Topic: MVEIRB-1 Construction Schedule

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board): The GNWT has proposed a construction timeline that extends unusually far into the future (up to 20 years). This extended timeline introduces additional uncertainty into construction impact predictions by requiring the Review Board and parties to assess impacts based on conditions that may well change over the lengthy construction period.

In a 2013 letter (attached) to the developer (PR#39), the Review Board previously raised this specific concern about the challenges of confidently predicting impacts given the unusual length of the proposed construction period. The Review Board expressed concern about the accuracy of impact predictions on wildlife, water resources, climate and permafrost, and socio-economics. Aspects of the environment, such as fire regime, certainly appear to have changed even since the Review Board raised the concern.

The Board has read GNWT's statement, in section 5.4.1 of the Developer's Assessment Report, that adaptive management and ongoing engagement are sufficient to predict and mitigate impacts and uncertainties in the future. This approach relies on adaptive management to quickly detect important impacts and for those impacts to be mitigated before they become significant. The Review Board is not convinced that the assurance of adaptive management is a sufficient substitute for credible impact prediction.

Request from the Review Board:

A. How likely is the predicted or alternative construction timeline presented in the Developer's Assessment Report?

B. Please justify and provide further details on the statement in DAR section 5.4.1 that adaptive management and ongoing engagement are sufficient to predict and mitigate impacts and uncertainties on the environment and people once construction is complete (a minimum of 20 years from now into the mid-2040s) and the road is entirely open to the public.

C. Please describe the GNWTs optimal construction schedule (that is, if financial resources are available to build the highway upon receipt of permitting approval), including:

- How long would it take to build the road from Wrigley to Norman Wells on this basis?
- Would the GNWT consider building from multiple headings at the same time (for example, from Normal Wells, Tulita, and Wrigley simultaneously)? What would this construction schedule look like?

Attachments:

1. MVEIRB letter to GNWT October 29, 2013
2. GNWT Response to MVEIRB November 13, 2013

Response from the Government of the Northwest Territories:

A. The GNWT has combined its responses to A and C in this section.

In its information requests, the Review Board is inquiring with respect to the GNWT's optimal construction schedule, as well as the predicted and alternative construction schedules as currently presented in the DAR.

i) Optimal schedule:

The GNWT's optimal schedule, subject to available financing and receipt of project authorizations, would be to construct the project from multiple headings at the same time, in as little as three to four years.

Given recent logistical challenges associated with forest fires, low water conditions on the Mackenzie River and the subsequent disruption of critical community resupply operations over the past two years, there is an urgent need for all-season access to the Sahtú Region. Unprecedented challenges this year associated with historic low water conditions along the Mackenzie River have resulted in the recent decision to cancel barging services to the communities of Norman Wells and Tulita, further amplifying the need for all season access to these communities.

Based on these factors, the GNWT's optimal construction approach and schedule for the Mackenzie Valley Highway Project would be to advance construction of the entire alignment concurrently and from multiple headings (e.g. construction advancing concurrently from Norman Wells to Tulita as well as from Tulita to Norman Wells; Wrigley to Tulita as well as Tulita to Wrigley). Section 7.3.2.2.1 of the DAR suggests that project construction can be completed in as few as three to four years, but this timeframe could extend outwards depending on the factors listed below.

Several significant assumptions are necessary to facilitate such an expedited schedule, including:

a. Design for construction, for the entire alignment, would need to be completed concurrent to the environmental assessment;

b. Land tenure, for the entire alignment, would need to be secured prior to the start of construction;

c. Funding to complete regulatory authorizations and advance construction, for the entire alignment, would need to be secured;

d. Regulatory authorizations and associated permitting, for the entire alignment, must be completed prior to construction; and

e. Procurement for construction, for the entire alignment, would need to be successful (i.e. successful bid from a contractor with the capacity to undertake the work in the period requested at an acceptable cost).

As demonstrated by the assumptions described above, executing an optimized project delivery schedule will require continued commitment from the GNWT, Government of Canada, Indigenous Governments, and other parties to plan, fund, and execute the project. It is clear that a more expedited construction schedule is strongly desired by Indigenous Governments and community residents who are experiencing recurring extreme weather events that both interrupt supply chains and impede community egress routes. The GNWT has clearly heard this feedback, and in response, work is underway to define an optimized schedule and potential implications for environmental and socio-economic impacts.

ii) Predicted and Alternate Construction Schedules

The conceptual schedule used as the basis for the environmental assessment is presented in Section 5.4.1 of the Developers Assessment Report (DAR) and illustrated in Figure 5.3. This conceptual schedule assumes the project will be delivered in three consecutive phases:

- Segment 1: Wrigley to the Dehcho–Sahtu border (102 km)
- Segment 2: Tulita south to the Dehcho–Sahtu border (134 km)
- Segment 3: Tulita north to the Prohibition Creek Access Road (45 km)

Construction of each phase is contingent upon the completion of final design, acquisition of construction funding and appropriate land tenure, regulatory approvals, and procurement, prior to construction.

The conceptual schedule presented in Section 5.4.1 of the DAR was informed by lessons learned on the Tłı̨chǫ Highway and Inuvik to Tuktoyaktuk Highway projects and was developed to achieve the goal of maximizing business, employment, and training opportunities for local workers, contractors and businesses.

The goal of maximizing employment opportunities by extending the construction period, was a strong theme discussed during early engagement (see Section 2.1.6.3, Table 2.3 Summary of Project Updates and Engagement Feedback; and Section 2.1.6.5, Table 2.5 Summary of Assessment Findings and Project Effects Engagement Feedback) but predates the unprecedented environmental conditions in recent years which have significantly impacted community re-supply. As mentioned above, it is clear that a more expedited construction schedule is strongly desired by many Indigenous Governments and community residents.

Consideration of schedules associated with alternate construction approaches is presented in

Section 7.3.1 of the DAR, and evaluation of construction approaches is presented in Section 7.3.2. The alternative construction schedule includes short highway segments (20 km or less) constructed under separate contracts over a timeframe that would likely exceed 20 years.

As stated in Section 7.3.2.3 of the DAR, both construction options are feasible. The likelihood of either approach being advanced depends on various factors including funding availability, strategic priorities, feedback from Indigenous Governments and community organizations, and the findings from the environmental assessment.

B. The GNWT has indicated in Section 5.4.1, that should the *construction* schedule [emphasis added] extend beyond 20 years, there may be a need for additional studies and mitigation measures to address uncertainty in predicting effects of construction activities specifically (which are generally of greater intensity than those of the operations and maintenance phase) on the environment so far into the future.

The statement was not made in the context of highway *operations*, which are inherently expected to extend well beyond 20 years into the future, and whose effects are already assessed in the DAR. The GNWT has discussed uncertainties and prediction confidence in each assessment section, applied a precautionary approach where needed, and has also committed to monitoring and adaptive management.

The GNWT's approach to adaptive management is described in Section 23.2. It is consistent with the adaptive management approach applied during the construction (complete) and operations (ongoing) of the Tłı̨chǫ Highway, and approaches in other jurisdictions (e.g., BCMECCS, 2022; Government of Yukon, 2021).

Adaptive management is not proposed to reduce prediction uncertainty. Adaptive management is proposed as a process to monitor, evaluate, and if necessary, respond, if specific conditions are observed that may indicate mitigation measures are not working as intended. Adaptive management can also identify when additional management actions are required to address any unanticipated effects.

The GNWT will engage with Indigenous Governments, Indigenous organizations, other land and resource managers, and co-management organizations on adaptive management actions.

C. See combined response above.

References:

British Columbia Ministry of Environment ad Climate Change Strategy (BCMECCS). 2022. Development and Use of Adaptive Management Plans v.3.0. Technical Guidance MIN-20. Available at: tg20_guide_to_preparing_adaptive_management_plans.pdf (gov.bc.ca)

Government of Yukon. 2021. Guidelines for developing adaptive management plans in Yukon. Water-related components of quartz mining projects. Available at: env-amp-guidelines.pdf (yukon.ca)

Topic: Mackenzie Valley Environmental Impact Review Board (Review Board) Information Request -2 Future Environmental Conditions

Preamble from the Review Board: The Review Board's 2013 letter (as described in the preamble of IR#1 above) described concerns about the long construction schedule and the uncertainties and challenges this creates for impact prediction. The GNWT responded, on Nov. 13, 2013, that "… the assessment will also include a review of best available data relating to predicted future potential changes to baseline conditions. For example, the potential effects of climate change (sic). This data will be used in the assessment to discuss how baseline conditions may change and how that could affect the conclusions of the assessment" (PR#40).

Section 24 and Appendix 24A provide clear evidence that climate conditions will be very different in the future than compared to historical conditions, for example in relation to permafrost. However, the Review Board sees little evidence of the GNWT considering this for most of its impact predictions in the DAR, and is not satisfied with the GNWT's efforts to do so for the majority of valued components. In the absence of predicted future conditions as resulting from climate change, the Review Board and parties cannot adequately evaluate the likely impacts on the highway, and stemming from the highway, nor adequately evaluate the effectiveness of proposed mitigations measures.

The Review Board understands the difficulties inherent in predicting future habitat and wildlife conditions. However, the evidence that past conditions are not likely to represent future conditions is clear (for example, looking at changes in fire regimes). A reasonable assessment approach to dealing with the range of potential future conditions is to project scenarios of environmental conditions, and assess what these mean for different valued components. These scenarios should be at a scale appropriate to evaluate project specific and cumulative effects to Key Lines of Inquiry and Subjects of Note.

Request from the Review Board:

A. Please apply the climate projections from the Climate Lens Part II: Climate Change Resilience Assessment (Appendix 24A) and assess what this would mean for future environment conditions, including for habitat and wildlife.
   i. Please provide projections of future environmental and habitat conditions for areas that include project local and regional assessment areas, as well as areas in relevant Boreal Caribou Range plans over the time periods used in Appendix 24A:
      - 2020s (2010 to 2039)
      - 2050s (2040 – 2069)
      - 2080s (2070 to 2099)
   ii. As part of these projections of future environmental conditions, the developer should:
      - consider changes to forest fire intensity and magnitudes
      - consider environmental extremes such as heat, wind, precipitation, icing events
      - base projections on best available science and Indigenous Traditional Knowledge
      - provide a detailed description of assumptions and limitations

Response from the Government of the Northwest Territories:

Introduction

The GNWT's response to Parts i. and ii. have been combined. To inform the response to the request for projections of future environmental and wildlife habitat conditions over the requested timeframes, the GNWT has provided an updated climate profile for the Project, based on more recent climate modeling information. The attached Climate Change Resilience Assessment (CCRA) Addendum (K'alo-Stantec, 2024) is an update to the CCRA previously included in the DAR as Appendix 24A. The CCRA Addendum includes an updated climate profile in Appendix A. To address the request to consider how forest fires and environmental extremes contribute to future environmental and wildlife habitat conditions, the GNWT has reviewed and summarized relevant scientific literature and available Traditional Knowledge[1] for each of the environmental valued components (VCs) including key lines of inquiry (caribou and moose), and subjects of note (vegetation, wildlife and wildlife habitat, birds, and bird habitat), and additionally, species at risk. Each VC section discusses uncertainties and limitations of the predictions presented in the published literature. After review of the scientific literature and Traditional Knowledge, conclusions of the assessment remain unchanged.

Overall, the updated climate profile projections for the Project (in K'alo-Stantec 2024), in combination with a literature review of potential climate-related changes to vegetation and wildlife habitat, suggest there could be both positive and adverse changes in the local and regional assessment areas (LAA and RAA) for valued components (VCs). These predictions are made with considerable uncertainty. Therefore, project design and adaptive management are appropriate to manage the considerable uncertainties associated with predicting environmental and habitat conditions into the far future.

The GNWT has taken into account that over the indeterminate, long life of the Project, there will be changes in future environmental and habitat conditions in the NWT and within the LAA and RAA. Measurable parameters of climate change (e.g., air temperature, active layer depth, precipitation, permafrost extent) are some of the variables that may contribute to changes in VCs over the long-term operation of the Project. Potential yet uncertain changes to baseline environmental and habitat conditions have been acknowledged in the DAR (Sections 15.7.2 [water quantity], 17.8.2 [fish and fish habitat], 18.7.2 [vegetation and wetlands], 19.7.2 [wildlife and wildlife habitat], birds and bird habitat [20.7.2]). It is the GNWT's view that, for the purposes of environmental assessment, current conditions are adequate to predict project effects, proposed management plans are likely to be effective, and conclusions can be relied upon.

In acknowledgement of uncertainty associated with predicting effects over a long timeframe, the GNWT has proposed various programs of additional monitoring, evaluation, and response as part of an adaptive management process to manage the effects of the Project on the environment over the long

[1] The GNWT-INF provided capacity funding for Pehdzéh Kį First Nation and Łíídlıı̨ Kúę́ First Nation to complete project-specific traditional land and resource use (TLRU) studies for the Project. No TLRU reports have been received from Pehdzéh Kį First Nation as of June 19 2024. Łíídlıı̨ Kúę́ First Nation's TLRU study report is anticipated in summer 2024.

term of operations. Adaptive management steps are included in the draft Wildlife Management and Monitoring Plan, draft Erosion and Sedimentation Control Plan, draft Fish and Fish Habitat Protection Plan, and draft Permafrost Protection Plan (DAR Volume 5).

The Importance of Considering Climate Change

The Review Board's request highlights the importance of considering climate change in project decisions. The GNWT's principal purpose for conducting a Climate Change Resilience Assessment (Appendix 24A, as updated in K'alo-Stantec [2024]) and assessing effects of the environment on the Project (Section 24), was to understand how climate change could impact the Project. This is especially important given that the Project will be piece of strategic infrastructure in the NWT. A key purpose of the Mackenzie Valley Highway is to provide resilient infrastructure to address the ongoing effects of climate change on the reliability of current transportation systems that connect communities in the Mackenzie Valley (winter road, barges). The design and ongoing management of the Project will reflect the GNWT's understanding of future impacts and risks associated with climate change. To this end, the CCRA's identification of risks to the infrastructure considered how changes to climate parameters can lead to impacts to the highway infrastructure and highway users through pathways such as loss of permafrost, changes in hydrology, increase in wildfires, wind events and icings. The GNWT's view is that adaptation to climate risks to infrastructure is the most important focus of consideration of climate change for a project of this size and importance.

In response to the Review Board's Information Request, additional information related to climate change projections of future environmental and wildlife habitat conditions is presented below. However, in addition to impacts to biophysical aspects of the Project, it is also important to consider how climate change will affect people and communities. In 2021, the GNWT contracted Intrinsik Corp, SLR Consulting (Canada) Ltd, and Sijja Consulting to prepare a Climate Change and Health Vulnerability Assessment for the Northwest Territories. While this report is not specific to the Mackenzie Valley Highway project itself, the report describes the impact of Climate Change on individuals and communities across the NWT (Intrinsik Corp et al. 2021). The report outlined that individuals who are already vulnerable, through existing long-term illness or disability, low income, or another social disadvantage, are likely to be disproportionately affected by climate change. Climate change and related events have been linked to increased mental health impacts, including rates of depression, anxiety, and pre- and post- traumatic stress; increased drug and alcohol usage; and increased suicidal ideation, suicide attempts, and death by suicide. In the NWT, Indigenous populations, on average, face poorer health outcomes primarily due to longstanding socioeconomic inequities, which are a result of the ongoing legacy of colonialism, the inter-generational trauma of residential schools, and inequalities in access to health services. Climate change impacts are likely to exacerbate these inequities. Increase in, and unpredictability of, extreme weather events can also have adverse impacts on traditional hunting and trapping grounds, including impacts to accessing them, impacts to the safety of those accessing them, and impacts to the animals that are hunted and trapped. This may eventually lead to a greater difficulty in Traditional Knowledge sharing between generations. Please note, the Climate Change and Health Vulnerability Assessment will be submitted to the Review Board's Public Registry as a separate document and will be available for the public to review.

Vegetation

The average annual mean temperatures in Norman Wells and Fort Simpson was predicted to increase 3.9 to 4.1 degrees by the 2050s and 6.5 to 6.9 degrees by the 2080s (K'alo-Stantec, 2024). With increasing temperature, there is a predicted reduction in area of permafrost and increase in fire frequency, intensity, and the length of the fire season (Canadian Forest Service 2024; K'alo-Stantec 2024). These factors were predicted to potentially change the composition and distribution of vegetation within the Taiga Plains ecozone in the NWT, which includes the RAA (Stewart et al. 2023). Regardless of the distribution of future landcover types in the LAA and RAA, with the mitigation for Project effects on vegetation presented in the DAR, there are no anticipated changes to the conclusions in the DAR, Section 18.

Predictions of the nature, extent, and distribution of the vegetation changes due to climate change varies by climate prediction model. Some models predicted a change from conifer dominated forest (either black spruce, white spruce, or both) to deciduous dominated forest (aspen) (Stewart et al. 2023). Specifically, Stewart et al. (2023) predicted that there will be a general shift from conifer to deciduous or mixedwood forest in the NWT (including the RAA) except in the Dehcho South region which is located south of the RAA. In this region, an increase in coniferous forest with a reduction in deciduous forest was predicted. In addition, they projected an average net increase in forest biomass in the NWT of 76 tons per hectare during the 21st century (Stewart et al. 2023).

Stewart et al. (2023) also predicted that the spread of invasive plant species into natural ecosystems and the spread of forest pests in the NWT including the RAA will accelerate with climate change. The spread was predicted to move from south to north along roads and other disturbances.

Although not specific to the RAA, Reid et al. (2022) identified widespread expansion of shrub communities and reduced tree growth in the Arctic including in the NWT as being directly attributable to warming temperatures, drought, and increased fire intensity associated with climate change. They further asserted there will be a shift from coniferous to deciduous dominance throughout the western boreal forest including in the NWT in general (Reid et al. 2022). In their estimation vegetation communities in some areas of the NWT and Yukon, generally, may begin to resemble existing vegetation communities in Alberta and British Columbia (Reid et al. 2022).

Associated with predictions of increased drought, Reid et al. (2022) predicted a potential increase in the extent of grasslands and a decrease in the extent of forest in the Yukon. They also predicted that drier conditions and associated increase in fire frequency and intensity will cause conversion of some coniferous forest to deciduous forest in the Yukon (Reid et al. 2022).

Blyth et al. (2016), citing Hogg and Bernier (2005), indicated that some models predicted that precipitation will be reduced due to climate change resulting in drying lakes and resulting in bogs being replaced by parkland and grassland ecosystems in the southern NWT including southern portions of the RAA. In addition, they also predicted a reduction in extent of conifer forest due to reduced precipitation resulting in lower rates of conifer regeneration. They estimated that conifer forest would be replaced by

deciduous (aspen) forest in the southern NWT including southern portions of the RAA (Blyth et al. 2016).

Huberman et al. (2022) indicated that thawing permafrost across southern and central portions of the NWT including portions of the RAA has been linked to localized flooding and would result in replacement of coniferous forests with shrub- and moss-dominated plant communities. Specifically, they indicated that thawing permafrost would cause spruce-lichen vegetation communities to be replaced with non-forested shrub and moss communities associated with permafrost collapse scars. Conversely, Huberman et al. (2022) estimated that permafrost thaw may lead to the development of forest in previously non-forested land and greater rates of tree growth in wetlands in the NWT; however, they indicated that this has not yet been observed in the NWT and they did not indicate what tree species would be favoured by this mechanism.

Huberman et al. (2022) further predicted that climate change would increase wildfire frequency and intensity, which would alter forest species composition by decreasing peat accumulation and increasing forest cover in the NWT generally, although not specifically in the RAA (Huberman et al 2022). They also did not specify which tree species have increase under this scenario.

Using ecosystem climate envelope (cliome) modelling, the University of Alaska Fairbanks (2012) predicted that under a whole world high emissions scenario landcover in southern portions of the NWT could become grasslands and that no areas of the NWT would retain their current landcover by the end of the 2090s. Using the Climate Moisture Index (CMI), Lemprière et al. (2008) and Wang et al. (2014) suggested significant change in NWT vegetation that it could become too dry for closed canopy forests in currently forested portions of the NWT, particularly in the southern NWT, by 2100 under a high emissions scenario.

As presented in the DAR, Section 18, coniferous forest is the most common landcover type in the RAA followed by wetlands and less commonly by shrublands. Deciduous (broadleaf) forest and mixedwood forest as well as herbaceous and unvegetated areas are the least abundant landcover types in the RAA.

Based on potential effects on landcover type distribution due to climate change (discussed in the preceding paragraphs), including potential changes in fire regime and permafrost distribution, it is possible that some of the current coniferous forest landcover in the LAA and RAA could change to deciduous or mixedwood forest by 2050 and an additional portion by 2080. Likewise, shrublands in the LAA and RAA could increase by 2050 and additionally by 2080. The percentage of wetland area may decrease with a warming and drying climate. The amount of deciduous and mixedwood forest could increase or decrease depending upon how much lost area of these landcover types is offset by gained area elsewhere in the LAA and RAA.

The literature and models discussed above do not provide enough certainty or precision to further quantitatively characterize changes to vegetation at the scale of the RAA. However, climate change is not expected to completely remove any of the existing landcover types from the LAA or RAA by 2050. Effects on vegetation cover over a longer period of time are more uncertain, but may include the removal of one or more landcover types.

Caribou

Based on results published in literature relevant to the boreal caribou (*Rangifer tarandus caribou*) NT1 range and Caribou and Moose local assessment area (LAA), climate change may both positively and negatively affect boreal caribou habitat and habitat selection. All studies emphasized that there is considerable uncertainty in these types of predictions due to the high variability in climate models, and the dynamic and complex nature of ecosystems, making it especially difficult to predict the effects of fire, particularly, on boreal caribou habitat.

Traditional Knowledge-related concerns regarding climate change and risks to boreal caribou are summarized in the updated CCRA for the Project (K'alo-Stantec, 2024; Addendum to Appendix 24A) and include observations of changing shifts in the timing of caribou calving; ice-crusting events making foraging and escape from predators difficult; changing weather patterns affecting lichen availability; and higher water levels in smaller waterbodies facilitating increased hunter access into caribou habitat. Other than those observations, no Traditional Knowledge was provided that specifically provides an answer to this Information Request.

The updated CCRA, and published reports of studies are relevant to describing potential climate-related changes to boreal caribou habitat. Studies that are pertinent to the Caribou and Moose LAA and NT1 range are discussed below.

One report and one published paper considered climate change and potential effects on caribou habitat in the NT1 range/Taiga Plans ecozone. 'Blyth et al. (2016) modelled combined forest fire and timber harvesting with different climate change scenarios to predict boreal caribou habitat disturbance levels up to 2090. Stewart et al. (2023) simulated forest growth and wildfire including changes to a caribou resource selection function (RSF) habitat model (also used in this assessment, DeMars et al. 2020) as well as caribou population growth from 2011 through 2100 in southern and northern monitoring areas within the NT1 population unit. Although the projections are not specific to the multi-decadal units requested, the information helps to consider caribou habitat possibilities to 2100.

Blyth et al. (2016) conducted 120 scenarios incorporating climate change in future fire regimes, forest succession and harvest, linear and areal disturbance, and disturbance recovery to 2090. The northern extent of the study includes the Dehcho portion of the Caribou and Moose LAA within the NT1 range. Based on some forecasting uncertainty that included mean annual burn rates, variability in climate models, forest fuel recovery, and no additional anthropogenic disturbance over time, boreal caribou habitat (based on a measure of disturbance) in the southern part of NT1 may change ±15% through to 2090, depending on the climate model used. There was no attempt to link habitat results to caribou population growth parameters.

Stewart et al. (2023) simulated forest growth and wildfire, changes to the caribou RSF habitat model and predicted caribou population growth from 2011 through 2100 in southern and northern monitoring areas within the NT1 population unit. The results suggest that habitat suitability might increase in the central and southwest regions of the NT1 range/Taiga Plains ecozone but decrease in the southern and northwestern portions of the area, suggesting a potential shift in the boreal caribou range. Regardless

of the expected changes in habitat conditions, population growth rates were predicted to remain stable until 2100, with no notable changes in the decadal periods requested by the Review Board. That study listed several assumptions and limitations associated with their forecasting approach, including uncertainty in local demographic rates, unknown changes to anthropogenic disturbance, and the assumption that caribou behaviour will remain unchanged through the modelling period.

The above studies have attempted to forecast habitat conditions with climate change considerations and anthropogenic disturbances to the end of the century, though not specific to the decadal periods requested. They clearly showed that climate change may positively and negatively affect boreal caribou habitat selection in the Caribou and Moose LAA. These specific studies also emphasized the considerable uncertainty in the model predictions.

