions regime. This is the current global trajectory based on current global GHG emissions; 2. RCP 6.0: GHG emissions double by 2060 and then decrease dramatically but remain above current GHG levels; 3. RCP 4.5: a medium GHG scenario derived from assumptions that global GHG emission reduction efforts result in approximately half of the emissions observed under RCP 8.5; and, 4. RCP 2.6: a scenario that aligns with global GHG emission reductions that maintain global warming below 2°C above pre-industrial global temperatures. – The IPCC's Special Report on Global Warming (2018) confirms that global GHG emissions continue to track along the RCP 8.5 pathway. This assessment will accordingly apply the RCP 8.5 scenario for the		number of different climate indicators for potential consideration in the assessment are provided in Table 6-1. The rationale on the fitness for purpose for individual indicators (i.e., usefulness of an indicator for assessment of potential impacts on particular aspect of the project) should be clearly provided. ■ The confidence in projections for different climate variables (e.g., temperature vs. precipitation-related parameters) and for different spatial scales is not uniform. Regional-scale projections are generally more robust than values at a single grid point or location. Values at a single grid point for some variables may be highly unreliable as future projections. Canada's Changing Climate Report (2) provides a discussion of the assessment of confidence in historically observed and projected future climate change in Canada for different climate parameters and spatial scales. In particular, ECCC notes that future projections of short-duration extreme precipitation at a point location or small spatial scale (either obtained directly from GCM output or downscaled GCM products) are unlikely to be robust (3). The recent Canadian Standards Association guidance on IDF for Canadian Water Resources practitioners (4) provides an assessment of current scientific understanding and provides some recommendations for considering future extreme precipitation projections at project-relevant scale. (2) Bush, E. and Lemmen, D.S., editors (2019): Canada's Changing Climate Report; Government of Canada, Ottawa, ON. 444 p. (https://changingclimate.ca/CCCR2019/) (3) Li, C., Zwiers, F., Zhang, X., & Li, G. 2019. How much information is required to well constrain local estimates of future precipitation extremes? Earth's		climate models (RCMs). Some suggestions for addressing this issue are described in the following response statement on IDF. For other variables (e.g., temperature and temperature based), there is sufficient certainty directly from modelled output, provided sufficient bias-removal processes are included. The delta approach employed using a large ensemble of model projections effectively removes any such individual model bias and provides a pure climate change signal. This signal, when applied to a reliable baseline period climate is a proven efficient and straightforward technique which requires no advanced statistical manipulation of the model output data. The key to this technique is the use of a large ensemble of model outcomes which can provide information on model sensitivities and ranges of possible projection outcomes that a single or few higher resolution models cannot. Although higher resolution RCMs are available, they are much fewer in number limiting any possible ensemble, and would carry forward any inherent bias from their driving GCM. The MFFN CAR Project Consultants acknowledges the restrictions of future climate projections dependent upon the variable being considered. ■ On IDF considerations, we acknowledge that confidence in projections for different parameters is not uniform, with greater veracity in temperature than precipitation. As a result different approaches may be required depending upon the parameter in question. For example, a regional large scale approach can be adequate for a climate change 'signal', whereas for short-duration, high intensity rainfall point measurements from representative locations can be more	

Comment # / Ref #	Study Plan Section	TISG Section	Comment / Context	Action Item	Response	Study Plan Reference
	projections used to anticipate future conditions.		Future, 7, 11–24. https://doi.org/10.1029/2018EF001001 (4) Canadian Standards Association. 2019. TECHNICAL GUIDE. CSA PLUS 4013-12: Development, interpretation, and use of rainfall intensity-duration-frequency (IDF) information: Guideline for Canadian water resources practitioners		appropriate. In fact, the future projection of extremes of rainfall is an active research area with previous demonstrations of very disparate results depending upon the selection of models and methodologies. Current practice should involve the consideration of historical trends, projected 'extreme indicators' such as changes in 99th percentile precipitation, the 'Clausius-Clapeyron' temperature correlation which has been applied successfully, and the possible development of extreme precipitation station combinations into 'superstations'. ECCC has demonstrated in their own analyses that there are no clear trends in historical IDF station amounts even within close proximity due to the nature of these extreme events (infrequent and falling between measurement locations, short station record lengths). The MFFN CAR Project Consultants acknowledge the limitations of extreme precipitation projections in such an actively changing research field and staff have participated in writing CSA guidance on this issue. Multiple approaches for the identification of extreme precipitation and their careful interpretation versus the acceptance of a single methodology is required.	
CC-04	■ **Section 7: Conformance with Federal and Provincial Guidance** – "Indigenous knowledge collected through engagement with traditional territories in the vicinity of the Project will be considered alongside background data collected and used to inform the effects assessment where applicable."	■ **Section 6** – "The proponent must engage with all Indigenous groups that may be impacted by the Project… – In addition to the requirements set out in section 6.1, 6.2 and 6.3, the proponent must provide Indigenous groups with an opportunity to: • provide Indigenous knowledge during baseline data collection; • comment on the list of valued components and indicators;…"	■ The Agency expects the proponent to engage with, at a minimum, the Indigenous groups listed in the Indigenous Engagement and Partnership Plan, as is directed in Section 6 of the Guidelines. The proponent must also provide Indigenous groups with an opportunity to comment on the list of valued components and indicators.	■ Update the study plan to include the list of all Indigenous groups that will be engaged, at a minimum the Indigenous groups listed in the Indigenous Engagement and Partnership Plan, as part of the baseline data collection, defining the list of criteria and indicators, and effects assessment analysis. The list should be consistent throughout the study plan.	■ Table 4-1 of the Study Plan, which is inclusive of all indigenous communities identified in Indigenous Partnership and Engagement Plan for the Marten Falls Community Access Road Project Impact Assessment (IAAC 2020a), indicates all indigenous communities that received outreach seeking participation for consultation. Study Plan Section 4 elaborates on how the MFFN CAR Project Team will be working with Indigenous communities to identify Climate Impacts.	■ Section 4