Moose

Several publications have suggested changes in moose (*Alces alces*) distribution associated with climate-induced changes to habitat. Based on the climate-related habitat change predictions noted in the literature and the summary of likely changes in vegetation noted previously, moose abundance and distribution will likely change in the RAA over the next century. No information was specific to the decadal periods requested by the Review Board, and no Traditional Knowledge information specific to moose and climate change was made available for this assessment.

Moose habitat conditions in northern Canada might increase with climate change. Across the North American continent, the moose range might increase by 34–40% by 2070, depending on the climate scenario considered (regions where climate conditions will be similar to that in the range already occupied) (Deb et al. 2020). This range expansion, mostly northward, might continue and has already been observed in Arctic North America, with moose abundance increasing above the tree line and climate-related increasing shrub habitat (Tape et al. 2016a, b).

A changing fire regime associated with climate change is noted in the updated CCRA for the Project (K'alo-Stantec, 2024; Addendum to Appendix 24A). Based on a study in northwestern Alaska, an expected increase in the average annual number of areas burned will bring habitat change that might benefit moose (Joly et al. 2012). While core caribou winter habitat is negatively affected, moose habitat might increase with increased fire regularity up to 2054 and be substantially greater by 2099 (Joly et al. 2012). If the RAA experiences a similar change in fire ecology (as predicted in the updated CCRA), proportional changes could be observed in the RAA over the next century.

As noted in other sections, numerous assumptions and limitations are associated with predicting climate change effects on moose and moose habitats. None of the papers explicitly stated the limitations of their models, but there were many implied limitations. Projections were limited by the ability of the forecasting models to account for the interaction of variables (e.g., changing temperature, moisture regimes, fire ecology) and effects on vegetation succession patterns. Deb et al. (2020) noted that detailed knowledge about dispersal and colonization capabilities limits their predictions on moose range expansion. Joly et al. (2012) acknowledged the challenges of unpredictable wildfire behaviour (e.g.,

extent and variability) and predicting vegetation successional pathways associated with climate change. They also noted the lack of inland climate monitoring stations as a data gap.

Wildlife and Wildlife Habitat

Based on the climate profile in the updated CCRA for the Project (K'alo-Stantec, 2024; Addendum to Appendix 24C), and projected changes in vegetation communities described earlier, future habitat conditions will likely change habitat suitability for wildlife species of conservation concern (SOCC), including species at risk and those considered to be important to Indigenous governments, Indigenous organizations, or other affected parties. The projected changes to fire regimes and possible shifts from coniferous to deciduous forest in parts of the NWT (Stewart et al. 2023) could potentially reduce habitat abundance or connectivity for marten (*Martes americana*) (Wasserman et al. 2012), lynx (*Lynx canadensis*), black bear (*Ursus americanus*), and grizzly bear (*Ursus arctos*) (Friggens et al. 2018) in the RAA, with potential increases in habitat for moose (see above) and little brown myotis (*Myotis lucifugus*). An increase in early successional habitats (due to wildfire) and shrub-dominated habitats might benefit moose (i.e., browse) or bears (i.e., berry-producing shrubs) depending on shrub species composition. The potential effects of climate change on wildlife species associated with wetlands will likely vary depending on projected changes to various wetland types (e.g., bog, fen, open water) and species-specific habitat requirements (e.g., muskrat [*Ondatra zibethicus*], beaver [*Castor canadensis*]). Although climate change projections indicate there will likely be changes to landcover and habitat suitability for various wildlife species, there is uncertainty associated with the spatial location and extent of landcover change (e.g., wildfire) in the RAA, which will vary over the short (2020s), medium (2050s) and long term (2080s). Prediction uncertainty is as noted previously for boreal caribou and moose.

Species at Risk

Singer and Lee (2021) provided a broad overview of the vulnerability of NWT species at risk to climate change. A summary of the vulnerability risk assessment for species at risk with potential to occur in the RAA is provided below.

Overall, forest fire frequency and intensity may increase in the future, which could result in heat stress as well as potential phenological mismatches between timing of forage availability and peak forage requirements for many mammal species. Climate change effects are expected to affect species range and distributions, food availability/accessibility, migration, health and survivability, with both positive and adverse changes possible.

Specifically, climate change may result in grizzly bear range expansion in the NWT due to changes in multiple climate variables (e.g., warmer summer temperatures) while other changes to vegetation communities due to fires, flooding, or drought, may affect grizzly bear food availability. In addition, climate change may result in shifts in the timing of seasons, and mismatches between spring den emergence and food availability (Singer and Lee 2021).

Wolverines (*Gulo gulo*) require spring snow cover for denning and reduced spring snow cover associated with climatic warming is expected to reduce the extent of wolverine habitat, with an

associated loss of connectivity (Copeland et al. 2010). The climate profile in K'alo-Stantec (2024) indicated snow accumulation may not substantially change over the short (2020s) or medium term (2050s); but there could be a 10-20% reduction by 2100. In addition, the duration of snow cover was expected to decline, which could affect spring snow cover and reduce denning habitat suitability. In the NWT, a projected increase in snowfall may be offset by a shorter snow season. In addition, earlier springs may improve primary productivity in wolverine habitat, resulting in a possible benefit to wolverines in the northern parts of their range (Singer and Lee 2021) including the RAA.

A warming climate may result in both positive and negative effects on hibernating bats in the RAA. Although an increase in mean annual and seasonal temperatures may increase the foraging season and decrease the duration of hibernation, changes to temperature and humidity conditions in hibernacula could result in a reduction in hibernation habitat suitability and survival. Warmer temperatures could also result in a northward range expansion for little brown myotis, but this will depend on roost availability. How climate change will affect the spread and virulence of white-nose syndrome is uncertain (Singer and Lee 2021).

Singer and Lee (2021) also assessed vulnerability of insect species at risk including gypsy cuckoo bumble bee (*Bombus bohemicus*), yellow-banded bumble bee (*Bombus terricola*), western bumble bee (*Bombus occidentalis*) and transverse lady beetle (*Coccinella transversoguttata*). The potential for mismatches to develop between bee emergence and flowering times/host emergence as a result of climate change could affect all three bumble bee species potentially present in the RAA and could result in severe population declines. The transverse lady beetle was expected to be less sensitive to climate change because they feed on a variety of prey items (i.e., not limited by a potential decline in one prey item) and are also threatened by competition from non-native beetles.

Although climate change has potential to change wildlife and wildlife habitat over the long term, it is important to recognize there is considerable uncertainty associated with predictions of ecological response to future climate changes, and each species adaptive capacity to respond to a changing climate will vary. In addition, there are non-climate stressors (e.g., anthropogenic disturbance, harvesting) (Singer and Lee 2021) that can also affect wildlife abundance and distribution in the RAA.

Birds and Bird Habitat

Based on the results of the climate profile included in the updated CCRA for the Project (K'alo-Stantec, 2024; Addendum to Appendix 24C), and projected changes in vegetation communities described above, future habitat conditions will likely result in changes to habitat suitability for bird species of conservation concern (SOCC) in the RAA, including species at risk, as well as those considered to be important to Indigenous governments, Indigenous organizations, or other affected parties.

Changes or shifts from coniferous to deciduous forest, where and if they occur in the RAA, will potentially reduce habitat abundance for spruce grouse (*Falcipennis canadensis*); however, changes in bird habitats are also influenced by fire severity (Knaggs et al. 2020). For example, an increase in fire frequency and severity may result in an increase in habitat for birds that utilize burns such as olive-sided flycatcher *(Contopus cooperi*) or black-backed woodpecker (*Picoides arcticus*), however, other

species may respond negatively to fire (e.g., ruby-crowned kinglet [*Regulus calendula*]) (Knaggs et al. 2020). A potential increase in shrub-dominated habitats might benefit upland game birds. Overall, it is difficult to predict potential effects of climate change on bird species that utilize a variety of landcover types. For example, Swainson's thrush (*Catharus ustulatus*) was detected in coniferous, broadleaf as well as mixedwood and shrubland habitats during the breeding bird surveys completed for the Project (Section 20.0, Appendix 20A, Birds and Bird Habitat Technical Data Report). As such, a projected decrease in coniferous forest over time may be partly offset by a potential increase in other suitable habitat types (e.g., deciduous, shrublands) for generalist species. The potential effects on bird species associated with wetlands will likely vary depending on projected changes to various wetland types (e.g., bog, fen, open water) and species-specific habitat requirements (e.g., rusty blackbird [*Euphagus carolinus*], yellow rail [*Coturnicops noveboracensis*], lesser yellow legs [*Tringa flavipes*], waterfowl).

The potential effects of climate change on specific bird species and/or groups have been addressed for specific regions in the NWT. For example, Micheletti et al. (2021) developed statistical and simulation models to integrate boreal landbird density, wildfire, and forest growth using the Spatial Discrete Event Simulation (SpaDES) modeling framework. The SpaDES models were developed and applied to the Taiga Plains ecozone in the NWT, which overlaps the RAA.

Projected changes in climate and habitat resulted in an increase in species distributions for 47 of 64 (73%) bird species studied, and a decrease in distributions for 16 of 64 (25%) bird species within the Taiga Plains ecozone by 2100 (Micheletti et al. 2021). Overall, the results of the SpaDES indicated that climate change would result in "winners" and "losers" depending on individual species habitat associations. Specifically, species that utilize a diverse range of habitat types and species associated with deciduous forest (e.g., yellow warbler [*Setophaga petechia*], ruffed grouse) were predicted to increase whereas species dependent on conifer forests (e.g., boreal chickadee [*Poecile hudsonicus*]), non-forested habitats (Lincoln's sparrow [*Melospiza lincolnii*]) and treeline-tundra (horned lark [*Eremophila alpestris*]) were expected to have less habitat available by 2100. Projected net decreases in bird species richness (i.e., number of bird species) were more pronounced in the northeast and south-central regions of the NWT outside of the RAA. Although there are areas between Tulita and Norman Wells that were projected to result in a reduction in bird species richness, other areas along the Mackenzie River were projected to show a potential increase in bird species richness (Micheletti et al. 2021).

Overall, Micheletti et al. (2021) reported that the abundance and distribution of landbirds were affected by climate change through the indirect effects of climate on their habitat (vegetation) as well as through direct climate effects (e.g., physiological responses to temperature and precipitation) (Riddell et al. 2021). However, direct climate effects were two orders of magnitude more important in explaining predicted changes in landbird occupancy than climate-induced changes in vegetation or wildfire (i.e. indirect effects). Micheletti et al. (2021) suggested that the marginal response of indirect effects on the distribution of boreal landbirds in the NWT may be due to time lags in vegetation response to changes in climate. They also acknowledged that the SpaDES did not include all ecological processes (e.g., wetland dynamics, permafrost, extreme weather events).

Gahbauer et al. (2022) used bird species distribution models to predict changes in environmental suitability during summer and winter for 434 bird species under a 2˚C warming scenario in Canada's national park system including parks representative of the Taiga region in the NWT. These authors acknowledged that there is considerable variability in the distributional shift of individual species, and in the resulting changes in community composition at individual parks. The parks assessed in the NWT (e.g., Nahanni National Park Reserve, outside of the RAA) indicated potential increases in bird species richness during both summer and winter. Although 70% of projections of suitability were predicted to change over time, those changes included both potential increases and decreases in suitability depending on individual bird species. In addition, parks were projected to experience either species colonization or extirpation.

The vulnerability risk assessment completed by Singer and Lee (2021) also addressed bird species at risk. The authors reported that changes to the forest fire frequency and intensity as well as changing moisture conditions are likely to result in changes to the abundance and distribution of suitable habitat for individual bird species. Specifically, forest fire frequency and severity are expected to increase with climate change, which may reduce the amount of breeding habitat available. Depending on the intensity, location and time since burn, insect availability (i.e., food source) may increase or decrease (Singer and Lee 2021).

Declines in insect prey availability and the potential for phenological mismatch between timing of insect emergence and bird breeding seasons are likely to affect aerial insectivores such as bank swallow, common nighthawk, and olive-sided flycatcher. In addition, extreme weather events, particularly rainfall, river flooding, and bank collapse can also cause mortality of adults and nestlings, which affects bird survival. The potential effects of climate change on birds may result in some bird species distributions shifting northwards (Singer and Lee 2021).

Overall, how animals respond to climate change (e.g., adapt, decline, move or shift) remains uncertain (Singer and Lee 2021) and the complexity of ecological interactions poses limitations to predicting how climate change will affect species-specific interactions such as predator-prey relationships (Laws 2017, Gahbauer et al. 2022).

Conclusion

The results of the climate profile projections for the Project (in K'alo-Stantec 2024), in combination with a literature review of potential climate change-related changes to vegetation and wildlife habitat, suggested there could be both positive and adverse changes in the RAA through the 2020s, 2050s and 2080s, depending on species-specific habitat associations. These predictions were made with considerable uncertainty.

The GNWT accepts that over the indeterminate, long life of the Project there will be changes in future environmental and habitat conditions in the NWT and within the RAA used to assess potential effects on environmental VCs. Measurable parameters of climate change (e.g., temperature, precipitation) will likely represent some of the many variables contributing to potential changes in environmental VCs over the long-term operation of the Project. The inherent complexity of ecosystem response is reflected in

the uncertainty of conclusions emphasized in the referenced literature. Potential, yet uncertain changes to baseline environmental and habitat conditions have been acknowledged in the DAR (Section 15.7.2 [water quantity], 17.8.2 [fish and fish habitat], 18.7.2 [vegetation and wetlands], 19.7.2 [wildlife and wildlife habitat], birds and bird habitat [20.7.2].

Notwithstanding the uncertainties, it is GNWT's view that, for the purposes of providing information in support of an environmental assessment, current conditions are adequate to predict effects, proposed effects management plans are likely to be effective, and conclusions can be relied upon. Climate change predictions do not necessarily improve the certainty of conclusions in the assessment. Uncertainty is acceptable in environmental assessment if actions are implemented to address uncertainty, through adaptive management. Adaptive management is not proposed to reduce prediction uncertainty – rather it is proposed to monitor specific predicted effects, so that changes (to management actions) are made if needed to manage the effects of the Project on the environment and the environment on the Project over the long term of operations.

The GNWT's approach to adaptive management is described in Section 23.2 of the DAR. It is consistent with purpose and approaches used in other jurisdictions (e.g., BCMECCS, 2022; Government of Yukon, 2021).

Throughout the DAR, and specifically in draft Management Plans of Volume 5 (for example the draft Wildlife Management and Monitoring Plan), adaptive management, or inspection and response, is described as a process to monitor, evaluate, and if necessary respond if specific conditions are observed that may indicate mitigation measures are not working as intended. Some management actions require collaboration with Indigenous governments, Indigenous organizations, other land and resource managers, and co-management organizations.

References

Blyth, C.A., D. Daust, B. Armitage, D. Cichowski, S. Alexander and K. Price. 2016. Landscape projections on boreal caribou habitat in NWT. Prepared for Government of Northwest Territories, Yellowknife, NWT.

British Columbia Ministry of Environment ad Climate Change Strategy (BCMOCCS). 2022. Development and Use of Adaptive Management Plans v.3.0. Technical Guidance MIN-20. Available at: tg20_guide_to_preparing_adaptive_management_plans.pdf (gov.bc.ca)

Canadian Forest Service. 2024. Canadian National Fire Database – Agency Fire Data. Edmonton, Canada: Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre. https://cwfis.cfs.nrcan.gc.ca/ha/nfdb.

Copeland, J. P., K.S. McKelvey, K.B. Aubry, A. Landa, J. Persson, R.M. Inman, J. Krebs, E. Lofroth, H. Golden, J.R. Squires, A. Magoun, M.K. Schwartz, J. Wilmot, C.L. Copeland, R.E. Yates, I. Kojola, and R. May. 2010. The bioclimatic envelope of the wolverine (Gulo gulo): Do climatic constraints limit its geographic distribution? Canadian Journal of Zoology 88: 233–246.

Davidson et al.2020. Ecological insights from three decades of animal movement tracking across a changing Arctic. Science 370: 712–715.

Deb, J.C., Forbes, G., and MacLean, D.A. 2020. Modelling the spatial distribution of selected North American woodland mammals under future climate scenarios. Mammal Review 50(4):440–452. DOI: 10.1111/mam.12210

DeMars, C., Hodson, J., Kelly, A., Lamontagne, E., Smith, L., Groenewegen, K., Davidson, T., Behrens, S., Cluff, D., and Gurarie, E. 2020. Influence of Land Cover, Fire and Human Disturbance on Habitat Selection by Boreal Caribou in the NWT. Project 202 of the Government of the Northwest Territories Department of Environment and Natural Resources, Northwest Territories Cumulative Impact Monitoring Program. 70 + 159 app pp.

Friggens, M.M., M.I. Williams, K. E. Bagne, T.T. Wixom, and S. A. Cushman. 2018. Effects of Climate Change on Terrestrial Animals – Chapter 9. Climate change vulnerability and adaptation in the Intermountain Region [Part 2]. USDA Forest Service RMRS-GTR-375

Gahbauer, M.A., S.R.. Parker, J.X. Wu, C. Harpur, B.L. Bateman, D.M. Whitaker, D.P. Tate, L. Taylor, and D. Lepage. 2022. Projected changes in bird assemblages due to climate change in a Canadian system of protected areas. PLoS ONE 17(1): e0262116. https://doi.org/ 10.1371/journal.pone.0262116

GNWT. 2022. NWT State of the Environment Report. TD 673-19(2).

Government of Yukon. 2021. Guidelines for developing adaptive management plans in Yukon. Water-related components of quartz mining projects. Available at: env-amp-guidelines.pdf (yukon.ca)

Hogg, E. H., and Bernier, P. Y. 2005. Climate change impacts on drought-prone forests in western Canada. The Forestry Chronicle, 81(5), 675-682.

Huberman, Y., J. Beckers, R. Brett, G. Castilla, R. Errington, E.C. Fraser-Reid, D. Goodsman, E.H. Hogg, J. Metsaranta, E. Neilson, J. Olesinski, M.-A. Parisien, D. Price, T. Ramsfield, C. Shaw, D. Thompson, M.F. Voicu, E. Whitman, and J. Edwards. 2022. The State of Northwest Territories Forests in the Wake of Climate Change: Baseline Conditions and Observed Changes to Forest Ecosystems. Information Report NOR-X-430, Northern Forestry Centre, Canadian Forest Service

Intrinsik Corp., SLR Consulting (Canada) Ltd, and Sijja Consulting. 2021. Climate Change and Health Vulnerability Assessment of the Northwest Territories. Prepared for the GNWT Department of Health and Social Services.

Joly, K., Duffy, P.A., and Rupp, T.S. 2012. Simulating the effects of climate change on fire regimes in Arctic biomes: implications for caribou and moose habitat. Ecosphere 3(5):1–18. DOI: 10.1890/ES12-00012.1

K'alo-Stantec. 2024. Mackenzie Valley Highway Project –CCRA Addendum (update to Mackenzie Valley Highway Project Climate Change Resilience Assessment [2021]). Prepared for Government of the Northwest Territories Department of Infrastructure.

K'alo-Stantec. 2021. Climate Lens Part II: Mackenzie Valley Highway Project Climate Change Resilience Assessment. Prepared for Government of the Northwest Territories Department of Infrastructure. Mackenzie Valley Highway Developer's Assessment Report Volume 4, Appendix 24A [PR#111] Accessed at: reviewboard.ca/upload/project_document/mvh_dar_vol_4_1of1_20231011_fin.pdf

Knaggs, M., S. Haché, S. E. Nielsen , R. F. Pankratz, and E. Bayne. 2020. Avian Response to Wildfire Severity in a Northern Boreal Region. Forests 2020, 11, 1330; doi:10.3390/f11121330

Laws. A. 2017. Climate change effects on predator-prey interactions. Current Opinion in Insect Science 23:28–34.

Lemprière, T.C.; Bernier, P.Y.; Carroll, A.L.; Flannigan, M.D.; Gilsenan, R.P.; McKenney, D.W.; Hogg, E.H.; Pedlar, J.H.; Blain, D. 2008. The importance of forest sector adaptation to climate change. Nat. Resour. Can., Can. For. Serv., North. For. Cent., Edmonton, AB. Inf. Rep. NOR-X-416E. https://cfs.nrcan.gc.ca/pubwarehouse/pdfs/29154.pdf

Malpeli, K.C., S. R. Weiskopf, L. Thompson, and A.R. Hardy. 2020. What are the effects of climate variability and change on ungulate life-histories, population dynamics, and migration in North America? A systematic map protocol. Environmental Evidence 9:21. https://doi.org/10.1186/s13750-020-00204-w

Micheletti, T., F. E. C. Stewart, S. Cumming, S. Haché, D. Stralberg, J. A. Tremblay, C. Barros. 2021. Assessing the Pathways of Climate Change Effects in SpaDES: An Application with Boreal Landbirds in Northwestern Canada. Frontiers in Ecology and Evolution 9: 679673. https://doi.org/10.3389/fevo.2021

Nelson,T.A., N.C. Coops, M.A. Wulder, L. Perez, J. Fitterer, R. Powers and F. Fontana. 2014. Predicting Climate Change Impacts to the Canadian Boreal Forest. Diversity 6: 133-157.

Reid, K.A,, D.G. Reid, and C.D. Brown. 2022. Patterns of vegetation change in Yukon: recent findings and future research in dynamic subarctic ecosystems. Environ.Rev. 30: 380–401.

Riddell, E. A., Iknayan, K. J., Hargrove, L., Tremor, S., Patton, J. L., Ramirez, R., et al. 2021. Exposure to climate change drives stability or collapse of desert mammal and bird communities. Science 371, 633–636. doi: 10.1126/science. abd4605

Singer, C., and C. Lee. 2021. NWT Climate Change Vulnerability Assessment Species at Risk. Environment and Natural Resources Government of the Northwest Territories. Manuscript Report 297.2

Stewart, F.E.C., Micheletti, T., Cumming, S.G., Barros, C., Chubaty, A.M., Dookie, A.L., Duclos, I., Eddy, I., Haché, S., Hodson, J., Hughes, J., Johnson, C.A., Leblond, M., Schmiegelow, F.K.A., Tremblay, J.A., and

McIntire, E.J.B. 2023. Climate-informed forecasts reveal dramatic local habitat shifts and population uncertainty for northern boreal caribou. Ecological Applications 33(3):e2816. DOI: 10.1002/eap.2816

Tape, K.D., Gustine, D.D., Ruess, R.W., Adams, L.G., and Clark, J.A. 2016a. Range Expansion of Moose in Arctic Alaska Linked to Warming and Increased Shrub Habitat. PLOS ONE 11(4):e0152636. DOI: 10.1371/journal.pone.0152636

Tape, K.D., Gustine, D.D., Ruess, R.W., Adams, L.G., and Clark, J.A. 2016b. Correction: Range Expansion of Moose in Arctic Alaska Linked to Warming and Increased Shrub Habitat. PLOS ONE 11(7):e0160049. DOI: 10.1371/journal.pone.0160049

University of Alaska Fairbanks. 2012. Predicting Future Potential Climate-Biomes for the Yukon, Northwest Territories, and Alaska. Available at: https://www.gov.nt.ca/ecc/sites/ecc/files/page_3_university_of_alaska_climate_biomes_full_report.pdf.

Wang, Y., Hogg, E.H., Price, D.T., Edwards, J. and Williamson, T., 2014. Past and projected future changes in moisture conditions in the Canadian boreal forest. The Forestry Chronicle, 90(5), pp.678-691. Available at: https://pubs.cif-ifc.org/doi/10.5558/tfc2014-134.

Wasserman, T.N., S.A Cushman, A.S. Shirk, E.L. Landguth and J.S. Litell. 2012. Simulating the effects of climate change on population connectivity of American marten (Martes americana) in the northern Rocky Mountains, USA . Landscpe Ecology 27: 211-225.)

White BP, Breakey S, Brown MJ, Smith JR, Tarbet A, Nicholas PK, Ros AMV. Mental Health Impacts of Climate Change Among Vulnerable Populations Globally: An Integrative Review. Ann Glob Health. 2023 Oct 6;89(1):66. doi: 10.5334/aogh.4105. PMID: 37810609; PMCID: PMC10558031.

Mackenzie Valley Highway Project – Climate Change Resilience Assessment Addendum (2024)

Prepared for:

Government of the Northwest Territories

Prepared by:

K'alo-Stantec Limited

June 19, 2024

Project No.: 123514886

K'alo-Stantec

Limitations and Sign-off

The conclusions in the Report are K'alo-Stantec's professional opinion, as of the time of the Report, and concerning the scope described in the Report. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. The Report relates solely to the specific project for which K'alo-Stantec was retained and the stated purpose for which the Report was prepared. The Report is not to be used or relied on for any variation or extension of the project, or for any other project or purpose, and any unauthorized use or reliance is at the recipient's own risk.

K'alo-Stantec has assumed all information received from the Client and third parties in the preparation of the Report to be correct. While K'alo-Stantec has exercised a customary level of judgment or due diligence in the use of such information, K'alo-Stantec assumes no responsibility for the consequences of any error or omission contained therein.

This Report is intended solely for use by the Client in accordance with K'alo-Stantec's contract with the Client. While the Report may be provided to applicable authorities having jurisdiction and others for whom the Client is responsible, K'alo-Stantec does not warrant the services to any third party. The report may not be relied upon by any other party without the express written consent of K'alo-Stantec, which may be withheld at K'alo-Stantec's discretion.

Prepared by Katherine A. Pingree-Shippee
(signature)
Katherine Pingree-Shippee, Ph.D.
Climate Scientist

[*Original signed by*]
Reviewed by _____
(signature)
Shane O'Hanlon, M.Sc., B.Eng.
Associate, Senior Climate Risk and Resilience Consultant

Approved by _____
(signature)
Norman Shippee, Ph.D.
Senior Climate Scientist; National Technical Lead, Climate Change Risk and Adaptation

Executive Summary

K'alo-Stantec Ltd. (Stantec) completed an update to the 2021 Mackenzie Valley Highway Project – Climate Lens Part II: Climate Change Resilience Assessment (CCRA). The main objectives of this update were to utilize new climate change projection data and subsequently update the CCRA, add new climate parameters to the assessment, and incorporate Traditional Knowledge gathered for the Mackenzie Valley Highway Project. For consistency, the same CCRA methods used in the 2021 CCRA were also used in this update.

The 2021 CCRA climate assessment was completed using Coupled Model Intercomparison Project Phase 5 (CMIP5) climate projections. CMIP5 climate projections formed the basis of the IPCC's *Fifth Assessment Report* (IPCC, 2013). Since the completion of the CCRA, the IPCC *Sixth Assessment Report* (IPCC, 2021) has been released with the latest global and regional assessments of climate change and its impacts using a set of five new illustrative emissions scenarios, referred to as Share Socioeconomic Pathways (SSP). The SSP-driven climate projections were completed for the Coupled Model Intercomparison Project Phase 6 (CMIP6) and downscaled for Canada by the Pacific Climate Impacts Consortium (PCIC). For climate hazards with limited or no CMIP6 SSP-derived climate projections available, CMIP5 RCP8.5-driven projections and/or specialized studies/scientific literature were utilized.

The updated CCRA resulted in an increase in risk ratings for precipitation extremes (short duration, high intensity precipitation) and freeze-thaw days. For most precipitation extremes and freeze-thaw days risks the risk classification remained consistent. For the three additional climate parameters added to the CCRA – wildfire, wind, and icing – high risks were identified associated with maintenance of the roadway and the health & safety of maintenance staff, road users, and other personnel. Adaptation recommendations developed in the 2021 CCRA remain relevant, and recommendations were developed for the new climate parameters. Adaptation recommendations for the three additional climate parameters include the following:

- Routine inspection of roadway for erosion and undertake maintenance actions as necessary
- Design and install permanent erosion control measures in areas anticipated to be suspectable to erosion
- Work with communities in the region to establish evacuation plans which take into consideration the possibility of road closure due to climate and weather-related events
- Establish Operations and Maintenance (O&M) policies for working in adverse conditions and include contingency plans in the event of wildfire and/or road closure
- Continue to use the established public notification system to communicate with road users and report on maintenance activities, road conditions, and weather conditions

Table of Contents

1 Introduction 1
1.1 Background 1
1.2 Objective 1
1.3 Scope 1

2 Climate Assessment Update 1
2.1 Climate Projections 1
2.2 Climate Parameters Update 2
2.3 Climate Parameter Probabilities 5

3 Traditional Knowledge 6
3.1 Dehcho Region 6
3.2 Sahtu Region 7

4 Risk Assessment Update 9
4.1 Methods 9
4.2 Consequence Ratings for Additional Climate Parameters 11
4.3 Risk Rating Updates 13

5 Adaptations Update 15

6 Limitations 21

7 Conclusion 22

8 References 23

List of Tables

Table 1-1 Project Components Assessed 1
Table 2-1 Updated Climate Parameters Summary 2
Table 2-2 Probability Rating 5
Table 2-3 2080s Probability Ratings: 2021 CCRA vs. 2024 Update 5
Table 4-1 Risk Classification and Treatment 10
Table 4-2 Consequence (Severity of Impact) Rating 11
Table 4-3 Potential Climate Parameter Impacts and Consequence Ratings for Additional Climate Parameters 12
Table 4-4 2080s Risk Ratings: 2021 CCRA vs. 2024 Update 14
Table 5-1 2080s Project Risk Profile – Wildfire, Wind, and Icing Climate Parameters 16
Table 5-2 2080s Project Risk Profile – Additional Adaptation Considerations 19

List of Figures

Figure 4-1 Risk Ratings Calculation Matrix 10

List of Appendices

Appendix A Climate Profile for the Mackenzie Valley Highway Project – Updated for 2024 CCRA Addendum

1 Introduction

K'alo-Stantec Ltd. (Stantec) completed a Climate Change Resilience Assessment (CCRA) in 2021 as part of the Climate Lens Analysis as required by the Investing in Canada Infrastructure Program (ICIP) for the Mackenzie Valley Highway (the Project). The ICIP is a bilateral agreement between Infrastructure Canada and the provinces and territories. As the Project proponent is seeking federal funding under the ICIP Community, Culture and Recreation Fund, the CCRA was prepared in accordance with Infrastructure Canada requirements and Infrastructure Canada's Climate Lens General Guidance Version 1.2[1]. The assessment applied approaches consistent with ISO 31000:2018 standard Risk Management – Principles and Guidelines, which are appropriate for climate resilience assessments for new assets under the Climate Lens.

Since the completion of the 2021 CCRA, the Intergovernmental Panel on Climate Change (IPCC) *Sixth Assessment Report* (IPCC, 2021) has been released with the latest global and regional assessments of climate change and its impacts using a set of five new illustrative emissions scenarios, referred to as Share Socioeconomic Pathways (SSP). This addendum report provides an updated climate assessment and related updates to the risk assessment and resilience measures reported in the 2021 CCRA. Additionally, Traditional Knowledge was not incorporated into the 2021 CCRA, therefore, this update will highlight Traditional Knowledge gathered through engagement and studies completed for the Project. This addendum report should be read in conjunction with the original report: *Mackenzie Valley Highway Project – Climate Lens Part II: Climate Change Resilience Assessment* (Stantec, 2021).

1.1 Background

The 2021 CCRA identified climate risks to the Project at a broad systems-level, providing an understanding of the potential climate impacts on the Project over its construction and operational life. The assessment was intended to inform the design team of projected changes in climate and associated risks to consider at the Project's detailed design stage. The Project assets and systems assessed in the CCRA are presented in Table 1-1. The assessment was limited to the roadway structure and did not include associated infrastructure (e.g., bridges, maintenance yards, camps, laydowns, pits). Additionally, the CCRA did not include the deconstruction or rehabilitation of the gravel road and associated structures at the end of their useful life.

[1] https://www.infrastructure.gc.ca/pub/other-autre/cl-occ-eng.html

Table 1-1 Project Components Assessed

Project Infrastructure Component	Project Infrastructure Sub-Components
Structural Elements / Physical Infrastructure	• Road Base and Subgrade • Road Embankments • Surface Drainage • Culverts
Miscellaneous	• Maintenance • Emergency Response • Administration / Personnel & Engineering

Climate parameters selected for assessment in the CCRA are as follows:

- Mean seasonal temperatures
- High temperature extremes
- Low temperature extremes
- Precipitation extremes
- Sustained rainfall
- Dry spells
- Frost days
- Freeze-thaw days

Permafrost thaw is strongly related to increases in air temperature and, therefore, changes in the temperature parameters were used as proxies for changes in permafrost in the 2021 CCRA. Potential impacts of permafrost thaw on the Project and possible resilience measures were developed during the 2021 CCRA. While permafrost thaw was considered in the original CCRA, a section on permafrost was added to the updated Climate Profile (Appendix A) to provide additional insight into the climate parameter. Similarly, temperature parameters were used as proxies for wildfire impacts.

1.2 Objective

The main objectives of this update to the Project CCRA were as follows:

- Utilize the new SSP-driven climate projection data and subsequently update the risk assessment
- Add new climate parameters to the CCRA that were noted by the Mackenzie Valley Environmental Impact Review Board in Information Request 2
- Incorporate Traditional Knowledge gathered through engagement with affected parties and Traditional Land and Resource Use studies

1.3 Scope

The following tasks have been completed as part of the CCRA update:

- The Climate Profile of the CCRA was updated using the SSP-driven climate projections and specialized studies. This task also included adding three new climate parameters (forest fires, wind, and icing), which were noted in the Mackenzie Valley Environmental Impact Review Board Information Request 2.
- The climate parameter probability scores used in the risk assessment were updated.
- Traditional Knowledge gathered for the Project was summarized and incorporated into the CCRA where appropriate.
- A Stantec Subject Matter Expert (SME)[2] was consulted to identify possible impacts on the Project associated with the new climate parameters added to the CCRA as well as assign consequence scores for use in the risk assessment.
- The risk assessment was updated to reflect changes in the probability scores and the addition of the new climate parameters.
- Adaptation considerations previously developed for high and extreme risks were reviewed and updated as necessary. Adaptation considerations were also developed for the high and extreme risks associated with the new climate parameters.

[2] Walter Orr, B.Sc., P.Eng., Principal Civil Engineer

2 Climate Assessment Update

This section presents the climate projections used to update the CCRA, a summary of the updated climate parameter data (including the new climate parameters added to the CCRA), and the updated climate parameter probabilities. The climate parameters assessed, and methods used to estimate probabilities align with the 2021 CCRA, except where otherwise noted.

The supplementary Climate Profile (Appendix A) provides further information on the climate data sources and the historical and projected climate conditions for the climate parameters considered in the CCRA.

2.1 Climate Projections

The climate assessment completed for the 2021 CCRA was based on Coupled Model Intercomparison Project Phase 5 (CMIP5; Taylor et al., 2012) Global Climate Models (GCMs) climate projections. CMIP5 climate projections formed the basis of the IPCC's *Fifth Assessment Report* (IPCC, 2013). Probability scores for the 2080s (2071-2100) time horizon were assessed based on the multi-model ensemble projections under the RCP8.5 scenario.

Since the completion of the 2021 CCRA, the IPCC's *Sixth Assessment Report* (IPCC, 2021) has been released with the latest global and regional assessments of climate change and its impacts using a set of five new illustrative emissions scenarios, referred to as Share Socioeconomic Pathways (SSP; Riahi et al., 2016). There are five SSP scenarios which were adopted by the IPCC for its Sixth Assessment Report, ranging from very low emissions (SSP1-1.9) to low emissions (SSP1-2.6) to intermediate emission (SSP2-4.5) to high emissions (SSP3-7.0) to very high emissions (SSP5-8.5). The SSP5-8.5 trajectory more closely aligns with historical and current emissions and represents a plausible emissions track into the future (Smith and Myers, 2018; Pedersen et al., 2020; Schwalm et al., 2020). While recent studies (Hausfather and Peters, 2020) suggest that the higher emissions scenarios (e.g., SSP5-8.5) may have become less likely due to technological developments and emerging climate policies, the higher emissions scenarios remain plausible trajectories and provide insight into "high-end" risks of climate change (IPCC, 2022). The SSP5-8.5 very high emissions scenario was therefore used in the CCRA update to present a conservatively high estimate of projected climate change and its associated impacts in the climate assessment. The SSP5-8.5 and RCP8.5 emissions scenarios generally correspond (Riahi et al., 2016).

The SSP-driven climate projections were completed for the Coupled Model Intercomparison Project Phase 6 (CMIP6; Eyring et al., 2016) GCMs. Downscaling methods are often used to produce finer spatial resolution projections from GCMs. Approximately 35 GCMs have contributed to CMIP6. The Pacific Climate Impacts Consortium (PCIC)[3] uses a subset of 26 of these models to produce reliable, high-resolution (~10 km) downscaled climate projections localized to specific areas of interest in Canada, referred to as the Canadian Downscaled Climate Scenarios – Univariate (CMIP6) (CanDCS-U6) (Cannon, 2015; Cannon et al., 2015). Where possible, probability scores for the 2080s time horizon were assessed

[3] https://www.pacificclimate.org/

based on the CanDCS-U6 multi-model ensemble projections under the SSP5-8.5 emissions scenario. For climate hazards with limited or no CMIP6 SSP-derived climate projections available, CMIP5 RCP8.5-driven projections and/or specialized studies/scientific literature were utilized.

2.2 Climate Parameters Update

Three additional climate parameters were noted by the Mackenzie Valley Environmental Impact Review Board in Information Request 2: forest fires (referred to as wildfires in the Climate Profile and henceforth in this report), wind, and icing. Information on the climate data sources and the historical and projected climate conditions for these additional climate parameters are presented in the supplementary Climate Profile (Appendix A). Table 2-1 presents an updated summary of the climate parameters assessed in the CCRA, reflecting the new SSP5-8.5 climate projections.

Table 2-1 Updated Climate Parameters Summary

Climate Parameter	Trend	Confidence Level in Projections	Parameter Remark*
Temperature			
Mean Seasonal Temperatures	Increase	High	**Norman Wells –** Average annual temperature is projected to increase by 6.9°C by the 2080s, with the largest seasonal increase (9.1°C) in winter and smallest seasonal increase (5.5°C) in the summer. **Fort Simpson -** Average annual temperature is projected to increase by 6.5°C by the 2080s, with the largest seasonal increase (8.4°C) in the winter and the smaller seasonal increase (5.7°C) in the summer.
High Temperature Extremes	Increase	High	There is a projected increase in the average annual number of days with a maximum temperature ≥ 30°C. **Norman Wells –** A projected increase from ~2 days/year in the baseline to ~24 days/year in the 2080s. **Fort Simpson –** A projected increase from ~4 days/year in the baseline to ~35 days/year in the 2080s.
Low Temperature Extremes	Decrease	High	There is a projected decline in the average annual number of days with a minimum temperature ≤ -30°C. **Norman Wells –** A projected decline from ~51 days/year in the baseline to ~7 days/year in the 2080s. **Fort Simpson –** A projected decline from ~38 days/year to ~3 days/year by the 2080s.
Frost Days	Decrease	Medium-High	A decrease in the average annual number of frost days (days with a minimum temperature < 0°C) is projected, resulting in a longer, extended frost-free season. **Norman Wells –** A projected decrease from ~240 frost days/year in the baseline to ~203 frost days/year in the 2080s. **Fort Simpson –** A projected decrease from ~225 frost days/year in the baseline to ~185 frost days/year in the 2080s.

Climate Parameter	Trend	Confidence Level in Projections	Parameter Remark*
Freeze-Thaw Days	Decrease	Medium-High	The average annual number of days with a freeze-thaw cycle is projected to decrease. **Norman Wells –** A projected decrease from ~44 freeze-thaw days/year in the baseline to ~37 freeze-thaw days/years in the 2080s. **Fort Simpson –** A projected decrease from ~57 freeze-thaw days/year in the baseline to ~45 freeze-thaw days/years in the 2080s.
Precipitation			
Precipitation Extremes	Increase	Medium-High	IDF data[4] projections indicate an increase in storm intensity for short duration rainfall events (5 min events to 24-hour events) under a warming climate. **Norman Wells –** Short duration rainfall event intensity is projected to increase by ~60% in the 2080s, relative to the 1974-2021 period. **Fort Simpson –** Short duration rainfall event intensity is projected to increase by ~55% in the 2080s, relative to the 1969-2021 period.
Sustained Rainfall	Increase	Medium-Low	Similar to short duration events, sustained rainfall events (e.g., 3- and 5-day rainfall accumulations) are likely to increase in intensity under a warming climate.
Dry Spells	Slight Decrease	Medium-Low	Historically, the trend in average maximum dry spell length for the region has been generally stable. In the future, the average annual longest dry spell duration (i.e., maximum number of consecutive dry days [days with < 1 mm of precipitation]) is projected to slightly decrease. **Norman Wells –** A projected decrease from a maximum of ~29 consecutive days/dry spell in the baseline to a maximum of ~25 consecutive days/dry spell in the 2080s. **Fort Simpson –** A projected decrease from a maximum of ~29 consecutive days/dry spell in the baseline to a maximum of ~27 consecutive days/dry spell in the 2080s.

[4] IDF (intensity-duration-frequency) data relates short-duration, high intensity rainfall with its frequency of occurrence. IDF data provides total precipitation amounts in specific time intervals (5 minutes to 24 hours) for various return periods (2 years to 100 years).

Climate Parameter	Trend	Confidence Level in Projections	Parameter Remark*
Additional Parameters			
Wildfires[5]	Increase	Low	The average annual number of large (> 200 ha) fires was 5 to 10 fires annually per 100,000 km^2 in the Great Bear Lake homogeneous fire regime (i.e., the Mackenzie Valley Highway region) during the 1961-1990 period. The average annual number of large fires is projected to increase by 2 to 3 times – up to 30 fires/year – in the 2080s. The average annual area burned and fire size are also projected to increase. Additionally, the fire season is projected to increase under a warming climate.
Wind[6]	Slight Increase	Low	The average annual number of days with high wind gusts (≥80 km/hr) is projected to increase slightly under a warming climate. **Norman Wells –** An increase from ~1.9 days/year in the baseline to ~2.3 days/year in the 2080s. During the 1981-2010 period, the maximum wind gust recorded at the Norman Wells airport was 106 km/hr. **Fort Simpson –** An increase from ~0.3 days/year in the baseline to ~0.4 days/year in the 2080s. During the 1981-2010 period, the maximum wind gust recorded at the Fort Simpson airport was 91 km/hr.
Icing[7]	Increase	Low	In the Mackenzie Valley Highway region, freezing rain events are historically short-duration events, with an average of up to ~3 to 4 hours annually of freezing rain, occurring typically in the fall, winter, or spring. Under a warming climate, the average annual number of hours of freezing rain are projected to increase by approximately 5 to 10 hours by the end of the century. Additionally, the 1-in-20-year ice accretion load is projected to increase by 60-100% by the end of the century.

Note:
* Projected changes are relative to the 1981-2010 period, unless otherwise noted.

[5] Wildfire specialized studies utilized include Boulanger et al., 2014, Huberman et al., 2022, Wang et al., 2022, and Jones et al., 2022.
[6] Wind specialized study utilized is Cheng et al., 2014.
[7] Icing specialized studies utilized are Kochtubajda et al., 2017, Cannon et al., 2020, Mekis et al., 2020, and McCray et al., 2022.

2.3 Climate Parameter Probabilities

Climate parameter probabilities were assigned using a rating scale of 1 to 5 (Table 2-2).

Table 2-2 Probability Rating

Occurrence	Qualitative Descriptor	Descriptor	Rating
>1:50 year	Highly Unlikely	Not likely to occur in assessment period; or not likely to increase in intensity and/or duration during the assessment period	1
1:10-50 year	Remotely Possible	Likely to occur once between 10-50 years; or likely to increase in intensity and/or duration over a 10 to 50-year period	2
1:1-10 year	Occasional	Likely to occur at least once a decade; or likely to increase in intensity and/or duration over a decade	3
10/year to 1:1	Normal	Likely to occur between one to ten times annually; or likely to increase in intensity and/or duration on an annual basis	4
>10/year	Frequent	Likely to occur more than ten times annually	5

Table 2-3 presents a comparison of the 2080s (2071-2100) probability ratings from the 2021 CCRA based on RCP8.5 climate projections and the updated probability ratings based on SSP5-8.5 climate projections. Table 2-3 also presents the probability ratings for the additional climate parameters (wildfires, wind, and icing). For climate parameters projected to undergo gradual changes under climate change (e.g., mean seasonal temperature), the probability rating reflected the likely rate of change (e.g., notable change on an annual, decadal, or multi-decadal scale).

Table 2-3 2080s Probability Ratings: 2021 CCRA vs. 2024 Update

Climate Parameter	2080s Probability Rating	
	2021 CCRA	2024 Update
Temperature		
Mean Seasonal Temperatures	5	5
High Temperature Extremes	5	5
Low Temperature Extremes	4	4
Frost Days	3	3
Freeze-Thaw Days	3	4
Precipitation		
Precipitation Extremes	2	3
Sustained Rainfall	5	5
Dry Spells	4	4
Additional Parameters		
Wildfires	N/A	5
Wind	N/A	4
Icing	N/A	4

3 Traditional Knowledge

Weather stations, such as those located at the Norman Wells and Fort Simpson airports used in the CCRA, provide detailed records of location-specific meteorological and climatic conditions. Traditional Knowledge provides holistic regional descriptions of observed changes including descriptions of changes in the meteorology, climatology, hydrology, geology, vegetation, and wildlife of a region. Weather stations and Traditional Knowledge both complement and supplement each other in developing an understanding of historic conditions and observed changes of a region. Traditional Knowledge typically provides qualitative descriptions of observed conditions and changes and can provide guidance into climate parameter selection for a CCRA. Traditional Knowledge, however, may not provide information on all climate parameters of interest for a CCRA and/or the quantitative details necessary to complete the assessment. As such, weather station records provide a main resource for CCRAs. Nevertheless, Traditional Knowledge is invaluable documentation of long-term environmental changes and is provided, as appropriate, as part of this CCRA to further highlight and reflect its importance.

The GNWT engaged with Indigenous Governments, Indigenous Organizations, and other affected parties such as renewable resource councils (including Tulita Renewable Resources Council [TRRC] and Norman Wells Renewable Resources Council [NWRRC]), which included project-specific community engagement activities and development of Traditional Land and Resource Use (TLRU) studies (between 2010-2012 and 2021-2023). Indigenous Governments, Indigenous Organizations, and other affected parties shared information, expressed concerns, and provided Project-specific information related to culture and traditional land use, including harvesting, hunting, and trapping. The information provided included observations and concerns about climate change, and the effects of a warming climate observed in the Study Area.

The Project occurs within the Dehcho Region and the Sahtu Region. Reported climate change concerns and observations relevant to the Project are organized by the Dehcho and Sahtu regions below.

3.1 Dehcho Region

Pehdzéh Kį First Nation reported the importance of water resources in the Dehcho Region, and identified watercourses and riverbanks that are important traditional land use areas, and rivers (e.g., Ochre River, Mackenzie River, Blackwater River) which are considered important habitat for waterfowl (Dessau, 2012 [PR#13]). Dehcho First Nations indicated many factors influence the water quantity in the Dehcho Region and noted that the region is getting warmer and wetter overall with more rainfall in August and September and even into October, which is resulting in higher water levels on smaller rivers and streams (Dehcho First Nations, 2011). Dehcho First Nations explained that increased wetness and rainfall has led to increased ice crusting along the ground, subsequently resulting in foraging difficulty for boreal caribou, and increased difficulty for caribou to escape predators at the end of summer. In addition, Dehcho First Nations reported that warmer temperatures, thawing permafrost, and other environmental changes, as a result of climate change, create overall environmental concerns in region, including thawing of frost, which harbours and protects lichens and will reduce the availability of lichen-rich habitats important for caribou in the region (Dehcho First Nations, 2011). Dehcho First Nations further report, warmer wetter

summers and falls increase water levels on smaller rivers and streams, allowing more boat access into boreal caribou habitat areas, potentially increasing hunting pressure on caribou (5658 NWT Ltd. and GNWT, 2011 [PR#16]; Dehcho First Nations, 2011; McDonald, 2010). Pehdzéh Kį First Nation and Dehcho First Nations identified concerns about potential effects on lands and forests, in particular changes in vegetation and wetlands and changes resulting from removal of permafrost resulting in decreased plants and plant harvesting locations available to Indigenous harvesters (Dessau, 2012 [PR#13]; Dehcho First Nations, 2011).