Draft Study Plan Comments – Provincial

Comment ID	Study Plan Section	Agency / Regulatory Body Comments Received From	Comment / Context	Action Item	Response	Study Plan Reference
1	▪ N/A	▪ MECP, Environmental Assessment Branch	▪ Please review EAB comments on the Wildlife, Ungulates, Vegetation and Groundwater work plans that may apply to this work plan.	▪ Please review EAB comments on the Wildlife, Ungulates, Vegetation and Groundwater work plans that may apply to this work plan.	▪ The Climate Change Study Plan pertains to assessment of the CAR route and its supporting infrastructure systems and subcomponents. Assessment of climate change impacts to Wildlife, Ungulates, Vegetation and Groundwater will be assessed within the Study Plans for those disciplines.	▪ Wildlife Study Plan Ungulates Study Plan Vegetation Study Plan
2	▪ Page 3, s. 3.0	▪ MECP, Environmental Assessment Branch	▪ Minor reference error in the paragraph above Table 3-1: "The LSA and RSA boundaries for climate change are detailed in Error! Reference source not found. and the LSA is shown in Error! Reference source not found."	▪ Correct References	▪ Error in translating reference has been corrected in revised study plan	▪ No Reference
3	▪ Page 10, s. 6.1	▪ MECP, Environmental Assessment Branch	▪ Minor reference error in the 1st paragraph of s. 6.1: "The indicators and rationale for selection and measurement of potential effects proposed to assess and evaluate the selected preferred route option in the IA/EA are provided in Error! Reference source not found."	▪ Correct References	▪ Error in translating reference has been corrected in revised study plan	▪ No reference
4	▪ Page 14, s. 6.3.1	▪ MECP, Environmental Assessment Branch	▪ Section 6.3.1 describing how the alternative routes will be assessed and the preferred route selected based on climate hazards is very helpful as it begins to describe the alternatives assessment methodology. It is also helpful to gain some clarity about how the proponent plans to differentiate between the alternatives assessment and the more detailed effects assessment of preferred alternatives. This section should include not just assessment of route alternatives but also supporting infrastructure alternatives. The proponent's other work should also have a section similar to section 6.3.1 that provides at least a high level methodology for how alternatives will be selected using the criteria/ indicators/ factors from each environmental component.	▪ In section 6.3.1 please include not just assessment of route alternatives but also supporting infrastructure alternatives. The proponent's other work plans should have a section similar to section 6.3.1 that provides at least a high level methodology for how alternatives will be selected using the criteria/indicators/factors from each environmental component. The other work plans should also begin to explain how the alternatives assessment and the more detailed effects assessment of preferred alternatives may differ, if that is the case. More detail on the alternatives assessment methodology and results will be required of the EA.	▪ Assessment of the CAR routing options will also assess the supporting components of the CAR system. Assessment of CAR route alternatives will also include feasible alternatives in the supporting infrastructure elements for the CAR project.	▪ Section 6 ▪ Section 9
5	▪ Page 15, 2. 6.3.2.1	▪ MECP, Environmental Assessment Branch	▪ The list of CAR infrastructure components should also include aggregate sources.	▪ Please add use of existing aggregate sources and/or development of new aggregate sources and associated access roads.	▪ Long-term pits a quarries and associated access roads has been added to the Study Plan	▪ Section 6.2.1 ▪ Section 9.1
6	▪ Page 16, s. 6.3.2.5	▪ MECP, Environmental Assessment Branch	▪ This section states a Risk Assessment Workshop will be convened to assess climate change impacts on the project, and local Indigenous communities will be invited. This invitation should be extended to all Indigenous communities that the Crown has identified for consultation. The proponent should consider extending the workshop idea (with Indigenous participation) for other environmental components if it is expected to provide a meaningful level of consultation. The workshop idea does not appear in other draft work plans.	▪ Please revise the work plan to indicate outreach to all Indigenous communities that have been identified for consultation to seek their participation. Please consider extending the workshop idea (with Indigenous participation) for other environmental components if this method is expected to provide a meaningful level of consultation.	▪ Table 4-1 of the study plan, which is inclusive of all indigenous communities identified in Indigenous Partnership and Engagement Plan for the Marten Falls Community Access Road Project Impact Assessment (IAAC 2020a), indicates all indigenous communities that received outreach seeking participation for consultation.	▪ Section 4