3.2 Sahtu Region

Participants of the NWRRC project-specific TLRU study reported observed changes to the land that they attribute to changes in the climate. They identified concerns about changing temperatures and effects of climate change on vegetation (NWRRC, 2023). NWRCC study participants explained that Elders of Norman Wells used to be able to predict weather patterns, but the recent fluctuations in weather have made predictions much more difficult (NWRRC, 2023). Study participants observed that weather in the Study Area has changed over the last few years, which affects the land and the permafrost and can influence the flow of creeks (NWRRC, 2023). NWRRC study participants observed that changing weather patterns can influence the accessibility and availability of lichen for caribou (NWRRC, 2023). A previous report stated that weather plays a significant role in the health and well-being of boreal caribou, noting that increasing extremes in temperatures and flooding negatively affect herds (McDonald, 2010). Other documented information relevant to the Project includes concerns that climate change, including change in ambient temperatures, are shifting the timing of caribou calving and reducing the availability of lichen-rich habitats, which is a primary source of caribou subsistence (SRRB, 2016). SRRB has reported concern that change in ambient temperature will cause early green-ups, and off-set the timing in relation to caribou calving (SRRB, 2016).

NWRRC TLRU study participants reported that the water in the lakes and rivers are taking longer to freeze because the temperatures are warmer and changing every year (NWRRC.4; NWRRC, 2023). It was also reported that large chunks of ice are no longer carried down the rivers because the water has been too low to move it. NWRRC TLRU study participants communicated that in general, snow dries up faster, and there is less rain and less snow, which has caused surface water to dry up (NWRRC, 2023). They raised concerns and provided examples of creeks and lakes drying up in the NWRRC TLRU Study Area (NWRRC, 2023).

NWRRC TLRU study participants identified concerns about warming temperatures affecting permafrost, especially around the Norman Wells Pipeline right-of-way (ROW), observing that thawing permafrost has contributed to land sinking around the pipeline (NWRRC, 2023). Through Project-specific TLRU studies, TRRC and NWRRC participants also discussed concerns about thawing permafrost and existing issues along the current winter road. Generally, in the Sahtu Region, the effects of climate change, in combination with wildfire, thawing permafrost, ground slumping, and shoreline erosion pose additional safety risks to infrastructure, including roads and buildings, as well as risks to traditional economies and TLRU (SLUPB, 2022). Erosion due to climate change can lead to sedimentation entering important waterbodies and can negatively affect water quality and important fish habitat.

Through Project-specific TLRU studies, NWRRC and TRRC study participants stated that the Study Area is important for harvesting [berries] in the summer months (NWRRC, 2023). NWRRC (2023) reported that there are not as many berries available for harvesting in the Study Area now as in the past, which participants attribute to the land drying up, potentially related to effects of climate change.

The SRRB has reported that fish habitat, populations, and abundances have decreased over the last 50 years as a result of past industrial disturbance and habitat disturbance as well as indirect effects associated with climate change (SRRB, 2021b). Elders and land users in the Sahtu Region have also expressed concern about potential effects in the Sahtu area, which may affect the health of the region's fish, specifically fish habitat, spawning, and fish abundance due to direct effects from development and industry, as well as indirect effects from climate change (SRRB, 2021b; Golder, 2015). In addition, through the Project-specific engagement program, NWRRC TLRU study participants reported that climate change affects food security, and explained that more people will fish if wildlife moves away, which may potentially affect fish and fish habitat (NWRRC, 2023).

4 Risk Assessment Update

4.1 Methods

In the CCRA, the risk rating is defined as follows:

Risk Rating = Probability Rating x Consequence of Impact Rating

- Probability Rating: a rating that represents the probability or likelihood of occurrence of a climate event above a selected threshold, ranging from 1(highly unlikely) to 5 (frequent)
- Consequence of Impact Rating: a rating of the impacts on the infrastructure asset or component should the climate event occur, ranging from 1 (insignificant) to 5 (catastrophic)

In the CCRA, the condition of the infrastructure in the future climate is assumed to be well maintained and, thus, will maintain a similar level of resilience to climate events. Deterioration of the Project components is not considered in the CCRA.

The risk rating calculation provides numerical risk ratings of 1 to 25 as shown in Figure 4-1. In Table 4-1, risk ratings are described along with suggested risk treatments as per the Climate Lens General Guidance. It should be noted that, since the completion of the 2021 CCRA, the Climate Lens General Guidance has been updated (Version 2.1; https://publications.gc.ca/collections/collection_2024/infc/T94-51-2023-eng.pdf). To remain consistent with the methods used in the 2021 CCRA, however, the previous version of the Guidance (Version 1.2) is used in this update.

Figure 4-1 Risk Ratings Calculation Matrix

Risk Rating = Probability Rating x Consequence of Impact Rating

Consequence Rating							
	Catastrophic (Very High)	**5**	5	10	15	20	25
	Major (High)	**4**	4	8	12	16	20
	Moderate	**3**	3	6	9	12	15
	Minor (Low)	**2**	2	4	6	8	10
	Insignificant (Very Low)	**1**	1	2	3	4	5
			1	**2**	**3**	**4**	**5**
			Highly Unlikely (Very Low)	**Remotely Possible (Low)**	**Occasional (Moderate)**	**Normal (High)**	**Frequent (Very High)**
			Probability Rating				

Table 4-1 Risk Classification and Treatment

Risk Classification	Risk Rating	Description of Risk	Risk Treatment
Negligible	1	• No permanent damage. • No service disruption occurs.	• Risks do not require further consideration
Low	2, 3	• Minor asset/equipment damage. • Minor service disruption may be possible. • No permanent damage. • Minor repairs or restoration expected.	• Controls likely, but not required.
Moderate	4, 5, 6	• Expected limited damage to asset or to equipment components. • Minor repairs and some equipment replacement may be required. • Brief service disruption may be possible.	• Some controls required to reduce risks to lower levels. Risk to be monitored for changes over time.
High	8, 9, 10, 12, 15	• May result in significant permanent damage; or loss of asset or component that may require complete replacement. • More lengthy service disruption may be possible.	• High priority control measures required.
Extreme	16, 20, 25	• May result in significant permanent damage; or loss of asset or component that may require complete replacement. • Significant service disruptions may be possible.	• Immediate controls required.

Risk ratings calculation matrix presented in Figure 4-1

4.2 Consequence Ratings for Additional Climate Parameters

Potential interactions with the Project infrastructure were assessed for the three climate parameters added to the CCRA update – wildfire, wind, and icing. Consequence (severity of impact) ratings were assigned using a rating scale of 1 to 5 (Table 4-2) and considered impacts to the structural integrity, operations and maintenance (O&M), and functionality of the infrastructure (additional details on the consequence categories are provided in Table 3 of the 2021 CCRA [Stantec, 2021]).

Table 4-2 Consequence (Severity of Impact) Rating

Consequence Rating	Qualitative Descriptor	Descriptor
1	**Insignficant** – No serious impact from a weather event.	• Can be corrected through routine maintenance with no impact to O&M budgets. • No structure damage to the road.
2	**Minor** – Some extra costs for repairs and maintenance.	• No loss of service. • Infrastructure is still operable and accessible. • Some extra costs associated with O&M budgets but no requirement for regional response funds.
3	**Moderate** – Some damage to infrastructure.	• Extra costs and labour required to complete repairs. • Some specialized labour or equipment required to complete repairs. • Some loss of service.
4	**Major** – Significant damage to infrastructure.	• Significant extra costs and labour required to complete repairs. • Specialized labour or equipment required to complete repairs. • Replacement of component required. • Significant loss of service – closure of one lane.
5	**Catastrophic** – Complete loss of the asset after a weather event.	• Repair not possible. • Extended period of loss of service – road closure.

Potential interactions and consequence ratings for the additional climate parameters are presented in Table 4-3. Consequence ratings assigned in the 2021 CCRA were not reassessed for this update. It should be noted that, while permafrost thaw is strongly related to increases in air temperature, permafrost is also vulnerable to other climate and weather events, such as wildfires, and can thaw rapidly once it is disturbed. Potential impacts of permafrost thaw on the Project and possible resilience measures were developed during the 2021 CCRA using changes in the temperature parameters as proxies for changes in permafrost. The occurrence of wildfire impacting sections of the roadway with permafrost may quicken and/or exacerbate the impacts of permafrost thaw.

Table 4-3 Potential Climate Parameter Impacts and Consequence Ratings for Additional Climate Parameters

Climate Parameter	Infrastructure Impacted		Description of Impact	Consequence Rating
	Component	Sub-Component		
Wildfire	Structural Elements / Physical Infrastructure*	Surface Drainage	A loss of vegetation from wildfire could result in increased runoff and impacts on roadside drainage (e.g., increased volume exceeding design flow capacity of culverts) and roadside erosion. Wildfire occurrence may quicken and/or exacerbate permafrost thaw and its impacts on the roadway drainage system.	2
		Culverts		
	Miscellaneous	Emergency Response	Wildfires could result in road closures, adding to the wildfire related health & safety risks to road users and maintenance staff.	3
		Administration / Personnel & Engineering	Wildfires and related poor air quality could result in a health & safety risk to road users, maintenance staff, and other personnel.	2
Wind	Miscellaneous	Maintenance	High winds could result in branches and windblown debris on the roadway, requiring increased maintenance to clear the road of potential obstacles. High winds may result in snow drifts which could results in additional maintenance and temporary road closure.	3

Climate Parameter	Infrastructure Impacted		Description of Impact	Consequence Rating
	Component	Sub-Component		
		Administration / Personnel & Engineering	High winds could result in reduced air quality due to dust, creating a health & safety risk to road users, maintenance staff, and other personnel. High winds also present an operational hazard to large vehicles (e.g., reduced visibility due to dust or blowing snow, potential for tipping over of tractor trailers).	2
Icing (including icing due to freezing rain and/or aufeis [overflow])	Structural Elements / Physical Infrastructure	Culverts	Icing could result in ice buildup in culverts, requiring thawing by maintenance staff to restore full functionality.	3
	Miscellaneous	Maintenance	Icing of the road surface could result in increased maintenance (distribution of gravel and/or grading) to maintain road access.	3
		Administration / Personnel & Engineering	Icing of the road surface and roadsides could result in a health & safety risk to road users, maintenance staff, and other personnel (e.g., increase potential for road accidents, slip-and-fall risk)	2
* While outside the scope of the CCRA, it should be noted that wildfire could damage or destroy maintenance yard infrastructure and, subsequently, result in impacts to the roadway (e.g., reduced ability to maintain the roadway and possible loss of service).				

4.3 Risk Rating Updates

Table 4-4 presents a comparison of the 2080s (2071-2100) risk ratings from the 2021 CCRA and the updated risk ratings for the climate parameter-infrastructure component interactions with a change in probability rating (as previously presented in Table 2-3). Table 4-4 also presents the risk ratings for the identified climate parameter-infrastructure component interactions for the additional climate parameters (wildfires, wind, and icing).

Table 4-4 2080s Risk Ratings: 2021 CCRA vs. 2024 Update

Climate Parameter	Infrastructure Impacted		2080s Risk Rating	
	Component	Sub-Component	2021 CCRA	2024 Update
Precipitation Extremes	Structural Elements / Physical Infrastructure	Road Base and Subgrade	6	9
		Road Embankments	8	12
		Culverts	8	12
	Miscellaneous	Maintenance	8	12
Freeze-thaw Days	Structural Elements / Physical Infrastructure	Road Base and Subgrade	9	12
		Road Embankments	9	12
		Culverts	12	16
Wildfire	Structural Elements / Physical Infrastructure	Surface Drainage	N/A	10
		Culverts	N/A	10
	Miscellaneous	Emergency Response	N/A	15
		Administration / Personnel & Engineering	N/A	10
Wind	Miscellaneous	Maintenance	N/A	12
		Administration / Personnel & Engineering	N/A	8
Icing	Structural Elements / Physical Infrastructure	Culverts	N/A	12
	Miscellaneous	Maintenance	N/A	12
		Administration / Personnel & Engineering	N/A	8

Risk Classification	Negligible/Low	Moderate	High	Extreme

5 Adaptations Update

Adaptation considerations were developed for high and extreme risks identified in the CCRA. While many climate risks can be mitigated through Operations and Maintenance (O&M) policies and procedures, it is outside the scope of the CCRA to complete a detailed review of O&M policies for their effectiveness in reducing climate risks. Table 5-1 presents a 2080s Project risk profile with adaptation considerations for the additional climate parameters (wildfires, wind, and icing).

Adaptation considerations developed in the 2021 CCRA remain applicable and valid. Nevertheless, additional adaptation considerations were developed during the update and are presented in Table 5-2. Adaptation considerations presented in Table 5-2 are in addition to the considerations developed in the 2021 CCRA and should, therefore, be assessed together.

Table 5-1 2080s Project Risk Profile – Wildfire, Wind, and Icing Climate Parameters

Climate Parameter	Infrastructure Component Impacted	Description of Climate Interaction	2080s Probability Rating	Consequence Rating	2080s Risk Rating	Adaptation Considerations
Wildfire	Structural Elements / Physical Infrastructure: Surface Drainage	A loss of vegetation from wildfire could result in increased runoff and impacts on roadside drainage (e.g., increased volume exceeding design flow capacity of culverts) and roadside erosion. Wildfire occurrence may quicken and/or exacerbate permafrost thaw and its impacts on the roadway drainage system.	5	2	10	Routine inspection of roadway sections impacted by wildfire for erosion and undertake maintenance actions as necessary. Design and install permanent erosion control measures in areas anticipated to be suspectable to erosion.
	Structural Elements / Physical Infrastructure: Culverts		5	2	10	Consider runoff volumes with no vegetation present in design criteria decisions. Establish an O&M policy for regular inspection to confirm culverts are working effectively and maintaining drainage patterns.
	Miscellaneous: Emergency Response	Wildfires could result in road closures, adding to the wildfire related health & safety risks to road users and maintenance staff.	5	3	15	Work with communities in the region to establish evacuation plans which take into consideration the possibility of road closure. Establish O&M policies that include contingency plans for maintenance staff in the event of wildfire and road closure.
	Miscellaneous: Administration / Personnel & Engineering	Wildfires and related poor air quality could result in a health & safety risk to road users, maintenance staff, and other personnel.	5	2	10	Establish O&M policies for working in adverse conditions, including poor air quality and heat, and regular monitoring of wildfire activity in the region.

Climate Parameter	Infrastructure Component Impacted	Description of Climate Interaction	2080s Probability Rating	Consequence Rating	2080s Risk Rating	Adaptation Considerations
Wind	Miscellaneous: Maintenance	High winds could result in branches and windblown debris on the roadway, requiring increased maintenance to clear the road of potential obstacles. High winds may result in snow drifts which could results in additional maintenance and temporary road closure.	4	3	12	Complete a roadway patrol for and removal of branches and windblown debris following high wind events. Use the established public notification system to communicate with road users and report on maintenance activities. Establish snow clearing practices as part of O&M that provide adequate capacity for clearing snow drifts from the most impacted areas of the roadway.
	Miscellaneous: Administration / Personnel & Engineering	High winds could result in reduced air quality due to dust, creating a health & safety risk to road users, maintenance staff, and other personnel. High winds also present an operational hazard to large vehicles (e.g., potential for tipping over of tractor trailers).	4	2	8	Establish O&M policies for working in adverse conditions, including poor air quality. Monitor weather forecasts and apply dust control measures prior to high wind events to reduce airborne dust. Use the established public notification system to communicate with road users and report on weather conditions.
Icing (including icing due to freezing rain and/or aufeis [overflow])	Structural Elements / Physical Infrastructure: Culverts	Icing could result in ice buildup in culverts, requiring thawing by maintenance staff to restore full functionality.	4	3	12	Establish an O&M policy to inspect culverts and complete necessary thawing prior to spring thaw or cold season rainfall events.
	Miscellaneous: Maintenance	Icing of the road surface could result in increased maintenance (distribution of gravel and/or salt) to maintain road access.	4	3	12	Implement an operator training program on best practices as it relates to the management of gravel roads (e.g., straight salt and liquids should not be used).

Climate Parameter	Infrastructure Component Impacted	Description of Climate Interaction	2080s Probability Rating	Consequence Rating	2080s Risk Rating	Adaptation Considerations
	Miscellaneous: Administration / Personnel & Engineering	Icing of the road surface and roadsides could result in a health & safety risk to road users, maintenance staff, and other personnel (e.g., increase potential for road accidents, slip-and-fall risk)	4	2	8	Use the established public notification system to communicate with road users and report on road conditions.

Risk Classification	Negligible/Low	Moderate	High	Extreme

Table 5-2 2080s Project Risk Profile – Additional Adaptation Considerations

Climate Parameter	Infrastructure Component Impacted	Description of Climate Interaction	2080s Probability Rating	Consequence Rating	2080s Risk Rating	Additional Adaptation Considerations
Mean Seasonal Temperatures	Structural Elements / Physical Infrastructure: Culverts	Increasing temperature would initiate snowmelt through either freshet or precipitation events. These events create fast flowing surface water and increase the potential erosion around culverts through the generation of fast flowing surface water.	5	4	20	Routine inspections for erosion and undertake maintenance actions as necessary. Design and install permanent erosion control measures in areas anticipated to be suspectable to erosion.
	Structural Elements / Physical Infrastructure: Road Base and Subgrade	Extreme temperatures and dry periods can result in cracking of the edges of the road. Cracking of the edges of the road can present safety issues for road users and would result in increased maintenance.	5	2	10	Routine inspections for roadway damage and undertake maintenance actions as necessary
High Temperature Extremes (>30°C)	Structural Elements / Physical Infrastructure: Road Base and Subgrade	Wildfires destroy insulating ground cover (grasses / vegetation) and can increase ground temperatures. This may impact permafrost resulting in accelerated thawing and structural problems.	5	3	15	Where permafrost is present, apply active and passive heat mitigation techniques such as thermosyphons, air convection embankments (ACE), air ducts and heat drains (HD), reflective surfaces, insulation and embankment thickening.
	Miscellaneous: Emergency Response	Wildfires are also a public and maintenance staff safety risk and can result in road closures.	5	3	15	Work with communities in the region to establish evacuation plans which take into consideration the possibility of road closure. Establish O&M policies that include contingency plans for maintenance staff in the event of wildfire and road closure.

Climate Parameter	Infrastructure Component Impacted	Description of Climate Interaction	2080s Probability Rating	Consequence Rating	2080s Risk Rating	Additional Adaptation Considerations
Precipitation Extremes	Structural Elements / Physical Infrastructure: Road Embankments	Embankments can be susceptible to changes in spring melt, rainfall frequency, intensity and duration, as well as groundwater levels resulting in internal erosion. Internal and external erosion can impact the structural integrity, raising the possibility of washouts, more repair work and loss of sediment to watercourses, affecting the	2	4	8	Routine inspections for erosion and undertake maintenance actions as necessary. Design and install permanent erosion control measures in areas anticipated to be suspectable to erosion. Consider projected changes in precipitation (including short duration, high intensity rainfall events) in the sizing of culverts.
Freeze-Thaw Days	Structural Elements / Physical Infrastructure: Road Embankments	Snowmelt-driven flooding create fast flowing surface water and groundwater and surface water flow which can lead to erosion and material movement down from steep embankments	3	3	9	Routine inspections for erosion and undertake maintenance actions as necessary. Design and install permanent erosion control measures in areas anticipated to be suspectable to erosion.

Risk Classification	Negligible/Low	Moderate	High	Extreme

6 Limitations

This update to the Mackenzie Valley Highway Climate Change Resilience Assessment (CCRA) was conducted using the best information available to the assessment team at the time of the study. The climate data and trends (current and future projections) used in this study were obtained through various sources. Cross-verification between climate information sources was conducted where possible to identify potential discrepancies between the data sources used. Climate data is inherently uncertain. The climate parameter probabilities provided should be considered as high-level estimates of future conditions. The primary source of uncertainty in climate projections is the estimate of greenhouse gas emissions that will be observed over the current century. Additional sources of uncertainty include (but are not limited to) climate model parameterization, bias, and resolution.

The CCRA provides a broad system-level assessment of the Project assets. The risk assessment for future time horizons is based on the assumption that the vulnerability of infrastructure components is the same as in today's climate, i.e., the infrastructure is maintained in the same physical condition as at the time of the study, and that maintenance and operation policies and processes will not change in the future.

Climate hazards can cause situational/locational impacts outside the CCRA Project boundary and result in cascading impacts to the Project. Climate related event impacts to other regions outside the Mackenzie Valley Highway region could result in cascading impacts, including services provided by third parties (e.g., supply chain issues), and have significant impacts to the Project. The boundary limits for this CCRA focus on the FBC service area, assets, and services and has not assessed the risks associated with cascading climate events occurring outside of the immediate Project boundary.

7 Conclusion

This update to the 2021 Mackenzie Valley Highway Climate Change Resilience Assessment was completed by K'alo-Stantec to provide updated climate projections under the SSP5-8.5 emissions scenario, climate parameter probability ratings and associated risk ratings, and adaptation recommendations. This update also considered three additional climate parameters noted by the Mackenzie Valley Environmental Impact Review Board in Information Request 2. Additionally, Traditional Knowledge gathered through engagement with affected parties and Traditional Land and Resource Use studies was incorporated into the CCRA update.

The updated climate assessment resulted in a 2080s (1971-2100) probability rating increase for the precipitation extremes (short duration, high intensity precipitation) and freeze-thaw days climate parameters. While risk ratings subsequently increased, the majority of the 2021 CCRA and 2024 update risk ratings are classified as high risk. The 2080s risk to culverts associated with freeze-thaw days, however, did change from high risk to extreme risk with the updated climate assessment. Adaptation recommendations developed in the 2021 CCRA remain relevant for the risks associated with precipitation extremes and freeze-thaw days.

For the three additional climate parameters – wildfire, wind, and icing – high risks were identified associated with maintenance of the roadway (e.g., increased maintenance necessary) and health & safety hazards to maintenance staff, road users, and other personnel (e.g., poor air quality associated with wildfires and airborne dust due to high winds). High risks were also identified for surface drainage and culverts in association with wildfires (impacts related to increased runoff due to loss of vegetation) and for culverts in association with icing (impacts related to ice buildup in the culverts requiring melting by maintenance staff). Adaptation recommendations for the three additional climate parameters include the following:

- Routine inspection of roadway for erosion and undertake maintenance actions as necessary.
- Design and install permanent erosion control measures in areas anticipated to be suspectable to erosion.
- Work with communities in the region to establish evacuation plans which take into consideration the possibility of road closure due to climate and weather-related events.
- Establish O&M policies for working in adverse conditions and include contingency plans in the event of wildfire and/or road closure.
- Continue to use the established public notification system to communicate with road users and report on maintenance activities, road conditions, and weather conditions.

8 References

5658 NWT Ltd. and GNWT (5658 NWT Ltd. and the Government of the Northwest Territories). 2011. Project Description Report For Construction of the Mackenzie Valley Highway Tulita District, Sahtú Settlement Area. Available at: https://www.inf.gov.nt.ca/sites/inf/files/resources/project_description_report_for_construction_of_the_mvh_tulita_district.pdf. PR#16.

Auld, J. and R. Kershaw. 2005. The Sahtú Atlas. Friesens, Canada. Available at: https://www.srrb.nt.ca/document-repository/public/ Sahtú-atlas/115- Sahtú-atlas-complete-document/file. Accessed November 2022.

Boulanger, Y., S. Gauthier and P.J. Burton. 2014. A refinement of models projecting future Canadian fire regimes using homogeneous fire regime zones. *Canadian Journal of Forest Research*, 44: 365-376. doi:10.1139/cjfr-2013-0372

Cannon, A. J. 2015. Selecting GCM Scenarios that Span the Range of Changes in a Multimodel Ensemble: Application to CMIP5 Climate Extreme Indices. *Journal of Climate*, 28: 1260-1267. doi:10.1175/JCLI-D-14-00636.1

Cannon, A.J., S.R. Sobie, and T.Q. Murdock. 2015. Bias Correction of GCM Precipitation by Quantile Mapping: How Well Do Methods Preserve Changes in Quantiles and Extremes? *Journal of Climate*, 28: 6938-6959. doi:10.1175/JCLI-D-14-00754.1

Cannon, A.J., D.I. Jeong, X. Zhang and F.W. Zwiers. 2020. *Climate-Resilient Buildings and Core Public Infrastructure: An Assessment of the Impact of Climate Change on Climatic Design Data in Canada*. Government of Canada, Ottawa, ON. 160 p. https://publications.gc.ca/collections/collection_2021/eccc/En4-415-2020-eng.pdf

Cheng, C.S., E. Lopes, C. Fu, and Z. Huang. 2014. Possible Impacts of Climate Change on Wind Gusts under Downscaled Future Climate Conditions: Updated for Canada. *Journal of Climate*, 27:1255-1270. doi:10.1175/JCLI-D-13-00020.1.

Dehcho First Nations. 2011. Traditional Knowledge Assessment of Boreal Caribou (Mbedzhi) in the Dehcho Region. Prepared by Dehcho First Nations for the Canadian Wildlife Service. Published by the Dehcho First Nations Fort Simpson, Northwest Territories.