Comment ID	Study Plan Section	Agency / Regulatory Body Comments Received From	Comment / Context	Action Item	Response	Study Plan Reference
1	▪ 5.0 Data Management & Analysis AND 6.2 Methods for Predicting Future Conditions	▪ MECP (Adaptation Unit)	▪ General Comment - it is recommended to use the best available climate data and information, especially when predicting future climate. Using the best available science will narrow the range of uncertainty for each emission scenario that is being used.	▪ We noticed there's a mention of datasets that will be used in Section 5.0 to identify past and future climate conditions. There is no mention in section 6.2 the source of climate data projection that will be used. Has the proponent considered regional/Ontario specific climate data and climate models including the Ontario Climate Data Portal (OCDP: www.ontarioccdp.ca)?	▪ Section 6.2 did provide a statement indicating the source of climate data projection data that will be used. "Climate change projections of temperature and precipitation for this project will be derived from an ensemble of 40 GCMs from the most recent IPCC 5th assessment report (AR5), published in 2013".	▪ Section 9
2	▪ 6.3.2 Climate Assessment and other sections referring to identifying climate risks/vulnerabilities at different phases	▪ MECP (Adaptation Unit)	▪ General Comment - When conducting risk assessments, it is recommended to use the best available climate data and information. Using the best available science will narrow the range of uncertainty for each emission scenario that is being used.	▪ It is important to note that there are several different methodologies when undertaking a risk assessment (i.e., qualitative, semi-quantitative or both, etc.). Our ministry position is that we cannot advise on the methodology to use, but it is important that the proponent ensure the methodology to used is robust enough to yield results that will adequately inform this project. In addition to this, it is recommended the proponent document the rationale for choosing the methodology and any assumptions/limitations associated with it.	▪ The methodology proposed for this scope will be a ISO 31000-consistent climate change assessment, in alignment with the principles of a PIEVC process conforming to the guidance for proponents provided in Section 5.3.1 of the Government of Canada's Draft Strategic Assessment of Climate Change and Ontario's Guide for Considering Climate Change in the Environmental Assessment Process (MOECC 2017).	▪ Section 9 ▪ Section 10
3	▪ 6.3.2 Climate Change Assessment of preferred alternative route	▪ MECP (Adaptation Unit)	▪ There is mention in section 6.3.2 that Indigenous knowledge will be incorporated throughout the project: "Indigenous Knowledge compiled through the project stakeholder interactions (refer to separate Work Plan) will be used to guide and inform the climate analytics development and the selection of project elements/considerations for the climate change risk assessment". Can this section of the work plan elaborate a bit more and/or provide a summary on how information will be collected and how it will used in combination with the risk assessment - based on this "separate" Work Plan that was created?	▪ Combining TEK with traditional western science may enhance the risk assessment when identifying climate impacts, which will be helpful in planning and decision making. The proponent may want to elaborate on how the Project Team will be working with First Nations communities to identify climate impacts (through TEK, as appropriate and in collaboration with the Indigenous Communities i.e. workshops, survey, etc.).	▪ Study Plan Section 4 elaborates on how the MFFN CAR Project Team will be working with First Nations communities to identify Climate Impacts.	▪ Section 4

Attachment B - Risk Treatment and Adaptation Measures

Climate Indicators	Valued Components	Risk	Justification	Adaptation Measure or Risk Treatment	Implementation Timeframe	Project Phase	Effectiveness
Extreme (high) Temperature and Heat Wave	Construction camps	10	■ Extreme temperature and heat waves can reduce productivity and cause delays in construction and maintenance work. ■ Extreme temperature and heat waves can increase indoor air temperature in construction trailers and therefore the need for cooling/ventilation systems. ■ High temperature and heat waves will reduce the loading rate (maximum power rate) of above ground transformers and other electrical equipment like generators. The life expectancy for transformers (as for other electrical equipment) is reduced by 50% for every 10°C over their rated temperature limit. ■ The demand for water may increase during periods of high temperature and heat waves.	■ Enforce breaks for workers during the construction, provide protective equipment and air conditions in camps, and implement flexible work schedules during heat waves.	Operations	Construction	Very effective
				■ Increase thermal efficiency (e.g., insulation, ventilation, choice of materials, green or pale coloured/reflective roofs) of construction trailers to decrease indoor air temperature, as well as power demand from cooling during hot days.	Design	Construction	Very effective
				■ Use white "cooling" boxes for outdoor electrical equipment (e.g., on the roof tops) to prevent overheating of power and heating equipment.	Design	Construction	Very effective
	People	20	■ Extreme temperature and heat waves can cause various health impacts, including skin rash, heatstroke, fainting, exhaustion, muscle cramps, dehydration, and edema. ■ Extreme temperatures and heat waves can affect vulnerable people in greater proportions and intensity.	■ Implement an alert protocol designed to identify and communicate hot weather and heat wave conditions that could impact the well-being of community members, visitors, and workers.	Policy	Construction Operations	Effective
				■ Communicate the health risks of extreme heat events with the public, as recommended by Health Canada (2011). For example, share heat wave warnings and health safety tips on display signs in construction camps and in community buildings.	Policy	Construction Operations	Very effective
				■ Limit the exposure of workers to extreme temperatures and heat waves by modifying physically demanding work schedules during periods of increased temperature, humidity, or insulation.	Policy	Construction	Very effective
				■ Provide designated cool, shaded, or air-conditioned areas for workers in order to limit their exposure to extreme temperatures and heat.	Design	Construction	Very effective
Melting Degree Days	Culverts and bridges	10	■ The increase in melting degree days can increase the amount of runoff water that converges in culverts.	■ Schedule inspections and maintenance of culverts to prevent the worsening of wear and tear following the winter season.	Operations	Operations	Effective
	People	10	■ The increase in melting degree days can lead to an increase in snow and ice melt, which in turn can lead to the deterioration of road conditions and accidents.	■ Communicate the condition of the roadway with the public in order to encourage people to be careful when traveling. For example, sharing the location of the greatest damage in construction camps and in community buildings.	Policy	Construction Operations	Very effective

Climate Indicators	Valued Components	Risk	Justification	Adaptation Measure or Risk Treatment	Implementation Timeframe	Project Phase	Effectiveness
Extreme Daily Rainfall, Short-duration, high-intensity Rainfall (50-year event), and Multi-day Heavy Precipitation	Community Access Road	20	■ Extreme rainfall can cause the erosion of the road surface and can create rills and gullies. ■ Road washouts are possible in areas where runoff or surface water congregates (i.e., culvert or bridge). Washouts may render the road impassable for an extended period. ■ Extreme rainfall may cause flooding. Road segments with culverts and bridges may be more vulnerable to flooding.	■ Design drainage systems to cope with heavy rainfall with well defined overland flow routes. On larger fill sites with expansive grade slopes, confirm that erosion protection measures are employed (blanket to foster revegetation growth, synthetic ditch checks, straw wattle, and others) to slow down erosive forces.	Design	Construction	Very effective
				■ Use non-moisture susceptible building materials so that work can continue during rain events (e.g., quarried rock, granular fill materials).	Design	Construction	Very effective
				■ Increase inspections and maintenance after extreme rainfall event to prevent the worsening of wear and tear of the road during heavy rainfall and flooding events.	Operations	Operations	Very effective
				■ Conduct frequent grading and maintenance of the road to fill potholes and maintain a crowned (4%) surface that can handle heavy rainfall more effectively.	Operations	Operations	Very effective
	Culverts and bridges	15	■ Extreme precipitations can cause an accelerated deterioration of culverts by increasing the amount of runoff water that converges through them. ■ Extreme precipitations can increase the scour rate of bridge foundations. ■ High volumes of water can overwhelm culverts and lead to failure and flooding.	■ Choose oversized culverts to take into account the increase in the recurrence of floods and extreme rainfall of about 172 mm (i.e., a 100-year rainfall event in 2071-2100).	Design	Construction	Very effective
				■ Raising the bridge deck will increase the hydraulic capacity of bridges, limiting damages sustained during flooding event.	Design	Construction	Very effective
				■ Proceed to scour monitoring to limit the extent of the damaged to bridges during a flood.	Operations	Operations	Very effective
				■ Increase inspections and maintenance of culverts to prevent the worsening of wear and tear during heavy rainfall and flooding events.	Operations	Operations	Very effective
	Construction camps	10	■ Extreme rainfall may result in premature deterioration of exterior building elements (e.g., windows, exterior doors) and the construction trailers due to water infiltration, resulting in increased inspections and maintenance costs. ■ Extreme rainfall can lead to water accumulation on flat roofs (ensuing drainage difficulties). ■ Extreme rainfall can cause delays in construction and maintenance work. ■ Extreme rainfall can cause the erosion of the hard-surfaces and can cause flooding	■ Increase inspections and maintenance of construction trailers and other installations to prevent the worsening of wear and tear during heavy rainfall and flooding events.	Operations	Operations	Very effective

Climate Indicators	Valued Components	Risk	Justification	Adaptation Measure or Risk Treatment	Implementation Timeframe	Project Phase	Effectiveness
Extreme Daily Rainfall, Short-duration, high-intensity Rainfall (50-year event), and Multi-day Heavy Precipitation (cont'd)	Rest stops and road turnout	10	■ Extreme rainfall can cause the erosion of the road turnout surface and can create rills and gullies. ■ Road washouts are possible in areas where runoff or surface water congregates (i.e., culvert or bridge). Washouts may render the road impassable for an extended period. ■ Extreme rainfall may cause flooding. Road turnouts near culverts and bridges may be more vulnerable to flooding.	■ Design drainage systems to cope with heavy rainfall with well defined overland flow routes.	Design	Construction	Very effective
				■ Increase inspections and maintenance to prevent the worsening of wear and tear of the rest stops and road turnouts after heavy rainfall and flooding events.	Operations	Operations	Very effective
	People	20	■ Extreme rainfall can cause dangerous driving conditions by reducing visibility and traction. Road conditions can deteriorate quickly. ■ Extreme rainfall may cause flooding or flash floods. Floods can reduce road safety for users and may cause road closures. This can cause delays in the mobilization and arrival of first responders during emergency situations.	■ Communicate the condition of the road with the public in order to encourage people to be careful when traveling. For example, share the location and status of floods or road washouts in construction camps and in community buildings. Include the road in the internet feed for road conditions reporting.	Policy	Construction Operations	Very effective
				■ Develop and implement an Emergency Preparedness and Management Plan in the case of a heavy rainfall or flood event.	Policy	Construction Operations	Effective
Daily Snowfall (50-year event)	People	12	■ Heavy snowfall can cause dangerous driving conditions which can lead to skidding and collisions. ■ Heavy snowfall can increase frequency and effort needed during snow removal operations. This can cause delays in the mobilization and arrival of first responders during emergency situations	■ Communicate the conditions of the roadway with the public in order to encourage people to be careful when traveling. For example, share the status of plowing operations in construction camps and in community buildings.	Policy	Construction Operations	Very effective
				■ Develop and implement an Emergency Preparedness and Management Plan in the case of a heavy snowfall event.	Policy	Construction Operations	Effective
Wildfire	Community Access Road	20	■ Wildfires can cause the closure of the road for safety reasons, preventing the road users from using it, causing delays in the mobilization and arrival of first responders, and disrupting supply chains. ■ Wildfires in surrounding areas can create dangerous driving conditions, such as reduced visibility from smoke and ash. Heat from wildfires can damage vehicles. ■ The road should not be damaged directly from wildfire flames and heat.	■ Conduct regular maintenance and inspection of the road and its cleared 60 m right-of-way to prevent the accumulation of flammable debris and improve safe travel.	Operations	Operations	Very effective
				■ Implement early warning systems to prepare for wildfire events and make informed decisions about road closures.	Policy	Operations	Effective