Dessau. 2012. Mackenzie Valley Highway Extension Pehdzeh Ki Ndeh – Dehcho Region. Project Description Report. Prepared for Government of the Northwest Territories, Department of Transport. PR#13.

Eyring, V. S. Bony, G.A. Meehl, C.A. Senior, B. Stevens, R.J. Stouffer and K.E. Taylor. 2016. Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization. *Geoscientific Model Development*, 9: 1937-1958. doi:10.5194/gmd-9-1937-2016

Golder. 2015. Central Mackenzie River Surface Water and Groundwater Baseline Assessment. Report 1: Technical State of Knowledge. Report Number: 1401835 Final Report 1. May 21, 2015.

Hausfather, Z. and G.P. Peters. 2020. Emissions – the 'business as usual' story is misleading. *Nature*, 577: 618-620. doi:10.1038/d41586-020-00177-3

Huberman, Y., J. Beckers, R. Brett, G. Castilla, R. Errington, E.C. Fraser-Reid, D. Goodsman, E.H. Hogg, J. Metsaranta, E. Neilson, J. Olesinski, M.-A. Parisien, D. Price, T. Ramsfield, C. Shaw, D. Thompson, M.F. Voicu, E. Whitman and J. Edwards. 2022 *The State of Northwest Territories Forests in the Wake of Climate Change: Baseline Conditions and Observed Changes to Forest Ecosystems.* Natural Resources Canada, Canadian Forest Service, Northern Forest Centre. Edmonton, AB. Information Report NOR-X-430. https://publications.gc.ca/collections/collection_2022/rncan-nrcan/Fo133-1-430-eng.pdf

IPCC. 2013. *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.

IPCC. 2021. *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* [Masson-Delmotte, V. P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. doi:10.1017/9781009157896

IPCC. 2022. *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Balkacemi, A. Hasija, G. Lisboa, S. Luz, and J. Malley (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi:10.1017/9781009157926

Jones, M.W., J.T. Abatzoglou, S. Veraverbeke, N. Andela, G. Lasslop, M. Forkel, A.J.P. Smith, C. Burton, R.A. Betts, G.R. van der Werf, S. Sitch, J.G. Canadell, C. Santín, C. Kolden, S.H. Doerr and C.L. Quéré. 2022. Global and Regional Trends and Drivers of Fire Under Climate Change. *Reviews of Geophysics*, 60: e2020RG000726. doi:10.1029/2020RG000726

Kochtubajda, B., C. Mooney and R. Stewart. 2017. Characteristics, atmospheric drivers and occurrence patterns of freezing precipitation and ice pellets over the Prairie Provinces and Arctic Territories of Canada: 1964-2005. *Atmospheric Research*, 191: 115-127. doi:10.1016/j.atmosres.2017.03.005

McCray, C.D., D. Paquin, J.M. Thériault and É. Bresson. 2022. A Multi-Algorithm Analysis of Projected Changes to Freezing Rain Over North America in an Ensemble of Regional Climate Model Simulations. *Journal of Geophysical Research: Atmospheres*, 127: e2022JD036935. doi:10.1029/2022JD036935

McDonald, R. 2010. Boreal Caribou Traditional Knowledge Collection Study: The Sahtu Settlement Area. Edited by A. Hrynkiw, G. Guthrie, and R. McDonald. For the Canadian Wildlife Service, Environment Canada.

Mekis, E., R.E. Stewart, J.M. Theriault, B. Kochtubajda, B.R. Bonsal and Z. Liu. 2020. Near-0 °C surface temperature and precipitation type patterns across Canada. *Hydrology and Earth System Sciences*, 24: 1741-1761. doi:10.5194/hess-24-1741-2020

NWRRC (Norman Wells Renewable Resource Council). 2023. Norman Wells Renewable Resources Council Traditional Land and Resource Use Study for Tulita District Mackenzie Highway Project. Prepared by K'alo-Stantec Limited. Prepared for Norman Wells Renewable Resources Council.

Pedersen, J.S.T., D.P. van Vuuren, B.A. Aparício, R. Swart, J. Gupta and F.D. Santos. 2020. Variability in historical emissions trends suggests a need for a wide range of global scenarios and regional analyses. *Communications Earth & Environment*, 1: 1-7, doi:10.1038/s43247-020-00045-y

Riahi, K., D.P. van Vuuren, E. Kriegler, J. Edmonds, B.C. O'Neill, S. Fujimori, N. Bauer, K. Calvin, R. Dellink, O. Fricko, W. Lutz, A. Popp, J.Crespo Cuaresma, Samir KC, M. Leimbach, L. Jiang, T. Kram, S. Rao, J. Emmerling, K. Ebi, T. Hasegawa, P. Havlik, F. Humpenöder, L. Aleluia Da Silva, S. Smith, E. Stehfest, V. Bosetti, J. Eom, D. Gernaat, T. Masui, J. Rogelj, J. Strefler, L. Drouet, V. Krey, G. Luderer, M. Harmsen, K. Takahashi, L. Baumstark, J.C. Doelman, M. Kainuma, Z. Klimont, G. Marangoni, H. Lotze-Campen, M. Obersteiner, A. Tabeau and M. Tavoni. 2016. The Shared Socioeconomic Pathways and their energy land use, and greenhouse gas emissions implications: An overview. *Global Environmental Change*, 42: 153-168. Doi:10.1016/j.gloenvcha.2016.05.009

Schwalm, C.R., S. Glendon and P.B. Duffy. RCP8.5 tracks cumulative CO_2 emission. *Proceedings of the National Academy of Sciences*, 117: 19656-19657. Doi:10.1073/pnas.2007117117

SLUPB (Sahtú Land Use Planning Board). 2022. eghalatseyeda kesoridatosedehake: Background Report 2022 Edition. Available at: https://Sahtúlanduseplan.org/sites/default/files/2022-07/slupb-background-report_web.pdf. Accessed September 2022.

Smith, M.R. and S.S. Myers. 2018. Impact of anthropogenic CO_2 emissions on global human nutrition. *Natural Climate Change*, 8: 834-839. doi:10.1038/s41558-018-0253-3

SRRB. 2016. ʔekwęHé Dene Ts'įlį Sustaining Relationships. Final Report of the ʔehdzo Got'įnę Gots'ę Nákedı (Sahtú Renewable Resources Board) Bluenose-East ʔekwę (Caribou) Hearing July 2016. Tulıʈ'a, Northwest Territories. Available at: https://www.srrb.nt.ca/docman/public/public-hearings-registry/srrb-hearing-rules-and-guiding-documents/2016/bluenose-east-caribou-final-march-2016/supporting-documents/final-report/1580-srrb-bne-caribou-hearing-report-16-07-28-final/file. Accessed June 2022.

SRRB. 2021a. Sahtú Ragóʔa (Hunting Law) and Approaches to Wildlife Harvesting. Available at: https://srrb.nt.ca/docman/public/public-hearings-registry/2020/8-0-final-report/2043- Sahtú -rago-a-hunting-law-and-approaches-to-wildlife-harvesting-second-report-summary-21-03-30/file. Accessed June 2022.

Stantec. 2021. *Mackenzie Valley Highway Project – Climate Lens Part II: Climate Change Resilience Assessment*. Prepared for Government of Northwest Territories by K'alo-Stantec Ltd., 26 April 2021.

Taylor, K.E., R.J. Stouffer, and G.A. Meehl. 2012. An Overview of CMIP5 and the Experiment Design. *Bulletin of the American Meteorological Society*, 93: 485-498. doi:10.1175/BAMS-D-11-00094.1

TRRC (Tulita Renewable Resource Council). 2022. Tulita Renewable Resources Council Traditional Land and Resource Use Study for Tulita District Mackenzie Highway Project. Prepared by: K'alo-Stantec Limited. Prepared for Tulita Renewable Resource

Wang, X., T. Swystun and M.D. Flannigan. 2022. Future wildfire extent and frequency determined by the longest fire-conductive weather spell. *Science of the Total Environment*, 830: 154752. doi:10.1016/j.scitotenv.2022.154752

Appendix A Climate Profile for the Mackenzie Valley Highway Project – Updated for 2024 CCRA Addendum

Climate Profile for the Mackenzie Valley Highway Project – 2024 CCRA Addendum

Prepared for:

Government of the Northwest Territories Department of Infrastructure

Prepared by:

K'alo-Stantec Limited

June 19, 2024

Project No.: 123514886

K'alo-Stantec

Table of Contents

1 Introduction 1
1.1 Description of Climate Profiles 1
1.1.1 Levels of Confidence in Projections 4
1.2 Climate Profiles for the Mackenzie Valley Highway Project 5

2 Temperature 9
2.1 Mean Temperature 9
2.2 Maximum Temperature 10
2.2.1 Annual and Seasonal Average 10
2.2.2 Extreme Maximum Temperature Frequency 11
2.3 Minimum Temperature 12
2.3.1 Annual and Seasonal Average 12
2.3.2 Extreme Minimum Temperature Frequency 13

3 Precipitation 14
3.1 Total Annual & Seasonal Accumulation 14
3.2 Intensity-Duration-Frequency (IDF) 15
3.2.1 Norman Wells – Tulita Climate Zone 16
3.2.2 Wrigley – Fort Simpson Climate Zone 18
3.3 1-, 3-, and 5-Day Accumulation 20
3.4 Snowfall 20
3.5 Dry Spells 24

4 Frost Days 26

5 Freeze-Thaws 27

6 Ice Accretion 28

7 Wind 30

8 Wildfire 39

9 Permafrost 43

10 References 49

List of Tables

Table 1 Observation Stations in the Study Region 7
Table 2 Climate Normals Differences between the Two Climate Zones 7
Table 3 Projected Average Annual Mean Temperature and Change from Baseline under SSP5-8.5 9
Table 4 Projected Average Annual Maximum Temperature and Change from Baseline under SSP5-8.5 10
Table 5 Annual Occurrence of Maximum Daily Temperatures > 30°C: Historic (1981-2010) and Projected under SSP5-8.5 11
Table 6 Projected Average Annual Minimum Temperature and Change from Baseline under SSP5-8.5 12
Table 7 Occurrence of Minimum Daily Temperatures < -30°C: Historic (1981-2010) and Projected under SSP5-8.5 13
Table 8 Projected Average Total Precipitation and Change from Baseline under SSP5-8.5 14
Table 9 Historical Precipitation Event Accumulation IDF data (mm) – Norman Wells Climate (Station ID: 2202810), 1974-2021 16
Table 10 Projected Precipitation Event Accumulation IDF data (mm), Norman Wells Climate (Station ID: 2202810), SSP5-8.5, 2020s 16
Table 11 Projected Precipitation Event Accumulation IDF data (mm), Norman Wells Climate (Station ID: 2202810), SSP5-8.5, 2050s 17
Table 12 Projected Precipitation Event Accumulation IDF data (mm), Norman Wells Climate (Station ID: 2202810), SSP5-8.5, 2080s 17
Table 13 Historical Precipitation Event Accumulation IDF data (mm) – Fort Simpson Climate (Station ID: 2202102), 1969-2021 18
Table 14 Projected Precipitation Event Accumulation IDF data (mm), Fort Simpson Climate (Station ID: 2202102), SSP5-8.5, 2020s 18
Table 15 Projected Precipitation Event Accumulation IDF data (mm), Fort Simpson Climate (Station ID: 2202102), SSP5-8.5, 2050s 19
Table 16 Projected Precipitation Event Accumulation IDF data (mm), Fort Simpson Climate (Station ID: 2202102), SSP5-8.5, 2080s 19
Table 17 Record Maximum 1-, 3-, and 5-day Precipitation Accumulation 20
Table 18 Average Annual Maximum Number of Consecutive Dry Days: Historical (1981-2010) and Projected under SSP5-8.5 25
Table 19 Average Annual Number of Frost Days: Historical (1981-2010) and Projected under SSP5-8.5 26
Table 20 Annual Freeze-Thaw Cycles: Historical (1981-2010) and Projected under SSP5-8.5 27
Table 21 Winter Season Freeze-Thaw Cycles: Historical (1981-2010) and Projected under SSP5-8.5 27
Table 22 Canadian Climate Normals, Wind, Norman Wells A Station (source: Environment and Climate Change Canada, 1981-2010 Climate Normals) 31
Table 23 Canadian Climate Normals, Wind, Fort Simpson A Station (source: Environment and Climate Change Canada, 1981-2010 Climate Normals) 32

Table 24 Percent Change in Daily Wind Gust Event Frequency (Data source: Cheng et al., 2014) 38
Table 25 Summary of Projected Changes in Large (> 200 ha) Fire Occurrence (Data sources: Boulanger et al., 2014; Wang et al., 2022) 41
Table 26 Projected Change in the Fire Weather Index (Data source: Wang et al., 2015) 42

List of Figures

Figure 1 Historical CO2 emissions for 1980-2017 and projected emissions trajectories until 2100 for the four RCP scenarios (Figure from Smith and Myers, 2018) 4
Figure 2 Mackenzie Valley Highway Project Overview and Eco Zones 6
Figure 3 Annual Total Snowfall for Norman Wells A and Fort Simpson A for available data between 1944 to 2023 and 1964 to 2023, respectively 21
Figure 4 Projected snow cover fraction and sea ice concentration trends for 2020-2050 (Figure source: Mudryk et al., 2018) 22
Figure 5 Projected trends in maximum snow water equivalent (SWE) for 2020-2050 under the RCP8.5 emissions scenario (Figure source: Mudryk et al., 2018) 23
Figure 6 Maximum Annual Dry Spells, Norman Wells A and Form Simpson A, 1943-2023 24
Figure 7 CanRCM4 LE projected changes to ice accretion loads (20-year return period) for three global warming levels (Figure source: Cannon et al., 2020) 29
Figure 8 Daily Maximum Wind Gust Speed and Direction from 1958-2024 Observed at the Norman Wells A (Station ID: 2202800 and 2202801) 33
Figure 9 Seasonal Daily Maximum Wind Gust Speed and Direction From 1958-2024 Observed at the Norman Wells A 34
Figure 10 Daily Maximum Wind Gust Speed and Direction From 1963-2024 Observed at the Fort Simpson A (Station ID: 2202101 and 2202103) 35
Figure 11 Seasonal Daily Maximum Wind Gust Speed and Direction From 1963-2024 Observed at the Fort Simpson A 36
Figure 12 Wind Gust Regions and Selected Stations Utilized in Cheng et al., 2014 (Figure Source: Cheng et al., 2014) 37
Figure 13 1980-2020 Large Fire (> 200 ha) Locations (Figure source: Canadian Forest Service) 39
Figure 14 Projected Changes in Annual Area Burned (AAB) and Fire Occurrence (FireOcc) Compared with the Baseline (1961-1990) Time Period. (Figure source: Boulanger et al., 2014) 40
Figure 15 Ratio of Shift (relative to 1981-2010 baseline) for Annual Area Burned (AAB), Annual Number of Fires (ANF), and Maximum Fire Size (MFS) by Ecozone Under RCP8.5 (Figure source: Wang et al., 2022) 41
Figure 16 Permafrost Zones in the Northwest Territories (Figure source: NWT SOE Report, 2022) 43
Figure 17 Spatial Distribution of Multiyear Average in-situ Active Layer Thickness Across the Northern Hemisphere (Figure source: Peng et al., 2018) 45
Figure 18 Mackenzie Valley Ecoregions and Permafrost Active Layer Monitoring Sites (Figure Source: Garibaldi et al., 2022) 46

Figure 19 Projected Change in Active Layer Thickness Between the 2071-2100 Climatology Under the RCP8.5 Emissions Scenario and the Historical 1971-2000 Simulation (Figure source: Peng et al., 2018)..... 47
Figure 20 Projected change in permafrost extent under +3°C of global warming (Figure source: Cannon et al., 2020)..... 48

1 Introduction

1.1 Description of Climate Profiles

Climate is usually defined as the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of meteorological variables such as temperature, precipitation, and wind over a period of time (e.g., a 30-year period or longer[1]). Climate profiles are important tools that describe what climate trends have been occurring in recent history, and also describe future climate conditions to help inform planners, stakeholders and decision makers in managing the climate change risks and planning for appropriate adaptation measures. Climate profiles rely on the historical climate record (usually in the form of meteorological data measured at weather stations) to describe climate from recent history, and on climate projections (developed by global climate models or GCMs). The historical climate profile puts future climate projections into context: the performance of the infrastructure from the past can be compared to both historical and future climate to better understand what (if any) adaptation measures should be implemented to ensure better performance in the future.

When developing a profile of the historic climate, meteorological data from a recent 30-year period (e.g., 1981-2010 or 1991-2020) is preferred to provide a representative estimate of the recent climate at a given location – though longer periods are of benefit in that they add even more to the story of an area's historical climate. Environment and Climate Change Canada (ECCC) provides the largest database of observational historical climate data in Canada. For locations that do not have good coverage from weather stations (e.g., remote locations), or when completing a regional scale assessment, gridded data products are also used. Natural Resources Canada (NRCan) has produced the NRCANmet gridded dataset, which includes daily maximum and minimum temperature and total precipitation data on a ~10 km grid resolution over Canada for the 1950-2017 time period (Hopkinson et al., 2011; McKenney et al., 2011). The NRCANmet data is interpolated from quality-controlled but unadjusted station data from the National Climate Data Archive of Environment and Climate Change Canada and is widely used by industry and researchers (Hutchinson et al., 2009). Although observational data from a weather station is preferable, gridded datasets such as NRCANmet are well accepted and researched and can provide reasonable approximations for locations when historic data is not inadequate for climate assessment.

Climate projections are descriptions of plausible future climate, dependent on assumptions about future economic, social, technological, and environmental conditions which will drive greenhouse gas concentrations in the atmosphere. Climate models are the primary tools used to develop three-dimensional climate projections. Since 1995, the Coupled Model Intercomparison Project (CMIP)[2] has coordinated the international design and distribution of global climate model (GCM) simulations of past, present, and future climate. It is not recommended to rely only on one or two of these GCMs to estimate future climate. Instead, an average of several GCMs (i.e., a multi-model ensemble) tends to give a more

[1] A timespan of 30 years is the classical period for defining climate, as established by the World Meteorological Organization (WMO). Calculating climate over a 30-year period removes short-term variability, e.g., year-to-year weather variability, and reveals long-term averages, trends, variability, and other statistical values, often referred to as the climate signal.
[2] https://www.wcrp-climate.org/wgcm-cmip

reliable estimate of future climate (Cannon et al., 2020; IPCC, 2021). Additionally, the use of a multi-model ensemble provides information on the range of model output (inter-model spread) and, therefore, insight into inter-model uncertainty. Most recently, GCMs have contributed to CMIP Phase 6 (CMIP6; Eyring et al., 2016), which forms the basis of the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6; IPCC 2021). Previous to this, a similar set of GCMs contributed to CMIP Phase 5 (CMIP5; Taylor et al., 2012), which formed the basis of the IPCC Fifth Assessment Report (AR5; IPCC, 2013). CMIP model performances have undergone evaluation and validation, both individually and collectively (IPCC, 2013). When possible, model evaluations are completed by comparing model output with observations and analyzing the resulting difference. In cases when observations are not available or insufficient, model evaluations are completed through intercomparison of model results, providing quantification of model uncertainty via inter-model spread.

Downscaling methods are often used to produce finer spatial resolution projections from GCMs. Approximately 35 Global Climate Models (GCMs) have contributed to CMIP6. The Pacific Climate Impacts Consortium (PCIC)[3] uses a subset of 26 of these models to produce reliable, high-resolution (~10 km) downscaled climate projections localized to specific areas of interest in Canada, referred to as the Canadian Downscaled Climate Scenarios – Univariate (CMIP6) (CanDCS-U6) (Cannon, 2015; Cannon et al., 2015). PCIC-downscaled CMIP6 climate projections are the primary source of climate projections data for this climate profile and CCRA for the Mackenzie Valley Highway. For climate hazards with limited or no CMIP6 SSP-derived climate projections available, CMIP Phase 5 (CMIP5) RCP-driven projections and specialized studies/scientific literature were utilized. CMIP5 projections form the basis of the IPCC's Fifth Assessment Report publications and a subset of 27 of the CMIP5 GCMs have been downscaled by PCIC, referred to as Canadian Downscaled Climate Scenarios – Univariate (CMIP5) (CanDCS-U5). For both CanDCS-U5 and CanDCS-U6, PCIC produced the downscaled projections for the simulated period of 1950-2100 using the hybrid Bias Correction/Constructed Analogues with Quantile delta mapping reordering, version 2, or BCCAQv2, downscaling method (Cannon, 2015; Cannon et al., 2015).

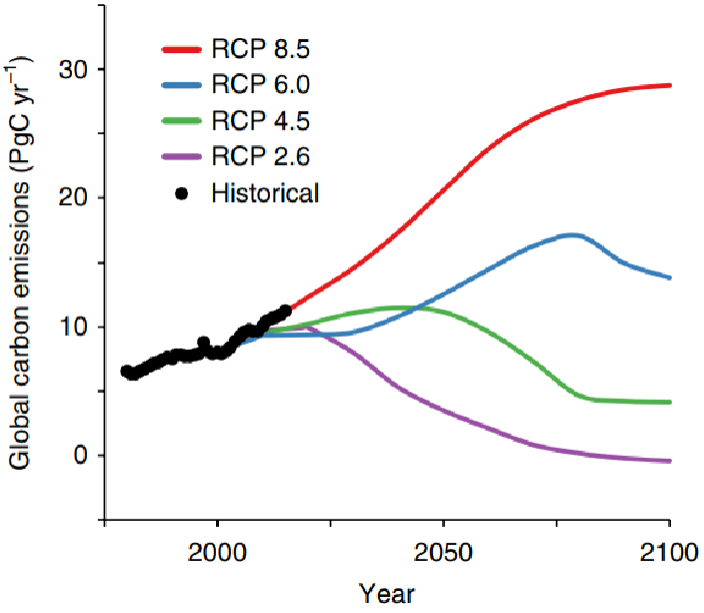
Actual climate conditions in the future will depend on the concentration of greenhouse gases (GHGs) in the atmosphere. Across multiple iterations of IPCC assessments, various scenarios have been developed to estimate GHG trajectories (emissions- or concentrations-driven) into the future, with focus on anthropogenic emissions. While these GHG scenarios provide a range of plausible futures for anthropogenic emissions, the exact rate of change and eventual concentrations in year 2100 (and beyond) can never be precisely predicted. As such, a large source of uncertainty in all future climate projections is based in the future trajectory of global GHG emissions as controlled by societal actions. The IPCC's Fifth Assessment Report (IPCC, 2013) presented climate change assessments using Representative Concentration Pathway (RCP) scenarios (van Vuuren et al., 2011)[4]. There are four RCP scenarios which were adopted by the IPCC for its Fifth Assessment Report, ranging from low emissions (RCP2.6) to moderate emissions (RCP4.5 and RCP6.0) to high emissions.

[3] https://www.pacificclimate.org/
[4] RCP: Representative Concentration Pathways – a greenhouse gas concentration (not emissions) trajectories adopted by the Intergovernmental Panel on Climate Change (IPCC) for its fifth Assessment Report (AR5) in 2013/2014.

(RCP8.5) trajectories. The IPCC's Sixth Assessment Report (IPCC, 2021) presents the latest global and regional assessments of climate change and its impacts using a set of five new illustrative emissions scenarios, referred to as Shared Socioeconomic Pathways (SSPs; Riahi et al., 2016). There are five SSP scenarios which were adopted by the IPCC for its Sixth Assessment Report, ranging from very low emissions (SSP1-1.9) to low emissions (SSP1-2.6) to intermediate emission (SSP2-4.5) to high emissions (SSP3-7.0) to very high emissions (SSP5-8.5). The SSP5-8.5 trajectory more closely aligns with historical and current emissions and represents a plausible emissions track into the future (Figure 1) (Smith and Myers, 2018; Pedersen et al., 2020; Schwalm et al., 2020). While recent studies (Hausfather and Peters, 2020) suggest that the higher emissions scenarios (e.g., SSP5-8.5) may have become less likely due to technological developments and emerging climate policies, the higher emissions scenarios remain plausible trajectories and provide insight into "high-end" risks of climate change (IPCC, 2022). The SSP5-8.5 very high emissions scenario was therefore recommended for use in the CCRA to present a conservatively high estimate of projected climate change and its associated impacts in the climate assessment.

> The IPCC is the international body for assessing the science related to climate change. The IPCC was set up in 1988 by the World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP) to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation.
>
> IPCC assessments provide a scientific basis for governments at all levels to develop climate related policies, and they underlie negotiations at the UN Climate Conference – the United Nations Framework Convention on Climate Change (UNFCCC). The assessments are policy-relevant but not policy-prescriptive: they may present projections of future climate change based on different scenarios and the risks that climate change poses and discuss the implications of response options, but they do not tell policymakers what actions to take.