Climate Indicators	Valued Components	Risk	Justification	Adaptation Measure or Risk Treatment	Implementation Timeframe	Project Phase	Effectiveness
Wildfire (cont'd)	Culverts and bridges	12	■ The flames and heat generated by forest fires can damage Marten Falls Community Access Road components, including bridges and culverts. ■ Wildfires can cause accelerated deterioration of bridge materials, especially fire-vulnerable materials such as timber. Such damage may affect the structural integrity of a concrete structure.	■ The use of timber in bridge structures is discouraged, and steel/concrete shall be incorporated.	Design	Construction	Very effective
				■ Conduct regular maintenance and inspection of bridges to prevent the accumulation of flammable debris and improve safe travel.	Operations	Operations	Very effective
				■ Increase inspections and maintenance after wildfire events to prevent the worsening of wear and tear of bridges and culverts.	Operations	Operations	Very effective
	Construction camps	16	■ Wildfires can cause major damages to construction camps and decrease air quality, resulting in operational impact. ■ Evacuation may be necessary. ■ If wildfires reach explosives storages, large explosions may occur.	■ Remove ground litter and high ignition vegetation (e.g., dead, dying, dried and overmature trees) on a regular basis to limit the presence of fire fuel around construction camp infrastructure, especially near explosives storage.	Operations	Construction	Very effective
				■ Keep grasses near the construction camp infrastructure cut at less than 10 cm in height during the fire season.	Operations	Construction	Very effective
				■ Install an external unmanned sprinkler system and have sources of water available (especially near storage of explosive materials).	Operations	Construction	Very effective
				■ Implement early warning systems to prepare for wildfire events and make informed decisions about construction camp closures.	Policy	Construction	Effective
	People	16	■ The intense heat caused by nearby wildfires can affect the integrity of vehicles. ■ Wildfires can cause the closure of the road, causing delays in the mobilization and arrival of first responders. ■ Wildfire smoke can decrease air quality by increasing the amount of Particular Matter (PM) 2.5. Wildfire smoke can be carried for considerable distances and for an extended period of time, depending on wind intensity and direction. ■ Decreased visibility due to wildfire smoke and debris on the road can cause dangerous driving conditions which can lead to accidents.	■ Monitor air quality and limit the exposure of workers to smoke by modifying work schedules during wildfire season. Keep monitoring the following website for smoke intensity and forecasts (https://firesmoke.ca/forecasts/current/).	Operations, Policy	Construction	Very effective
				■ Communicate the health risks of wildfires and wildfire smoke with the public. For example, share wildfire, road, and evacuation status on display signs in construction camps and in community buildings.	Policy	Construction Operations	Very effective
				■ Develop and implement an Emergency Preparedness and Management Plan in the case of a wildfire event.	Policy	Construction Operations	Effective

Climate Indicators	Valued Components	Risk	Justification	Adaptation Measure or Risk Treatment	Implementation Timeframe	Project Phase	Effectiveness
Thunderstorm	Community Access Road	10	■ Thunderstorms, combined with heavy winds and/or precipitations, may cause flooding and soil erosion.	■ Design drainage systems to cope with heavy rainfall with well defined overland flow routes.	Design	Construction	Very effective
				■ Increase inspections and maintenance after extreme rainfall event to prevent the worsening of wear and tear of the road during heavy rainfall and flooding events.	Operations	Operations	Very effective
				■ Conduct frequent grading and maintenance of the road to fill potholes and maintain a crowned (4%) surface that can handle heavy rainfall more effectively.	Operations	Operations	Very effective
	Culverts and bridges	10	■ Thunderstorms, combined with heavy winds and/or heavy precipitations, can cause an accelerated deterioration of bridges. ■ High volumes of water can overwhelm culverts and lead to failure and flooding.	■ Increase inspections and maintenance of culverts to prevent the worsening of wear and tear during heavy rainfall and flooding events.	Operations	Operations	Very effective
	Illumination	10	■ Dense clouds associated with thunderstorms can extend the duration of illumination of the roadway and therefore use up the battery charge. ■ Thunderstorms, including heavy precipitations, strong winds, lightning and/or hail, can damage solar streetlights.	■ Keep backup solar streetlights in stock in order to be able to replace quickly any damaged equipment after a thunderstorm.	Operations	Operations	Very effective
	Construction camps	10	■ Thunderstorms, combined with heavy winds, heavy precipitations, lightning, and/or hail, can cause damage to construction site equipment. ■ Thunderstorms can cause delays in construction and maintenance work.	■ Secure construction equipment and material in preparation of thunderstorms (heavy wind).	Policy	Construction	Very effective
				■ Communicate the health risks of thunderstorms with the public. For example, track and share status of thunderstorms on display signs in construction camps and in community buildings. Use the following website to confirm threat (https://weather.gc.ca/lightning/index_e.html).	Policy	Construction	Very effective
				■ Develop and implement an Emergency Preparedness and Management Plan in the case of a thunderstorm.	Policy	Construction	Effective
	Rest stops and road turnout	10	■ Thunderstorms, combined with heavy winds and/or precipitations, may cause flooding and soil erosion.	■ Design drainage systems to cope with heavy rainfall with well defined overland flow routes.	Design	Construction	Very effective
				■ Increase inspections and maintenance after a thunderstorm to prevent the worsening of wear and tear of the rest stops and road turnouts.	Operations	Operations	Very effective

Climate Indicators	Valued Components	Risk	Justification	Adaptation Measure or Risk Treatment	Implementation Timeframe	Project Phase	Effectiveness
Thunderstorm (cont'd)	People	20	■ Thunderstorms, including heavy winds, heavy rain and lightning, can cause dangerous driving conditions which can lead to accidents.	■ Establish a storm warning system that alerts road users in advance so that they can plan their travel.	Policy	Construction Operations	Very effective
				■ Establish and communicate guidelines on what to do in case of a thunderstorm to road users.	Policy	Construction Operations	Effective

Implementation Phase	Description
Design	Measures to be incorporated during the design or restorative maintenance phase of infrastructure, and that requires a capital investment.
Operations	Measures to be implemented during routine maintenance on a short timeline (<5 years).
Policy	Policy development that can act as a bridge as restorative maintenance is undertaken.