Figure 1 **Historical CO2 emissions for 1980-2017 and projected emissions trajectories until 2100 for the four RCP scenarios (Figure from Smith and Myers, 2018)**



1.1.1 Levels of Confidence in Projections

Future climate conditions for the 2020s (2011-2040), 2050s (2041-2070), and 2080s (2071-2100) under the SSP5-8.5 emissions scenarios were retrieved from climate projections produced with the downscaled Global Climate Models (GCMs), as well as from specialized literature, and professional judgement of Stantec's climate scientists. Some climate variables can be projected into the future with more confidence than others. The level of confidence in climate projections is dependent on the understanding of the processes involved in the climate phenomena, ability of climate models to simulate the phenomena, the degree of agreement among the climate models (e.g., range of uncertainty), and the supporting evidence (e.g., theory, specialized literature, expert judgement). In general, projections based on Global Climate Models (GCMs) and downscaling of such models are considered:

- Adequate (high confidence) for general temperature and precipitation projections,
- Less adequate (moderate confidence) for extreme parameters, and
- Inadequate for combined events (low confidence) such as wildfires.

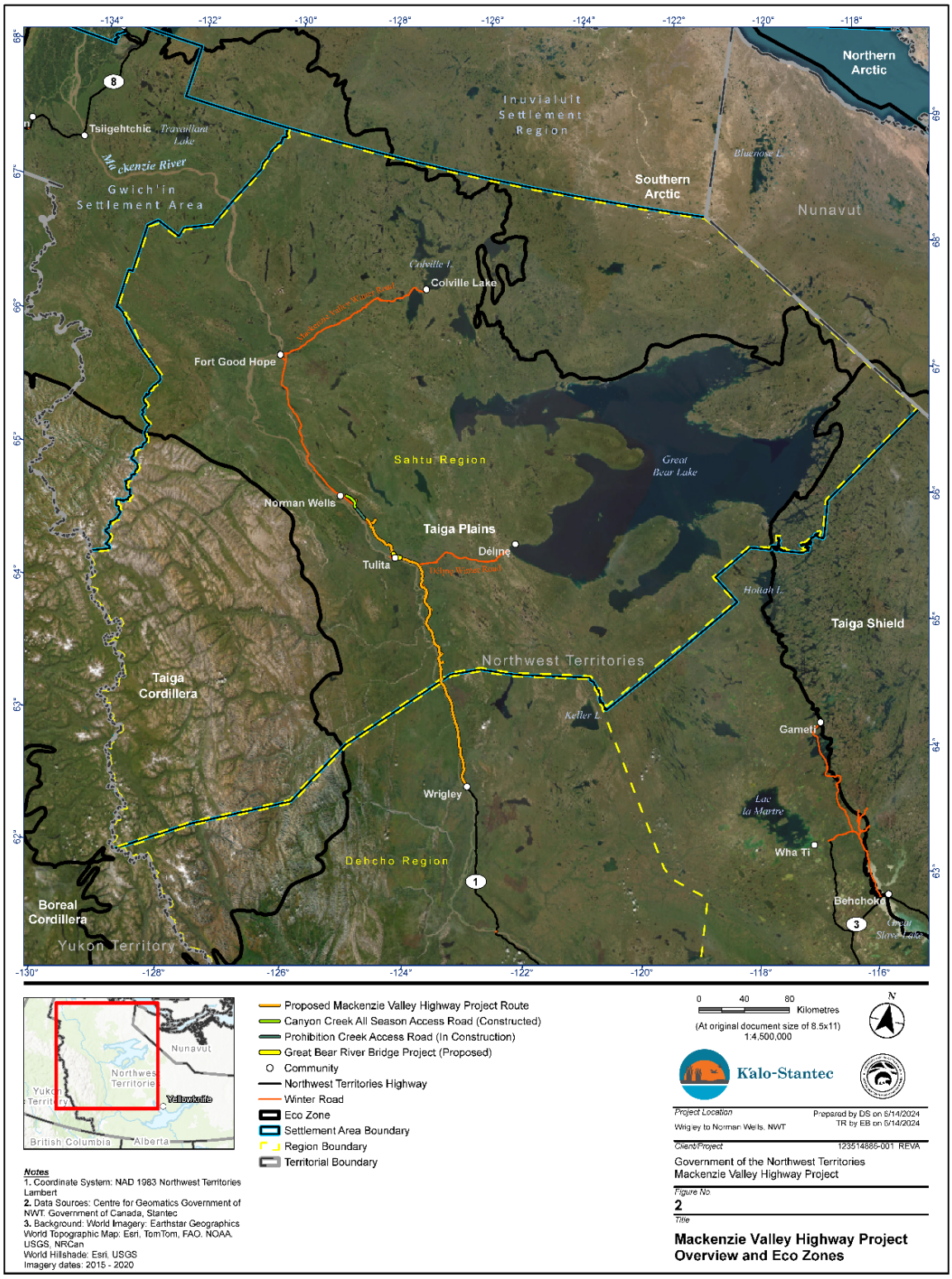
Combined or complex climate variables are normally inferred from other climate variables and result in lower confidence for projections. For example, wildfire is a complex process and the occurrence of wildfires depends on numerous variables, including temperature and precipitation (which influence moisture/dryness conditions), ignition sources (including lightning/atmospheric discharge activity), fuel characteristics, and fire management actions. As a result, the projected changes in wildfire activity under future climate conditions is not as well understood as other variables such as temperature. Confidence may also refer to whether other specialized studies have been done for the climate events projections in the geographical area of interest.

Despite low levels of confidence in some climate projection values, the general projected trend in frequency can provide valuable information for planning purposes (e.g., adaptation strategies). For climate variables with low confidence levels in the projections, additional studies (e.g., sensitivity analyses) can provide further insight into the potential impacts of climate change on infrastructure reliability in different warming and load combination scenarios.

1.2 Climate Profiles for the Mackenzie Valley Highway Project

Two climate zones were defined, corresponding with ecological regions in the area, which generally align with differentiation in climate and weather patterns of the breadth of the Mackenzie Valley Highway (Figure 2). A review of available historical observation data identified various weather stations throughout the region with data archived by Environment and Climate Change Canada (ECCC). Many of these stations, however, either are no longer in operation or have short records and, as such, do not provide sufficient data for climate analysis (including the calculation of 1981-2010 Climate Normals values). Of the stations with sufficiently long records covering the recent decades, an individual station was selected to represent each climate zone and used for detailed analysis (Table 1). Station proximity to the proposed highway was also considered when selecting the representative stations. A summary of the coordinates of the ECCC weather stations used for each climate zone is also shown in Table 1. The Norman Wells A station was selected because of its long record, the completeness of the dataset, and its location with respect to the proposed highway. The Fort Simpson A station was chosen for similar reasons; however, it is located at a distance from the proposed terminus of the highway (~180 km to the southeast). The further away Fort Simpson A station was selected over the closer Wrigley A weather station due to the Wrigley A weather station's poor record, which has a significant number of missing days of data. Regardless, comparison of the datasets between available data in the area suggests that Fort Simpson A is adequately representative of the climate in the region.

Figure 2 Mackenzie Valley Highway Project Overview and Eco Zones



Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.

Table 1 Observation Stations in the Study Region

Climate Zone	Observation Station Name (Station ID)	Latitude	Longitude	Daily Data Record Coverage (Length in yrs)
Norman Wells – Tulita	Norman Wells A* (ID: 2202800/2202801)	65.2813 N	-126.7986 W	1943-2024 (82)
	Norman Wells Climate▲ (ID: 2202810)	65.2875 N	-126.7534 W	1974-2021 (42)
	Tulita A (ID: 2201700/2201705)	64.9097 N	-125.5694 W	1903-2024 (122)
Wrigley – Fort Simpson	Wrigley A (ID: 2204000/2204005)	63.2094 N	-123.4366 W	1943-2024 (82)
	Fort Simpson A* (ID: 2202101/2202103/2202104)	61.7602 N	-121.2366 W	1963-2024 (62)
	Fort Simpson Climate▲ (ID: 2202102)	61.7603 N	-121.2367 W	1969-2021 (46)

Notes:

* Selected station to represent the respective climate zone

▲ Station with available Intensity-Duration-Frequency (IDF) rainfall data for the respective climate zone; Record range and length in years reflects IDF data availability

In order to characterize the general differences among the two climate zones, below are general comparisons of 1981-2010 Climate Normals values between weather stations available among each climate zone with sufficient data for analysis (where available).

Table 2 Climate Normals Differences between the Two Climate Zones

Climate Parameter	Norman Wells A (ID: 2202800/1) 1981-2010	Fort Simpson A (ID: 2202104) 1981-2010
Annual Mean Temperature (°C)	-5.1	-2.8
Annual Maximum Temperature (°C)	-0.4	2.7
Annual Minimum Temperature (°C)	-9.9	-8.2
Annual Total Precipitation (mm)	294.4	387.6
# of Days/Year with Tmax > 30°C	2.1	4.2
# of Days/Year with Tmin < -30°C	51.0	37.5

The time horizons for the study were selected as current conditions (based on 1981-2010 Climate Normals) establishing the baseline[5]. This climate profile presents projected climate information for three time horizons: the 2020s (2011 to 2040), the 2050s (2041 to 2070), and the 2080s (2071 to 2100).

Generally, the 2020s are used to evaluate how recent trends correlate with projections in the near future. The 2050s and 2080s climate time horizons are presented as the longer-term climate projections to help inform infrastructure design and adaptation planning.

Climate parameters presented in this climate profile align with the climate parameters assessed for the Climate Change Resilience Assessment. Additional climate-adjusted design criteria which may be of interest for the Mackenzie Valley Highway Project are also available through PCIC's Design Value Explorer (https://pacificclimate.org/analysis-tools/design-value-explorer). The Design Value Explorer provides climate-adjusted design data relevant to the National Building Code of Canada (NBCC 2015) and the Canadian Highway Bridge Design Code (CHBDC/CSA S6 2014). Climate parameters included in the Design Value Explore include hourly design temperatures (e.g., January 2.5% dry bulb), annual maximum 1-day 50-yr return period rainfall, intensity-duration-frequency (IDF) rainfall data, and annual maximum hourly wind pressures (10- and 50-yr return periods). Additional information and details on the methodology used to develop climate-adjusted design data are presented in Cannon et al. 2020.

[5] When the 2021 Climate Change Resilience Assessment (CCRA) was completed, 1991-2020 Climate Normals were not available from ECCC and, therefore, the 1981-2010 Climate Normals were used to estimate baseline climate. The scope of the 2024 CCRA update did not include updating the baseline climate period.

2 Temperature

2.1 Mean Temperature

Table 3 Projected Average Annual Mean Temperature and Change from Baseline under SSP5-8.5

Time Period	Climate Zone (Station Name; ID)	1981-2010 Baseline (°C)	Projected Annual Mean Temperature* (Change from 1981-2010 Baseline [50th percentile]; 10th percentile, 90th percentile) (°C)		
			2020s	2050s	2080s
Annual	Norman Wells A (ID: 2202800)	-5.1	-3.4 (+1.7; +1.6, +1.9)	-1.0 (+4.1; +3.5, +4.8)	1.8 (+6.9; +6.0, +8.7)
	Fort Simpson A (ID: 2202104)	-2.8	-1.1 (+1.7; +1.4, +1.9)	1.1 (+3.9; +3.3, +4.6)	3.7 (+6.5; +5.7, +8.2)
Winter	Norman Wells A (ID: 2202800)	-24.5	-22.4 (+2.1; +2.0, +2.1)	-19.2 (+5.3; +4.6, +5.8)	-15.4 (+9.1; +8.3, +10.9)
	Fort Simpson A (ID: 2202104)	-22.2	-20.3 (+1.9; +1.9, +2.1)	-17.2 (+5.0; +4.3, +5.2)	-13.8 (+8.4; +7.8, +9.9)
Spring	Norman Wells A (ID: 2202800)	-5.7	-4.2 (+1.5; +1.4, +1.9)	-1.9 (+3.8; +3.4, +4.2)	0.9 (+6.6; +6.0, +7.4)
	Fort Simpson A (ID: 2202104)	-1.6	-0.1 (+1.5; +1.4, +1.6)	1.9 (+3.5; +3.0, +3.8)	4.4 (+6.0; +5.4, +6.6)
Summer	Norman Wells A (ID: 2202800)	15.3	16.7 (+1.4; +1.1, +1.6)	18.5 (+3.2; +2.6, +3.9)	20.8 (+5.5; +4.3, +7.2)
	Fort Simpson A (ID: 2202104)	15.8	17.1 (+1.3; +1.2, +1.7)	19.0 (+3.2; +2.7, +4.1)	21.5 (+5.7; +4.4, +7.5)
Fall	Norman Wells A (ID: 2202800)	-5.6	-3.7 (+1.9; +1.9, +1.9)	-1.4 (+4.2; +4.1, +4.5)	1.0 (+6.6; +6.4, +8.1)
	Fort Simpson A (ID: 2202104)	-3.1	-1.3 (+1.8; +1.7, +1.9)	0.8 (+3.9; +3.7, +4.5)	3.2 (+6.3; +6.0, +7.8)

Note:

* Multi-model ensemble average of the CanDCS-U6 downscaled climate projections

2.2 Maximum Temperature

2.2.1 Annual and Seasonal Average

Table 4 Projected Average Annual Maximum Temperature and Change from Baseline under SSP5-8.5

Time Period	Climate Zone (Station Name; ID)	1981-2010 Baseline (°C)	Projected Annual Maximum Temperature* (Change from 1981-2010 Baseline [50th percentile]; 10th percentile, 90th percentile) (°C)		
			2020s	2050s	2080s
Annual	Norman Wells A (ID: 2202800)	-0.4	1.2 (+1.6; +1.5, +1.8)	3.5 (+3.9; +3.4, +4.4)	6.2 (+6.6; +5.6, +8.0)
	Fort Simpson A (ID: 2202104)	2.7	4.3 (+1.6; +1.4, +1.8)	6.3 (+3.6; +3.2, +4.3)	8.9 (+6.2; +5.3, +7.7)
Winter	Norman Wells A (ID: 2202800)	-20.4	-18.6 (+1.8; +1.8, +2.0)	-15.6 (+4.8; +4.4, +5.0)	-12.0 (+8.4; +7.9, +9.6)
	Fort Simpson A (ID: 2202104)	-17.5	-15.7 (+1.8; +1.8, +1.8)	-12.9 (+4.6; +4.1, +4.6)	-9.6 (+7.9; +7.2, +8.7)
Spring	Norman Wells A (ID: 2202800)	0.2	1.6 (+1.4; +1.3, +1.8)	3.7 (+3.5; +3.1, +3.9)	6.3 (+6.1; +5.5, +6.7)
	Fort Simpson A (ID: 2202104)	4.8	6.2 (+1.4; +1.4, +1.5)	8.0 (+3.2; +2.8, +3.5)	10.3 (+5.5; +4.9, +6.1)
Summer	Norman Wells A (ID: 2202800)	20.7	22.0 (+1.3; +1.1, +1.7)	23.9 (+3.2; +2.5, +4.0)	26.3 (+5.6; +4.1, +7.4)
	Fort Simpson A (ID: 2202104)	22.1	23.5 (+1.4; +1.3, +1.9)	25.4 (+3.3; +2.6, +4.3)	27.9 (+5.8; +4.2, +7.8)
Fall	Norman Wells A (ID: 2202800)	-1.9	-0.2 (+1.7; +1.7, +1.8)	2.0 (+3.9; +3.9, +4.1)	4.4 (+6.3; +6.1, +7.2)
	Fort Simpson A (ID: 2202104)	1.3	3.0 (+1.7; +1.6, +1.7)	5.0 (+3.7; +3.6, +4.2)	7.3 (+6.0; +5.5, +7.2)

Note:

* Multi-model ensemble average of the CanDCS-U6 downscaled climate projections

2.2.2 Extreme Maximum Temperature Frequency

It can also be useful to view projected increases in temperatures as the change in the occurrence of days with a temperature higher than a certain extreme heat threshold. The climate projections for the occurrence of days with temperatures greater than 30°C are presented in Table 5.

Table 5 Annual Occurrence of Maximum Daily Temperatures > 30°C: Historic (1981-2010) and Projected under SSP5-8.5

	Annual Occurrence of Days with Max. Temp > 30°C (days/year)* 50th percentile (10th percentile, 90th percentile)			
Climate Zone (Station Name)	**1981-2010**	**2020s**	**2050s**	**2080s**
Norman Wells-Tulita (Norman Wells A)	2.1	4.5 (2.2, 7.7)	11.3 (3.9, 22.0)	24.2 (8.6, 47.0)
Wrigley-Fort Simpson (Fort Simpson A)	4.2	7.8 (4.8, 12.1)	17.7 (8.3, 30.5)	35.4 (14.4, 60.6)

Note:

* Multi-model ensemble average of the CanDCS-U6 downscaled climate projections

2.3 Minimum Temperature

2.3.1 Annual and Seasonal Average

Table 6 Projected Average Annual Minimum Temperature and Change from Baseline under SSP5-8.5

Time Period	Climate Zone (Station Name; ID)	1981-2010 Baseline (°C)	Projected Annual Minimum Temperature* (Change from 1981-2010 Baseline [50th percentile]; 10th percentile, 90th percentile) (°C)		
			2020s	2050s	2080s
Annual	Norman Wells A (ID: 2202800)	-9.9	-8.1 (+1.8; +1.6, +2.1)	-5.6 (+4.3; +3.7, +5.3)	-2.7 (+7.2; +6.3, +9.6)
	Fort Simpson A (ID: 2202104)	-8.2	-6.5 (+1.7; +1.4, +2.0)	-4.2 (+4.0; +3.5, +4.9)	-1.4 (+6.8; +6.0, +8.8)
Winter	Norman Wells A (ID: 2202800)	-28.5	-26.3 (+2.2; +2.2, +2.4)	-23.0 (+5.5; +4.8, +6.2)	-18.7 (+9.8; +8.7, +11.9)
	Fort Simpson A (ID: 2202104)	-26.8	-24.9 (+1.9; +1.9, +2.3)	-21.6 (+5.2; +4.6, +5.6)	-17.8 (+9.0; +8.2, +10.8)
Spring	Norman Wells A (ID: 2202800)	-11.6	-10.0 (+1.6; +1.4, +2.1)	-7.5 (+4.1; +3.5, +4.8)	-4.7 (+6.9; +6.3, +8.3)
	Fort Simpson A (ID: 2202104)	-8.1	-6.6 (+1.5; +1.4, +1.8)	-4.3 (+3.8; +3.2, +4.1)	-1.7 (+6.4; +5.7, +7.2)
Summer	Norman Wells A (ID: 2202800)	9.7	11.1 (+1.4; +1.1, +1.6)	12.9 (+3.2; +2.7, +3.8)	15.2 (+5.5; +4.5, +7.0)
	Fort Simpson A (ID: 2202104)	9.5	10.8 (+1.3; +1.1, +1.6)	12.7 (+3.2; +2.8, +3.9)	15.1 (+5.6; +4.6, +7.1)
Fall	Norman Wells A (ID: 2202800)	-9.3	-7.4 (+1.9; +1.9, +2.1)	-4.9 (+4.4; +4.3, +5.0)	-2.4 (+6.9; +6.8, +9.0)
	Fort Simpson A (ID: 2202104)	-7.6	-5.8 (+1.8; +1.8, +2.0)	-3.5 (+4.1; +3.9, +4.8)	-1.1 (+6.5; +6.3, +8.4)

Note:

* Multi-model ensemble average of the CanDCS-U6 downscaled climate projections

2.3.2 Extreme Minimum Temperature Frequency

It can also be useful to view projected increases in temperatures as the change in the occurrence of days with a temperature lower than a certain extreme cold threshold. The climate projections for the occurrence of days with temperatures less than -30°C are presented in Table 7.

Table 7 Occurrence of Minimum Daily Temperatures < -30°C: Historic (1981-2010) and Projected under SSP5-8.5

	Annual Occurrence of Days with Min. Temp < -30°C (days/year)* 50th percentile (10th percentile, 90th percentile)			
Climate Zone Station Name)	**1981-2010**	**2020s**	**2050s**	**2080s**
Norman Wells-Tulita	51.0	37.6	21.2	7.0
(Norman Wells A)		(38.6, 37.0)	(25.1, 21.8)	(17.7, 4.4)
Wrigley-Fort Simpson	37.5	27.2	14.4	2.9
(Fort Simpson A)		(27.8, 27.2)	(18.1, 13.8)	(12.7, 0.0)

Note:

* Multi-model ensemble average of the CanCDS-U6 downscaled climate projections

3 Precipitation

3.1 Total Annual & Seasonal Accumulation

Table 8 Projected Average Total Precipitation and Change from Baseline under SSP5-8.5

Time Period	Climate Zone (Station Name; ID)	1981-2010 Baseline (°C)	Projected Total Precipitation (mm)* (Change from 1981-2010 Baseline (%) [50th percentile]; 10th percentile, 90th percentile)		
			2020s	2050s	2080s
Annual	Norman Wells A (ID: 2202800)	294.4	322.8 (+9.6%; +9.6%, +11.8%)	355.2 (+20.7%; +19.2%, +24.0%)	400.5 (+36.0%; +34.1%, +44.4%)
	Fort Simpson A (ID: 2202104)	387.6	415.7 (+7.3%; +5.1%, +7.6%)	452.8 (+16.8%; +16.6%, +17.2%)	486.8 (+25.6%; +24.1%, +30.4%)
Winter	Norman Wells A (ID: 2202800)	48.7	54.9 (+12.8%; +9.1%, +12.8%)	58.9 (+21.0%; +17.5%, +21.0%)	65.8 (+35.1%; +26.8%, +37.8%)
	Fort Simpson A (ID: 2202104)	55.6	59.0 (+6.1%; +6.1%, +8.1%)	64.1 (+15.3%; +11.8%, +18.0%)	67.8 (+22.0%; +20.6%, +27.1%)
Spring	Norman Wells A (ID: 2202800)	40.8	43.2 (+6.0%; +3.1%, +10.7%)	48.6 (+19.1%; +14.8%, +25.5%)	54.7 (+34.1%; +25.4%, +42.0%)
	Fort Simpson A (ID: 2202104)	61.8	64.2 (+3.8%; +2.3%, +6.4%)	71.8 (+16.2%; +13.9%, +20.6%)	78.2 (+26.6%; +22.8%, +31.9%)
Summer	Norman Wells A (ID: 2202800)	126.3	133.7 (+5.9%; +2.7%, +7.9%)	143.1 (+13.3%; +11.8%, +17.3%)	153.3 (+21.4%; +16.2%, +26.8%)
	Fort Simpson A (ID: 2202104)	173.8	179.6 (+3.3%; +0.5%, +5.9%)	186.6 (+7.4%; +7.4%, +14.5%)	187.4 (+7.8%; +4.6%, +20.3%)
Fall	Norman Wells A (ID: 2202800)	78.5	87.6 (+11.7%; +9.4%, +11.7%)	94.8 (+20.8%; +14.4%, +24.0%)	111.3 (+41.7%; +34.4%, +43.2%)
	Fort Simpson A (ID: 2202104)	96.4	104.3 (+8.2%; +8.1%, +11.7%)	118.2 (+22.6%; +21.3%, +22.6%)	131.4 (+36.3%; +36.2%, +39.5%)

Note:

* Multi-model ensemble average of the CanDCS-U6 downscaled climate projections

3.2 Intensity-Duration-Frequency (IDF)

In the following subsections, total precipitation amount (mm) in specific time intervals (5 minutes to 24 hours) for various return periods (2 years to 100 years) are provided. These precipitation amounts are part of intensity-duration-frequency (IDF) data, which relates short-duration, high rainfall intensity with its frequency of occurrence. Evaluating historic and projected IDF data provides insight into how the short-duration, high intensity rainfall events will change under future climate conditions.

Historical IDF data generated by Environment and Climate Change Canada (ECCC) from the Norman Wells Climate (Station ID: 2202810) and Fort Simpson Climate (Station ID: 2202102) weather stations are used. ECCC derives IDF curves from rate-of-rainfall observations by fitting a Gumbel extreme value distribution to the annual maximum series of each rainfall duration. Extreme value distributions are theoretical statistical descriptions of the probability of extreme events.

To prepare projected IDF data for future climate, the Canadian Standards Association's (CSA) Rainfall Intensity-Duration-Frequency Guide (CSA PLUS 4013:19) and ECCC both recommend (Cannon et al., 2020) using the Clausius-Clapeyron relation method for estimating projected changes to short duration storm events. The Clausius-Clapeyron relation is founded on the atmospheric physics theoretical relationship between air temperature and the amount of water the air could potentially contain, otherwise known as its holding capacity. The Clausius-Clapeyron relation indicates that there is an average of 7% increase in the air's holding capacity per 1°C of local warming. Therefore, when using the Clausius-Clapeyron relation method, rainfall intensity projections are calculated using temperature scaling where, for every 1°C increase in temperature, rainfall intensity increase by 7%; Projected rainfall intensity (Rp) is calculated as follows:

$$R_p = R_c \times (CC_{adj})^{\Delta T}$$

where Rc is the current (historical) rainfall intensity or IDF value, CCadj is the rainfall intensity vs. temperature relationship adjustment factor, and ΔT is the projected change in local temperature. When using the general recommendation of 7% per 1°C warming, CCadj = 1.07 and the equation becomes Rp = Rc x 1.07T. Rainfall vs. temperature relationships close to the Clausius-Clapeyron relation have been detected globally and regionally in observational studies (Westra et al., 2013; Panthou et al., 2014; Prein et al., 2016; Barbero et al., 2017). IDF projections for this assessment therefore follow the Clausius-Clapeyron relation method. In addition to the IDF projections presented below, IDF projections are also available through PCIC's Design Value Explorer[6].

It is recognized that extreme weather events, such as convective heavy rainfall, are often very localized, so it is possible the weather stations used in this analysis may not have captured or may not provide representative measurement of the intensity of some of these extreme rainfall events. This uncertainty is considered by the CCRA methodology during the analysis.

[6] https://services.pacificclimate.org/design-value-explorer/?dv=IDFCF

3.2.1 Norman Wells – Tulita Climate Zone

For the Norman Wells-Tulita climate zone, historical IDF data from the Norman Wells Climate weather station (ID: 2202810), with 42 years of data spanning from 1974 to 2021, is used. Historical and projected total precipitation amount (mm) in specific time interval (5 minutes to 24 hours) for various return periods (2 years to 100 years) are provided below. Under the SSP5-8.5 scenario, short-duration, high intensity precipitation events are projected to increase 12.2% for the 2020s, 32.0% for the 2050s, and 59.5% for the 2080s, relative to the historical data.

Table 9 Historical Precipitation Event Accumulation IDF data (mm) – Norman Wells Climate (Station ID: 2202810), 1974-2021

T (years)	2	5	10	25	50	100
5 min	3.0	4.7	5.8	7.2	8.3	9.3
10 min	4.3	6.7	8.3	10.3	11.8	13.3
15 min	5.1	7.9	9.8	12.2	13.9	15.6
30 min	6.7	10.4	12.9	16.0	18.3	20.6
1 h	8.8	13.4	16.4	20.2	23.0	25.8
2 h	11.4	16.1	19.2	23.1	26.1	29.0
6 h	16.3	21.6	25.1	29.6	32.9	36.1
12 h	19.6	26.2	30.6	36.1	40.1	44.2
24 h	23.8	34.2	41.0	49.7	56.2	62.6

Table 10 Projected Precipitation Event Accumulation IDF data (mm), Norman Wells Climate (Station ID: 2202810), SSP5-8.5, 2020s

T (years)	2	5	10	25	50	100
5 min	3.4	5.3	6.5	8.1	9.3	10.4
10 min	4.8	7.5	9.3	11.6	13.2	14.9
15 min	5.7	8.9	11.0	13.7	15.6	17.5
30 min	7.5	11.7	14.5	18.0	20.5	23.1
1 h	9.9	15.0	18.4	22.7	25.8	28.9
2 h	12.8	18.1	21.5	25.9	29.3	32.5
6 h	18.3	24.2	28.2	33.2	36.9	40.5
12 h	22.0	29.4	34.3	40.5	45.0	49.6
24 h	26.7	38.4	46.0	55.8	63.1	70.2

Note:
IDF projections calculated using the Clausius-Clapeyron relation, using a 7% increase per 1°C of local warming and change in temperature of 1.7°C for the 2020s

Table 11 Projected Precipitation Event Accumulation IDF data (mm), Norman Wells Climate (Station ID: 2202810), SSP5-8.5, 2050s

T (years)	2	5	10	25	50	100
5 min	4.0	6.2	7.7	9.5	11.0	12.3
10 min	5.7	8.8	11.0	13.6	15.6	17.6
15 min	6.7	10.4	12.9	16.1	18.3	20.6
30 min	8.8	13.7	17.0	21.1	24.2	27.2
1 h	11.6	17.7	21.6	26.7	30.4	34.0
2 h	15.0	21.2	25.3	30.5	34.4	38.3
6 h	21.5	28.5	33.1	39.1	43.4	47.6
12 h	25.9	34.6	40.4	47.6	52.9	58.3
24 h	31.4	45.1	54.1	65.6	74.2	82.6

Note:
IDF projections calculated using the Clausius-Clapeyron relation, using a 7% increase per 1°C of local warming and change in temperature of 4.1°C for the 2050s

Table 12 Projected Precipitation Event Accumulation IDF data (mm), Norman Wells Climate (Station ID: 2202810), SSP5-8.5, 2080s

T (years)	2	5	10	25	50	100
5 min	4.8	7.5	9.3	11.5	13.2	14.8
10 min	6.9	10.7	13.2	16.4	18.8	21.2
15 min	8.1	12.6	15.6	19.5	22.2	24.9
30 min	10.7	16.6	20.6	25.5	29.2	32.9
1 h	14.0	21.4	26.2	32.2	36.7	41.1
2 h	18.2	25.7	30.6	36.8	41.6	46.3
6 h	26.0	34.5	40.0	47.2	52.5	57.6
12 h	31.3	41.8	48.8	57.6	64.0	70.5
24 h	38.0	54.5	65.4	79.3	89.6	99.8

Note:
IDF projections calculated using the Clausius-Clapeyron relation, using a 7% increase per 1°C of local warming and change in temperature of 6.9°C for the 2080s

3.2.2 Wrigley – Fort Simpson Climate Zone

For the Wrigley-Fort Simpson climate zone, historical IDF data from the Fort Simpson Climate weather station (ID: 2202102), with 46 years of data spanning from 1969 to 2021, is used. Historical and projected total precipitation amount (mm) in specific time interval (5 minutes to 24 hours) for various return periods (2 years to 100 years) are provided below. Under the SSP5-8.5 scenario, short-duration, high intensity precipitation events are projected to increase 12.2% for the 2020s, 30.2% for the 2050s, and 55.2% for the 2080s, relative to the historical data.

Table 13 Historical Precipitation Event Accumulation IDF data (mm) – Fort Simpson Climate (Station ID: 2202102), 1969-2021

T (years)	2	5	10	25	50	100
5 min	4.5	6.8	8.3	10.2	11.6	13.0
10 min	6.5	10.2	12.6	15.6	17.9	20.2
15 min	8.0	12.5	15.5	19.3	22.2	25.0
30 min	10.0	15.5	19.1	23.6	27.0	30.4
1 h	11.9	17.7	21.5	26.3	29.9	33.4
2 h	14.7	20.5	24.4	29.3	32.9	36.5
6 h	21.3	28.1	32.6	38.3	42.5	46.7
12 h	26.6	35.1	40.7	47.9	53.1	58.4
24 h	33.7	46.3	54.6	65.1	72.9	80.7

Table 14 Projected Precipitation Event Accumulation IDF data (mm), Fort Simpson Climate (Station ID: 2202102), SSP5-8.5, 2020s

T (years)	2	5	10	25	50	100
5 min	5.0	7.6	9.3	11.4	13.0	14.6
10 min	7.3	11.4	14.1	17.5	20.1	22.7
15 min	9.0	14.0	17.4	21.7	24.9	28.0
30 min	11.2	17.4	21.4	26.5	30.3	34.1
1 h	13.4	19.9	24.1	29.5	33.5	37.5
2 h	16.5	23.0	27.4	32.9	36.9	40.9
6 h	23.9	31.5	36.6	43.0	47.7	52.4
12 h	29.8	39.4	45.7	53.7	59.6	65.5
24 h	37.8	51.9	61.3	73.0	81.8	90.5

Note:
IDF projections calculated using the Clausius-Clapeyron relation, using a 7% increase per 1°C of local warming and change in temperature of 1.7°C for the 2020s

Table 15 Projected Precipitation Event Accumulation IDF data (mm), Fort Simpson Climate (Station ID: 2202102), SSP5-8.5, 2050s

T (years)	2	5	10	25	50	100
5 min	5.9	8.9	10.8	13.3	15.1	16.9
10 min	8.5	13.3	16.4	20.3	23.3	26.3
15 min	10.4	16.3	20.2	25.1	28.9	32.5
30 min	13.0	20.2	24.9	30.7	35.2	39.6
1 h	15.5	23.0	28.0	34.2	38.9	43.5
2 h	19.1	26.7	31.8	38.1	42.8	47.5
6 h	27.7	36.6	42.4	49.9	55.3	60.8
12 h	34.6	45.7	53.0	62.4	69.1	76.0
24 h	43.9	60.3	71.1	84.8	94.9	105.1

Note:
IDF projections calculated using the Clausius-Clapeyron relation, using a 7% increase per 1°C of local warming and change in temperature of 3.9°C for the 2050s

Table 16 Projected Precipitation Event Accumulation IDF data (mm), Fort Simpson Climate (Station ID: 2202102), SSP5-8.5, 2080s

T (years)	2	5	10	25	50	100
5 min	7.0	10.6	12.9	15.8	18.0	20.2
10 min	10.1	15.8	19.6	24.2	27.8	31.4
15 min	12.4	19.4	24.1	30.0	34.5	38.8
30 min	15.5	24.1	29.7	36.6	41.9	47.2
1 h	18.5	27.5	33.4	40.8	46.4	51.8
2 h	22.8	31.8	37.9	45.5	51.1	56.7
6 h	33.1	43.6	50.6	59.5	66.0	72.5
12 h	41.3	54.5	63.2	74.4	82.4	90.7
24 h	52.3	71.9	84.8	101.1	113.2	125.3

Note:
IDF projections calculated using the Clausius-Clapeyron relation, using a 7% increase per 1°C of local warming and change in temperature of 6.5°C for the 2080s

3.3 1-, 3-, and 5-Day Accumulation

Table 17 Record Maximum 1-, 3-, and 5-day Precipitation Accumulation

Climate Zone (Station Name)	Duration	Precipitation Accumulation (mm)	Event End Date
Norman Wells-Tulita (Norman Wells A)	1-day	50.8	September 6, 1988
	3-day	77.8	June 24, 1981
	5-day	82.0	June 27, 1981
Wrigley-Fort Simpson (Fort Simpson A)	1-day	85.8	June 30, 1988
	3-day	127.9	July 2, 1988
	5-day	132.4	July 2, 1988

1-day (24 hour) accumulation projections are provided in the Intensity-Duration-Frequency (IDF) section above. While projections for multi-day (3- and 5-day) accumulations are available, these projections do not necessarily capture extremes and have higher uncertainty and, therefore, are not provided in this climate profile. Since climate model grid box precipitation projections are usually interpreted as spatially averaged values, the outputs tend to reduce extreme precipitation magnitudes (Chen and Knutson, 2008; Seneviratne et al., 2012), contributing to the systematic underestimation of precipitation. Nevertheless, considering the Clausius-Clapeyron relation, it is probable an increasing trend in precipitation accumulation would extend to longer rainfall duration events.

3.4 Snowfall

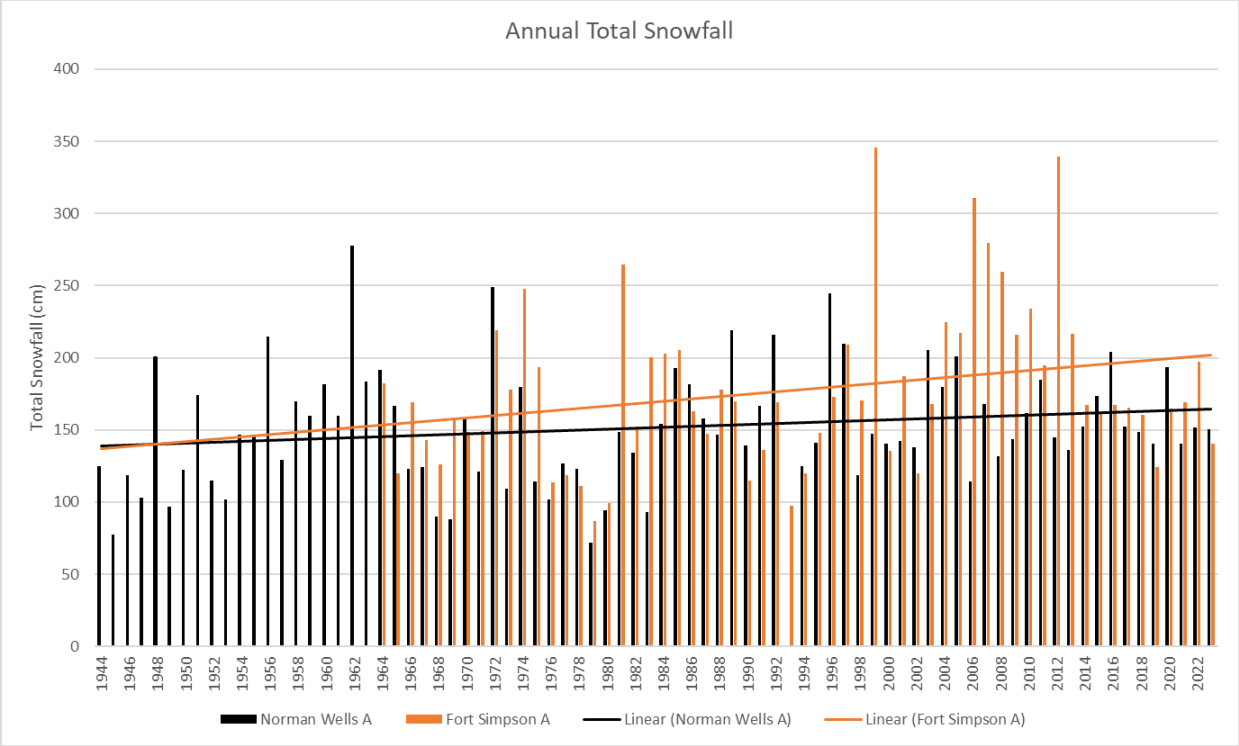
Total annual snowfall is presented in Figure 3 for historical periods at Norman Wells A from 1944 to 2023 and at Fort Simpson A from 1964 to 2023. The average annual total snowfall for the 1981-2010 time period was 161.5 cm for Norman Wells A and 187.0 cm for Fort Simpson A. Historical trends in precipitation falling as snow are generally observed to increase in this area, especially for Fort Simpson

A. Significant departures from the mean are intermittently observed, these inconsistencies may be due to sporadic short periods of extreme precipitation resulting from subtropical air currents that flow northeastwards from the Hawaiian Islands towards the Mackenzie Basin (termed the “Pineapple Express”) (Woo et al 2007), resulting in a high level of variability in precipitation records for the area.

It should be noted that Figure 3 presents snowfall data as calculated from the in-situ weather station records. Changes in weather station instrumentation, measurement methodologies (e.g., manual observation vs. automated precipitation gauges), and/or location can result in inhomogeneities (non climatic shifts) which can influence precipitation trends. The number of stations with homogenized precipitation data has been decreasing in Canada (Mekis et al., 2018; Wan et al., 2023) and the homogenized data records for Norman Wells and Fort Simpson do not include recent years (e.g., 2018 to present). ECCC and its partners have noted that “extensive data integration” is required to account for the

implementation of automated precipitation gauges into long-term historical records[7]. As such, there is lower confidence in the snowfall trends presented in Figure 3.

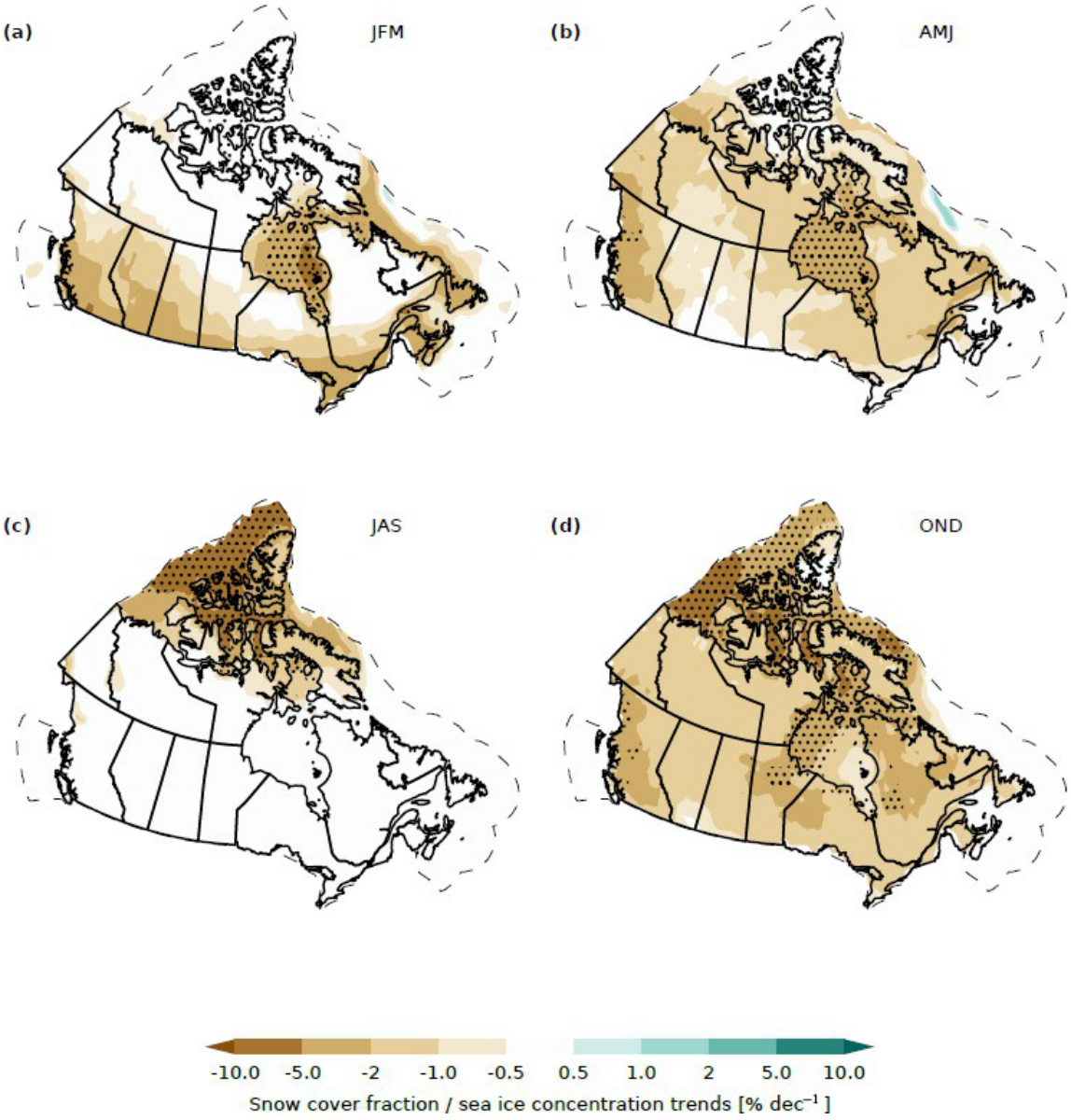
Figure 3 Annual Total Snowfall for Norman Wells A and Fort Simpson A for available data between 1944 to 2023 and 1964 to 2023, respectively



Under a warming climate, the snow cover duration (i.e., the period of the year with snow cover) will reduce, with reduced snow cover particularly during the spring and fall transition seasons (Figure 4) (Mudryk et al., 2018; CCCR, 2019). Small changes in snow accumulation are projected for northern regions of Canada, with no significant change in average annual maximum snow water equivalent (SWE)[8] in the Mackenzie Valley Highway region through mid-century under the RCP8.5 emission scenario (Figure 5) (Mudryk et al., 2018; CCCR, 2019). A decrease of approximately 10 to 20% in annual SWE, however, is projected by the end of the century under the RCP8.5 emissions scenario (Shi and Wang, 2015).

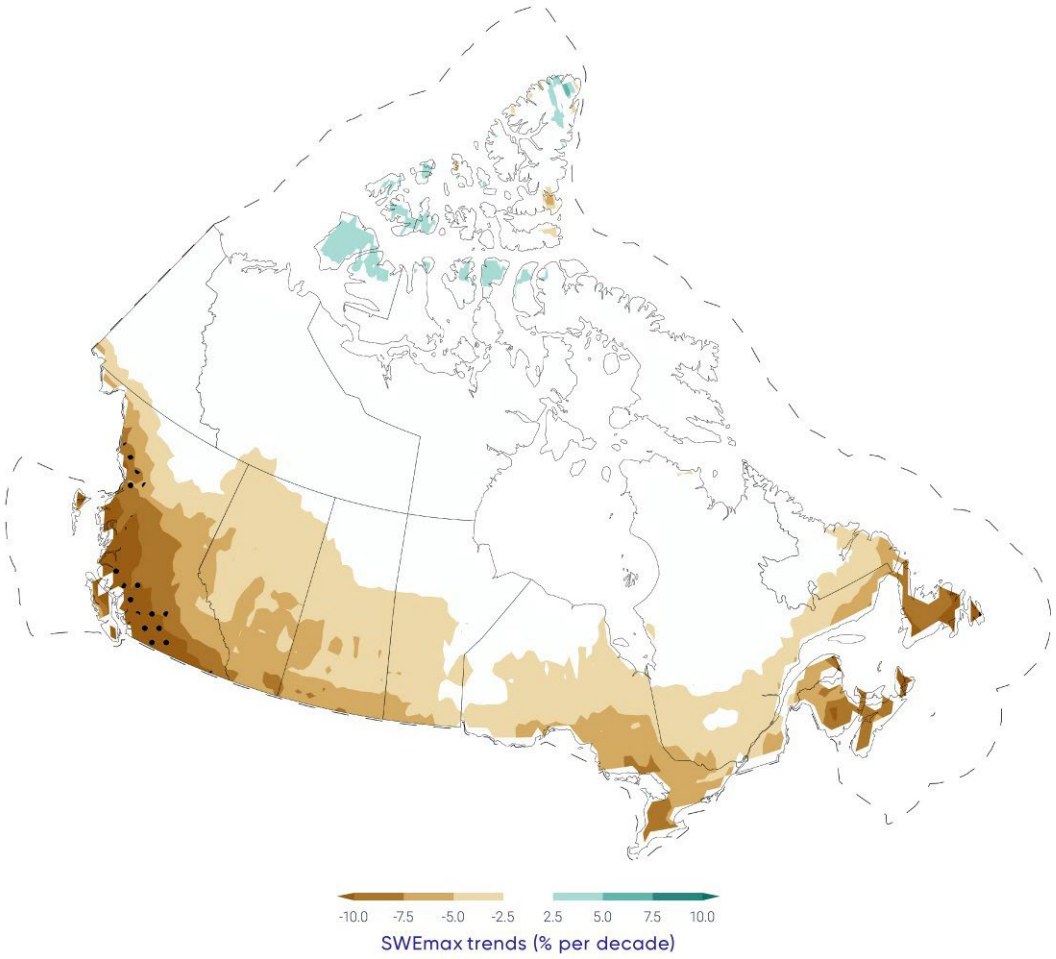
[7] https://www.canada.ca/en/environment-climate-change/services/climate-change/science-research-data/climate-trends-variability/trends-variations.html
[8] Seasonal maximum snow water equivalent (SWE) represents the seasonally accumulated snow available for spring melt.

Figure 4 **Projected snow cover fraction and sea ice concentration trends for 2020-2050 (Figure source: Mudryk et al., 2018)**



Stippling indicates statistical significance at the 90th percentile.

Figure 5 **Projected trends in maximum snow water equivalent (SWE) for 2020-2050 under the RCP8.5 emissions scenario (Figure source: Mudryk et al., 2018)**



Stippling indicates statistical significance at the 90th percentile.

3.5 Dry Spells

Dry spell is a measure of the number of consecutive days where daily precipitation is less than 1 mm. The historic data for longest annual dry spell duration for Norman Wells and Fort Simpson is summarized in Figure 6. It should be noted that there may be more than one dry spell of significant length in a given year but Figure 6 only shows the longest dry spell. The figure shows that between the two locations, slightly diverging trends appear in the maximum annual dry spell length. Norman Wells' average annual maximum dry spell appears to be stable historically while Fort Simpson is slightly decreasing.