Attachment C - Climate Change Impacts on Ecosystems

A community of organisms living and interacting within a physical environment is described as an ecosystem. Marten Falls First Nation is located in the Hudson Bay Lowlands, characterized by upland boreal forest and varied wetland ecosystems (ID 203 from the Indigenous Knowledge table, confidential). Climate change has a direct impact on the integrity and stability of ecosystems by altering biodiversity, habitats, and ecosystem processes and services (U.S. Climate Resilience Toolkit, no date). It poses a threat to many species, mainly due to increased temperatures, changes in precipitation patterns, disturbances in inter-species relationships, increases in pests and pathogens, in addition to anthropogenic pressure on natural habitats (Applequist et al., 2020). Social, cultural, and economic activities that revolve around land, such as hunting, trapping, gathering, and fishing, are, therefore, deeply impacted by the changing climate.

The impacts of climate change on ecosystems are complex and operate at multiple scales, from individuals to populations, communities, and species. These impacts include changes in morphology, phenology, behaviour, and range (Weiskopf, et al., 2020). Morphological changes which are often related to body size are hard and complex to understand and predict. It is therefore difficult to attribute observed changes to climate change. On the other hand, changes in phenology, or the recurrence and seasonal timing of biological events, are some of the first signs of species responding to climate change.

Although a wide range of species across most of the world's biomes have exhibited changes in phenology, the magnitude of these changes varies greatly. Thereby, the phenological shifts are often asynchronous, resulting in the disruption of inter-species relationships as well as in the functioning, persistence, and resilience of ecosystems. For plants, these changes can influence the beginning of the growing season or the timing of budding and flowering. For terrestrial and aquatic animals, phenological changes can result in an earlier migration and breeding periods. Marten Falls First Nation has observed a disruption in migratory paths (ID 305 from the Indigenous Knowledge table), whereas other communities (i.e., Kitchenuhmaykoosib Inninuwug First Nation, Wapekeka First Nation, Weesnuk First Nation) have reported that the seasonal migration rhythms of birds like waterfowl are disturbed, affecting the communities' capacity to predict their arrival times (ID 389 from the Indigenous Knowledge table and ID 427; Weensuk First Nation Existing Conditions Report, page 89). Other behavioural changes include seeking refuge or shade, altered feeding times, and shifts in the circadian rhythms (e.g., hibernation).

On a larger scale, climate change manifests its impacts on ecosystems through key drivers such as changes in extreme events and biological invasions. Extreme events like extensive and/or recurring droughts and wildfires have long-lasting and synergistical impacts on ecosystem resilience (Whitman et al., 2019). In forested ecosystems, tree defenses are weakened by these perturbations and are more vulnerable to insects, diseases, and invasive species. Indeed, climate change is facilitating the introduction and proliferation of exotic, invasive species. Many of these species are opportunistic generalists that can take advantage of changing environmental conditions, spread to new areas and out-compete local species (Weiskopf et al., 2020).The invasion of non-local, invasive species can be linked to the decline of biodiversity by the alteration of community composition and the extinction of the more vulnerable species. As an example, Marten Falls First Nation has reported a decline in native birds, while non-native species have synchronously increased in the area (ID 305 from the Indigenous Knowledge table). As shared during the Open House, there has been a noticeable decrease in trapping of fur bearing animals around Marten Falls First Nation except for martens (ID 443 from the Indigenous Knowledge table).

These described pressures, mainly driven by changes in temperature and precipitations, result in large-scale shifts in species distribution, abundance, and reorganization of terrestrial and aquatic ecosystems. In reaction to the increase in temperature and changes in precipitations, the suitable range of many plant and animal species is expected to shift mainly to higher latitudes and/or altitude. It has been found that already 55% of plant and animal species across North America have expanded their range to cooler zones and retreated from the warmer front of their range (i.e., local extinctions) (Wiens, 2016; Wang et al., 2023). While temperature and precipitations are typically the two key abiotic drivers of ecosystem shifts, other parameters, such as topography, land use, and microclimates, can influence the shifts as well.

The shift of ecosystems will take place over decades and is projected to continue in the next century. The speed with which the transition will happen is different from the rate of climate change as plants have greater inertia and follow the climatic changes more slowly. Furthermore, the ecosystem transition will happen heterogeneously, depending greatly on seed dispersal ability, the deterioration of soil moisture and warming, as well as disturbances like diseases, pests, wildfire, drought, and windthrow that will advantage new species to shift in the disturbed ecosystem (Sauchyn et al., 2020). Human activities that cause habitat destruction and fragmentation, such as deforestation and mining exploitation, can also affect the ability of plants and animals to migrate. For example, the fragmentation of watercourses can compromise the ability of certain fish species, which are very sensitive to biotic and abiotic changes, to migrate to suitable habitats. Even though animals are more mobile than plants, some species that are more sensitive to habitat suitability (e.g., presence of specific plants or prey) will be limited by the rate of their habitat transition.

Climate change also impacts the capacity of ecosystems to provide for human communities and societies (i.e., ecosystem services). The alterations to ecosystem services may include impairment of water supply and quality, increase of food insecurity, loss of medicinal plants, and threat to the maintenance of culture and traditions (Jones et al., 2020; Rall and LaFortune, 2020). Indeed, drier years can lead to surface water shortage, while the increase of stream water temperature alters water quality and promotes harmful algae blooms. Warmer winter temperatures, early ice melts and sudden thaw of rivers, as well as reduced snow and ice cover, alters the capacity of community members to travel, hunt and trap during winter as already observed by members of the Indigenous communities (Climate Change Webinar, 2024; Weeksnuk First Nation Existing Conditions Report, page 47). As an example, changes in waterfowl migration routes have negative economic impacts on Fort Albany First Nation (ID 362 from the Indigenous Knowledge table). Also, fish communities decline or die-off, induced by regional climate change, have threatened Fort Albany First Nation's food security (ID 364 from the Indigenous Knowledge table).

Moreover, climate change can have detrimental effects on medicinal plants by decreasing their availability, abundance, and accessibility, inducing extinction for the more vulnerable species, and altering the phytochemical content and pharmaceutical properties of these plants (Applequist et al., 2020). Culturally important species shift their range further than tribal land area (Weiskopf, et al., 2020). Ecosystem and range shifts constitute a threat to Indigenous cultural maintenance: the potential loss of the wild growth of these medicinal plants might necessitate the cultivation of these valued plants.

Adaptation and resilience to the impacts of climate change on ecosystems is possible through some pro-active and conservation measures. On one hand, identifying, through a climate change vulnerability assessment, the exposure, sensitivity and adaptative capacity of important, traditionally used species can help focus the attention on specific threats to the community. On the other hand, maintaining habitat integrity and connectivity can help in limiting the non-climate stressors like pollution, invasive species, and habitat fragmentation. One avenue to prevent uncontrollable wildfires and improve habitat cohesion is the continuation of prescribed and/or cultural burning, tree thinning, pruning of understorey vegetation and litter. Prescribed and cultural burning has other positive effects, mainly on berry production/quality and for hunting/trapping activities (Christianson et al., 2022). Finally, restoring and protecting zones that provide valued resources are important to maintain ecosystem resilience and cultural needs.

Attachment D - Future Usability of the Winter Road

With climate change and the associated increase in winter temperatures, the operating window for the winter road is reduced. Any delays in construction and reductions in operating length may have significant financial and social impacts for Marten Falls First Nation. The winter road is the most economical way to transport essential supplies like food, fuel, equipment, and construction materials to communities in northern Ontario (Barrow, et al., 2022). The reduction in the winter road season and extended winter road closures will limit access reliability, resulting in increased prices, shortages, and further isolation of the communities. Significantly warmer winters have prompted councils, chiefs, and government officials to declare a state of emergency (The Canadian Press, 2024).

To assess the current and future winter road conditions, multiple design criteria for the establishment of winter and ice roads are available. As the operation duration depends predominately on the natural surface conditions, road use requirements and regional weather conditions (e.g., air temperature and snowfall), criteria such as a minimum of 15 cm of snow on the ground and 30 cm of frozen soil are used (Sladen et al., 2020). Since soil temperatures are difficult to obtain, an alternative, temperature-dependent criterion is used for this project.

Based on historical observations, a freezing degree-day indicator was found to capture the conditions for winter roads well. The freezing degree day is established by calculating the difference between the daily mean temperature and a temperature threshold and the subsequent summary of the difference starting from October 1.

$$Freezing\ degree\ day = \sum_{i=\text{October 1st}} \left(T_{\text{Threshold}} - T_{\text{mean},i}\right)$$

The temperature threshold is set to 0°C. For daily mean temperatures above 0°C, the difference is negative and freezing degree days is reduced, while daily mean temperatures below 0°C increase the freezing degree days. For the western James Bay region, a minimum freezing degree-day values of 380°C is required to begin the construction of the winter road (Hori et al., 2017).

Using this construction criterion for the Marten Falls winter road, the average construction start day for the 1981-2010 reference time-horizon was calculated to be December 20. With climate change and the later start of the frost season, the construction start will occur later into the winter season (**Table D-1**). Based on community experience, it takes about 3 weeks to complete the winter road if the temperatures remain below freezing throughout.

Table D-1: Construction Start Date of Marten Falls Winter Road with Climate Change

	1981-2010	2041-2070	2071-2010
Construction Start Date	December 20	January 5	January 18

A similar approach is employed to calculate the end date for the winter road. Relying on reports of historical winter road closures and correlating them with local temperature-related observations, it was determined that spring melting degree days greater than 10°C is a suitable threshold:

$$Melting\ degree\ day = \sum_{i=\text{March 1st}} \left(T_{\text{Threshold}} - T_{\text{mean},i}\right)$$

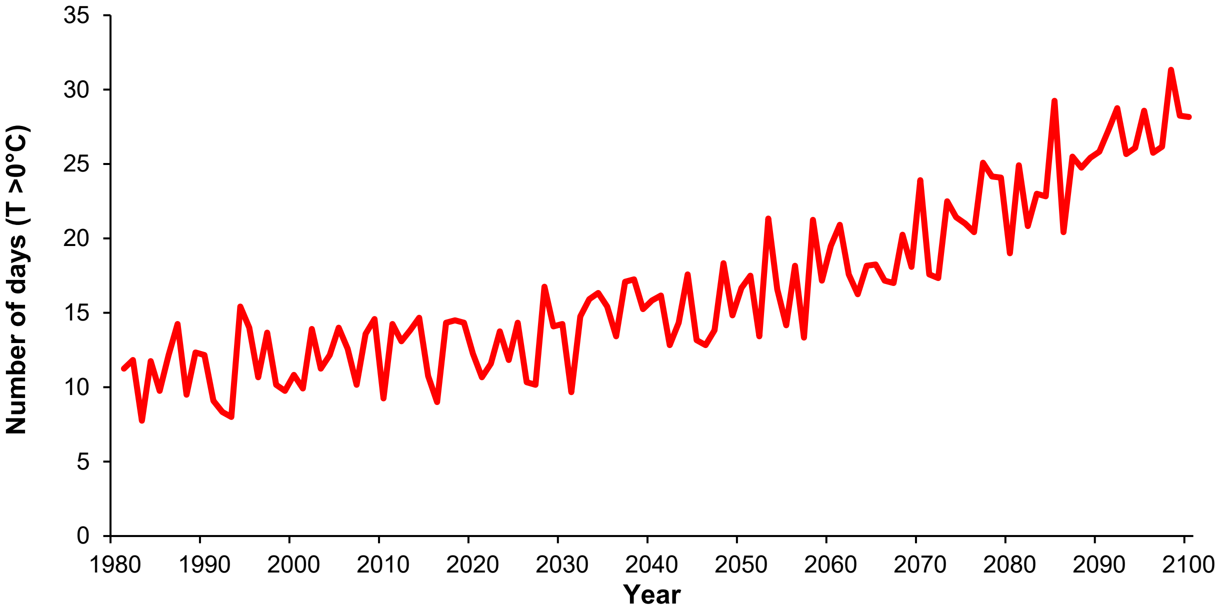
where the meteorological definition of spring which starts on March 1 is used. Using this estimate, the end date of the winter road season for the historical reference period was determined to be April 5. The increase in temperature due to climate change leads to earlier winter road season ends (**Table D-2**).

Table D-2: End Date of Marten Falls Winter Road with Climate Change

	1981-2010	2041-2070	2071-2010
End Date	April 5	March 27	March 21

Furthermore, the winter months in northern Ontario will also be characterized by more frequent mid-season days with temperature greater than 0°C. Due to these melting conditions, the winter road potentially looses its internal stability and must be partially or completely closed. For the historical reference period, an average of 14 days with temperatures greater than 0°C have been recorded. At the end of the century (i.e., 2071-2100), the number of will likely increase to about 27 days per year (**Figure D-1**).

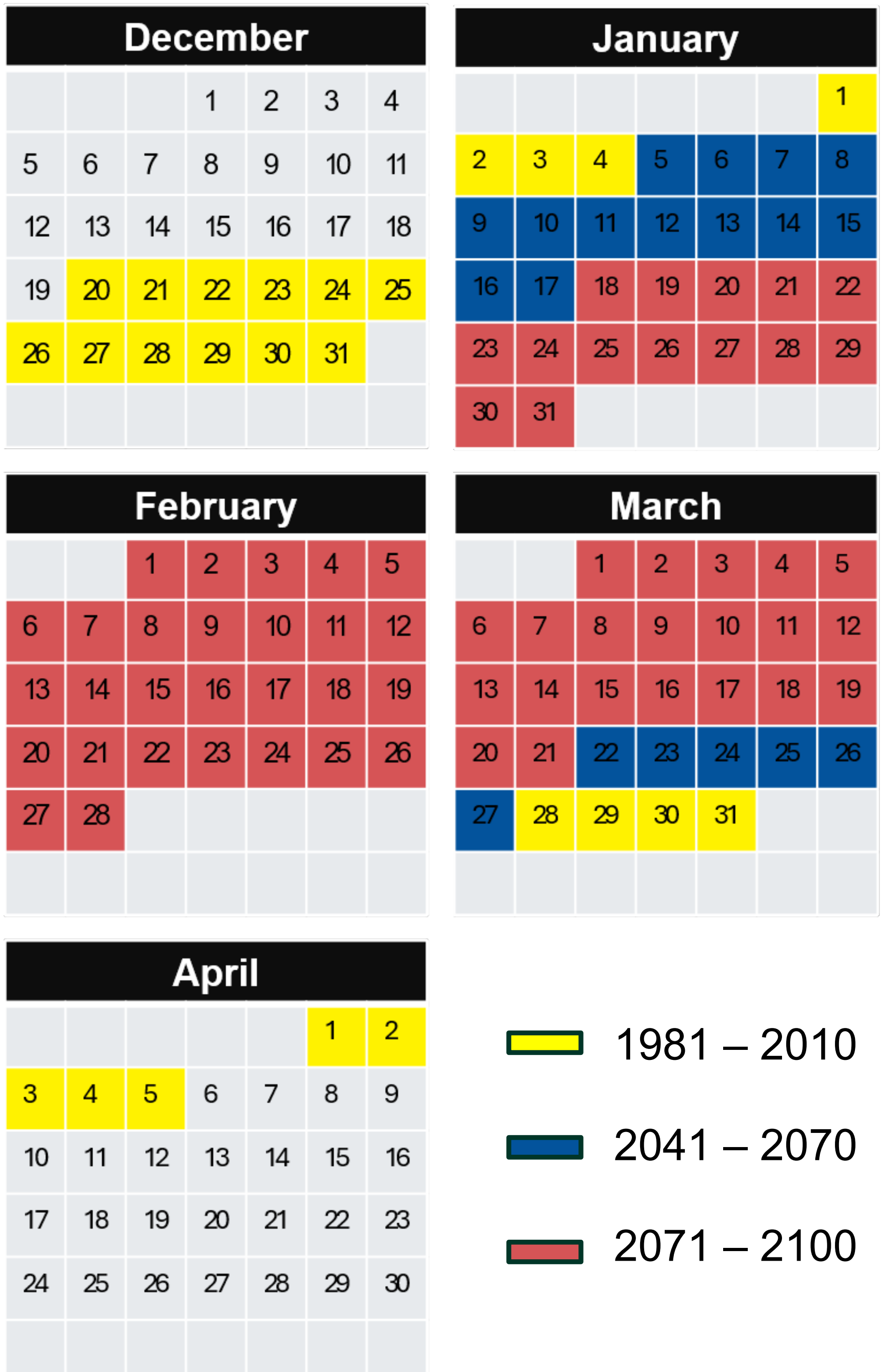
Figure D-1: Number of Days with Temperatures Greater Than 0°C



In addition to later construction starts and more frequent occurrence of melting conditions throughout the winter, it is expected that the winter road will close earlier in the spring due to the earlier onset of the spring-melt. During the historical reference period, on average the winter road was operational until early April. At the end of the century (2071-2100), the winter road will be closed by mid- to late-March (**Figure D-2**).

The reduction of the construction and operating length of the winter road will have significant financial and social impacts for communities in northern Ontario, as they are the most economical way to transport essential supplies like food, fuel, equipment, and construction materials (Barrow et al., 2022).

Figure D-2: Winter Road Calendar



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