Nonetheless, average maximum dry spell length for the region is generally stable historically. Projected average annual maximum number of consecutive dry days (i.e., average annual longest dry spell duration) are presented in Table 18. The length of the maximum dry spell for both locations is projected to slightly decrease under climate change. The projections for dry spell duration are not made with the same level of confidence as other climate variables in this report.

Figure 6 Maximum Annual Dry Spells, Norman Wells A and Form Simpson A, 1943-2023

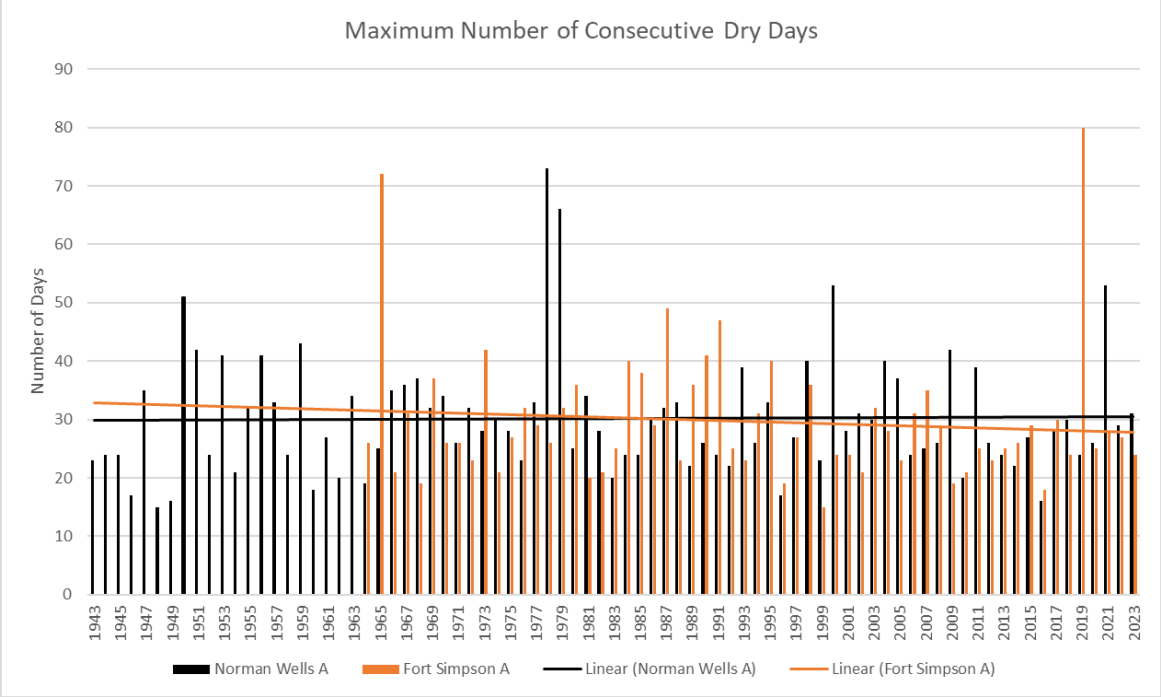


Table 18 Average Annual Maximum Number of Consecutive Dry Days: Historical (1981-2010) and Projected under SSP5-8.5

Climate Zone (Station Name)	Average Annual Maximum Number of Consecutive Dry Days			
	1981-2010	2020s	2050s	2080s
Norman Wells-Tulita (Norman Wells A)	29.3	27.8	27.7	25.2
Wrigley-Fort Simpson (Fort Simpson A)	29.0	28.5	27.6	26.8

4 Frost Days

The number of frost days per year for the historical baseline period as well as future projections periods is summarized in the table below for Norman Wells and Fort Simpson. Frost days are defined as the number of days per year where the minimum daily temperature is less than 0°C. The data presented here demonstrates a projected decreasing trend in the number of frost days per year, which aligns with temperature trends identified in Section 2.

Table 19 Average Annual Number of Frost Days: Historical (1981-2010) and Projected under SSP5-8.5

Climate Zone	Average Annual Number of Frost Days			
	1981-2010	2020s	2050s	2080s
Norman Wells-Tulita	240.0	229.0	217.4	202.9
Wrigley-Fort Simpson	224.7	213.5	199.3	185.3

5 Freeze-Thaws

Freeze-thaw cycles are days (24-hr periods) when the air temperature fluctuates between freezing and non-freezing temperatures. A freeze-thaw cycles is, therefore, a day with the maximum temperature greater than 0°C and the minimum temperature equal to or less than -1°C. A minimum temperature threshold of -1°C (instead of 0°C) is used to increase the likelihood that water present at the surface actually freezes. The historic and projected annual number of freeze-thaw cycles for each climate zone is presented in Table 20.

Table 20 Annual Freeze-Thaw Cycles: Historical (1981-2010) and Projected under SSP5-8.5

Climate Zone (Station Name)	Average Annual Freeze-Thaw Cycles (Days with Maximum Temperature > 0°C and Minimum Temperature ≤-1°C)			
	1981-2010	2020s	2050s	2080s
Norman Wells-Tulita (Norman Wells A)	43.8	41.7	37.9	36.7
Wrigley-Fort Simpson (Fort Simpson A)	57.1	51.8	47.1	44.7

While the projected overall decrease in the annual number of freeze-thaw cycles, the number of freeze-thaw cycles during the colder months is projected to increase. For example, winter season (December-January-February) average number of freeze-thaw cycles projections are presented in Table 21. With warmer winter conditions projected under climate change, temperature fluctuations around 0°C are projected to become more common during the colder months.

Table 21 Winter Season Freeze-Thaw Cycles: Historical (1981-2010) and Projected under SSP5-8.5

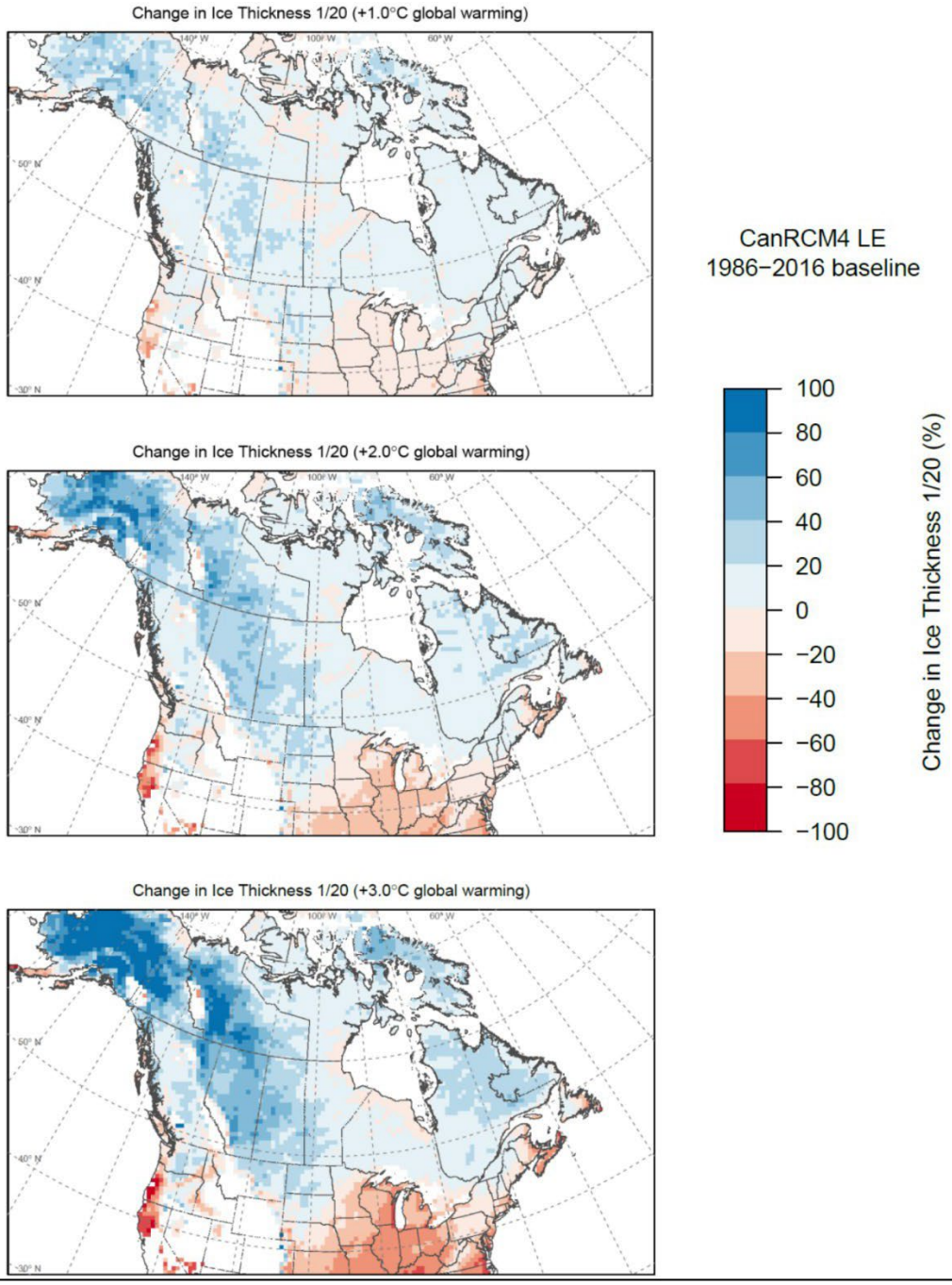
Climate Zone (Station Name)	Average Number of Winter Season* Freeze-Thaw Cycles (Days with Maximum Temperature > 0°C and Minimum Temperature ≤-1°C)			
	1981-2010	2020s	2050s	2080s
Norman Wells-Tulita (Norman Wells A)	~0	0.2	0.6	1.2
Wrigley-Fort Simpson (Fort Simpson A)	1.4	1.7	2.1	3.0

Note:
* Winter season is defined as December-January-February

6 Ice Accretion

Ice accretion loads are specified in the Canadian Highway Bridge Design Code (CHBDC/CSA S6 2014, Annex A3.1) and are mainly the result of freezing rain events across Canada. In the Mackenzie Valley Highways region, freezing rain events are historically short-duration events, with an average of up to ~3 to 4 hours annually of freezing rain, occurring typically in the fall, winter, or spring (Kochtubajda et al., 2017; Mekis et al., 2020). Under a warming climate, the average annual number of hours of freezing rain and resulting ice thickness are projected to increase. Under a +3°C global warming scenario, the average annual number of hours of freezing rain is projected to increase by approximately 5 to 10 hours per year (McCray et al., 2022) and the 1-in-20-year ice thickness is projected to increase by 60-100% (Cannon et al., 2020). Figure 7 shows the projected changes in the 1-in-20-year ice accretion load when compared to the 1986-2016 baseline for the +1.0°C, +2.0°C and +3.0°C global warming levels. Under the RCP8.5 scenario, +1.0°C global warming is projected to be reached by 2035, +2.0°C global warming is projected to be reached by 2059, and +3.0°C global warming is projected to be reached by 2080. In general, the duration and intensity of freezing rain events are projected to increase for the Mackenzie Valley Highway region under a warming climate. It should be noted, however, freezing rain projections have significant uncertainty.

Figure 7 **CanRCM4 LE projected changes to ice accretion loads (20-year return period) for three global warming levels (Figure source: Cannon et al., 2020)**



Under the RCP8.5 scenario, +1.0°C global warming is projected to be reached by 2035, +2.0°C global warming is projected to be reached by 2059, and +3.0°C global warming is projected to be reached by 2080.

7 Wind

Wind data is available from the Norman Wells A and Fort Simpson A weather stations from the early 1960s through 2024. The wind data records are sporadic earlier in the records and then with increasing data frequency in the second half of the record. Historical maximum wind speed and maximum gust records at the Norman Wells A and Fort Simpson A weather stations are presented in Table 22 and Table 23, respectively.

The available wind data from the Norman Wells A and Fort Simpson A weather stations is used to generate windroses[9] for this climate profile. Wind data from the three Norman Wells A stations and the two Fort Simpson A stations were merged, respectively, to generate the windroses. The following windroses contain some amount of missing information as direction information was not recorded when wind gusts were less than 31 km/h; These points were excluded from the plots. The figures below display daily maximum gust wind speed and direction observed at the Norman Wells A station (Figure 8 and Figure 9) and Fort Simpson A station (Figure 10 and Figure 11) annually and seasonally. It should be noted that wind regimes are influenced by topography and, therefore, can vary within a region. For example, wind direction is predominately west-northwest or east-southeast in Norman Wells, which has higher terrain to the northeast and southwest, while north-northeast winds are also commonly observed in Tulita (Fort Norman Airport, ~80 km southeast of Norman Wells), which does not have higher terrain to the northeast.

For the Climate Change Resilience Assessment, high winds (i.e. wind gusts) were considered to account for potential impacts on roadway maintenance and possible temporary road closures (e.g., windblown tree branches and other debris, snow drifts) as well as potential impacts on staff and road users (e.g., reduced air quality due to blowing dust, reduced visibility due to blowing dust or snow, potential for tipping over of tractor trailers). Wind pressure climate-adjusted design criteria may also be of interest to the Mackenzie Valley Highway Project and are available through PCIC's Design Value Explorer[10].

[9] Windroses show the distribution of wind direction (direct from which the wind is blowing) observed at a particular location over a time period. The length of each line represents the frequency of the wind from that direction and, therefore, windroses provide information on the prevailing wind direction(s) at a given location. Windroses, such as those presented in this profile, can also provide information on the wind speeds observed from each direction.
[10] Annual maximum wind pressure 10-yr return period data: https://services.pacificclimate.org/design-value-explorer/?dv=WP10
Annual maximum wind pressure 50-yr return period data: https://services.pacificclimate.org/design-value-explorer/?dv=WP50

Table 22 Canadian Climate Normals, Wind, Norman Wells A Station (source: Environment and Climate Change Canada, 1981-2010 Climate Normals)

Month	Speed (km/h)	Most Frequent Direction	Maximum Hourly Speed (km/h)	Date (yyyy/dd)	Direction of Maximum Hourly Speed	Maximum Gust Speed (km/h)	Date (yyyy/dd)	Direction of Maximum Gust	Days with Winds >= 52 km/h	Days with Winds >= 63 km/h
Jan	8.3	SE	80	1962/22	W	113	1962/22	W	0.6	0.1
Feb	8.9	SE	74	1986/19	NW	106	1986/19	NW	0.5	0.2
Mar	10.3	W	66	1971/07	SE	114	1965/10	NW	0.3	0.1
Apr	11	SE	68	1965/12	W	97	1965/12	W	0.2	0.1
May	11.9	SE	59	1980/03	NW	85	1979/02	SE	0.1	0
Jun	11.7	SE	65	1979/11	NW	83	1979/11	NW	0.2	0
Jul	11	SE	61	1959/25	NW	100	1967/24	W	0.2	0
Aug	10.5	SE	80	1962/31	W	117	1962/31	W	0.2	0.1
Sep	10.7	SE	70	1988/06	NW	94	1988/07	NW	0.1	0.1
Oct	10.4	NW	63	1978/31	NW	93	1990/27	E	0.2	0
Nov	8.4	NW	67	1977/21	NW	101	1962/03	E	0.3	0.1
Dec	8.3	SE	72	1963/12	E	105	1963/12	E	0.5	0.1
Year	10.1	SE	80	1962/22	W	117	1962/31	W	3.3	0.9
Record Length Assessed	1981-2010		1953-2010			1958-2010			1981-2010	1981-2010

Table 23 Canadian Climate Normals, Wind, Fort Simpson A Station (source: Environment and Climate Change Canada, 1981-2010 Climate Normals)

Month	Speed km/h)	Most Frequent Direction	Maximum Hourly Speed (km/h)	Date (yyyy/dd)	Direction of Maximum Hourly Speed	Maximum Gust Speed (km/h)	Date (yyyy/dd)	Direction of Maximum Gust	Days with Winds >= 52 km/h	Days with Winds >= 63 km/h
Jan	7.2	NW	46	2003/07	NW	80	1985/03	SW	0	0
Feb	8.4	NW	59	1988/21	NW	89	1988/21	NW	0.1	0
Mar	9.8	NW	50	1995/22	N	79	1967/13	N	0	0
Apr	10.1	SE	56	1986/20	SW	83	1984/16	SW	0.2	0
May	10.1	SE	59	1983/21	N	91	1983/21	N	0.2	0.1
Jun	9.1	SE	46	2002/22	NW	72	1964/26	N	0.2	0
Jul	8.2	NW	48	1964/10	S	89	1970/19	S	0.1	0
Aug	8.5	NW	66	1974/04	SW	146	2004/17	N	0.1	0
Sep	8.5	SE	65	1985/12	NW	87	1964/04	N	0.1	0
Oct	8.7	NW	50	1971/25	N	77	1971/25	N	0	0
Nov	7.9	NW	46	1985/20	N	78	1985/20	N	0	0
Dec	6.8	NW	48	1999/24	NW	80	1999/23	SW	0	0
Year	8.6	SE	66	1974/04	SW	146	2004/17	N	1.2	0.2
Record Length Assessed	1981-2010		1963-2010			1963-2009			1981-2010	1981-2010

Figure 8 **Daily Maximum Wind Gust Speed and Direction from 1958-2024 Observed at the Norman Wells A (Station ID: 2202800 and 2202801)**

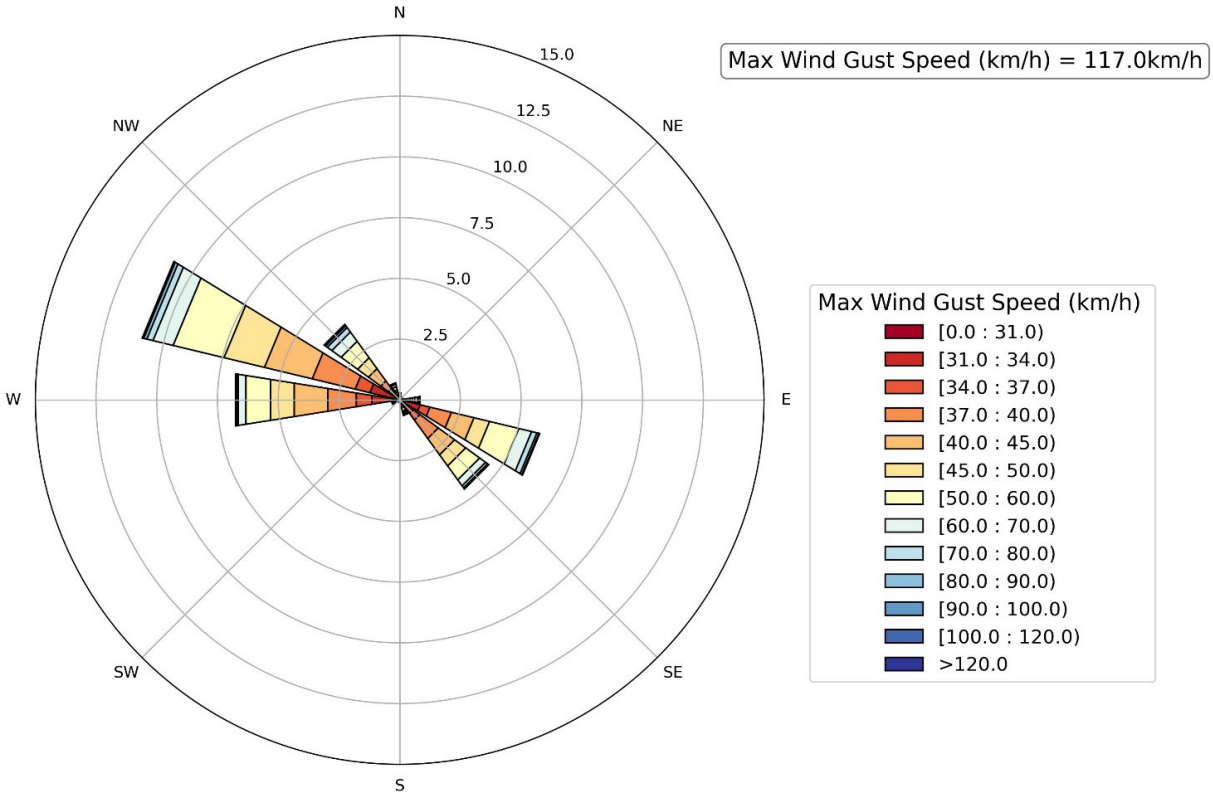


Figure 9 Seasonal Daily Maximum Wind Gust Speed and Direction From 1958-2024 Observed at the Norman Wells A

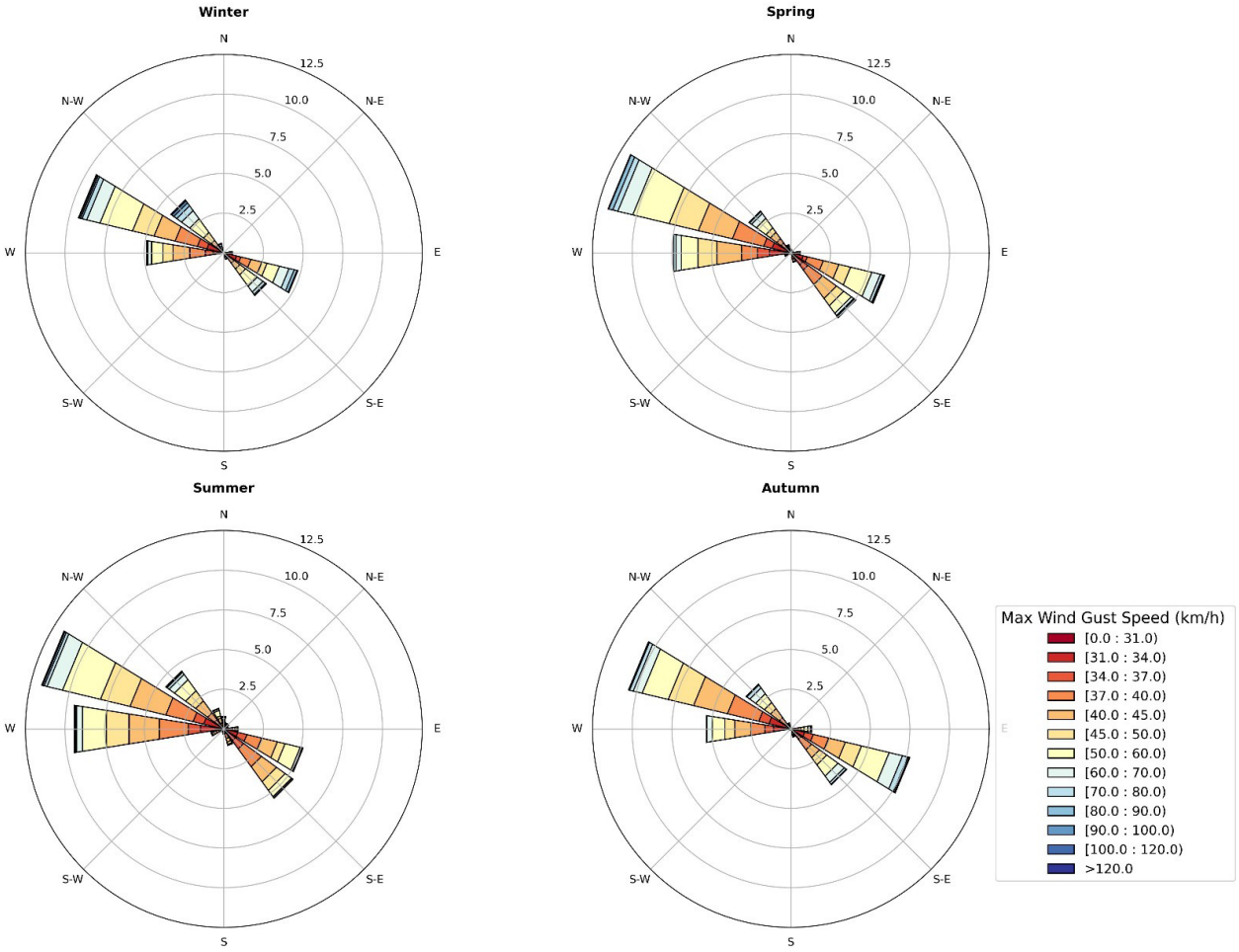


Figure 10 Daily Maximum Wind Gust Speed and Direction From 1963-2024 Observed at the Fort Simpson A (Station ID: 2202101 and 2202103)

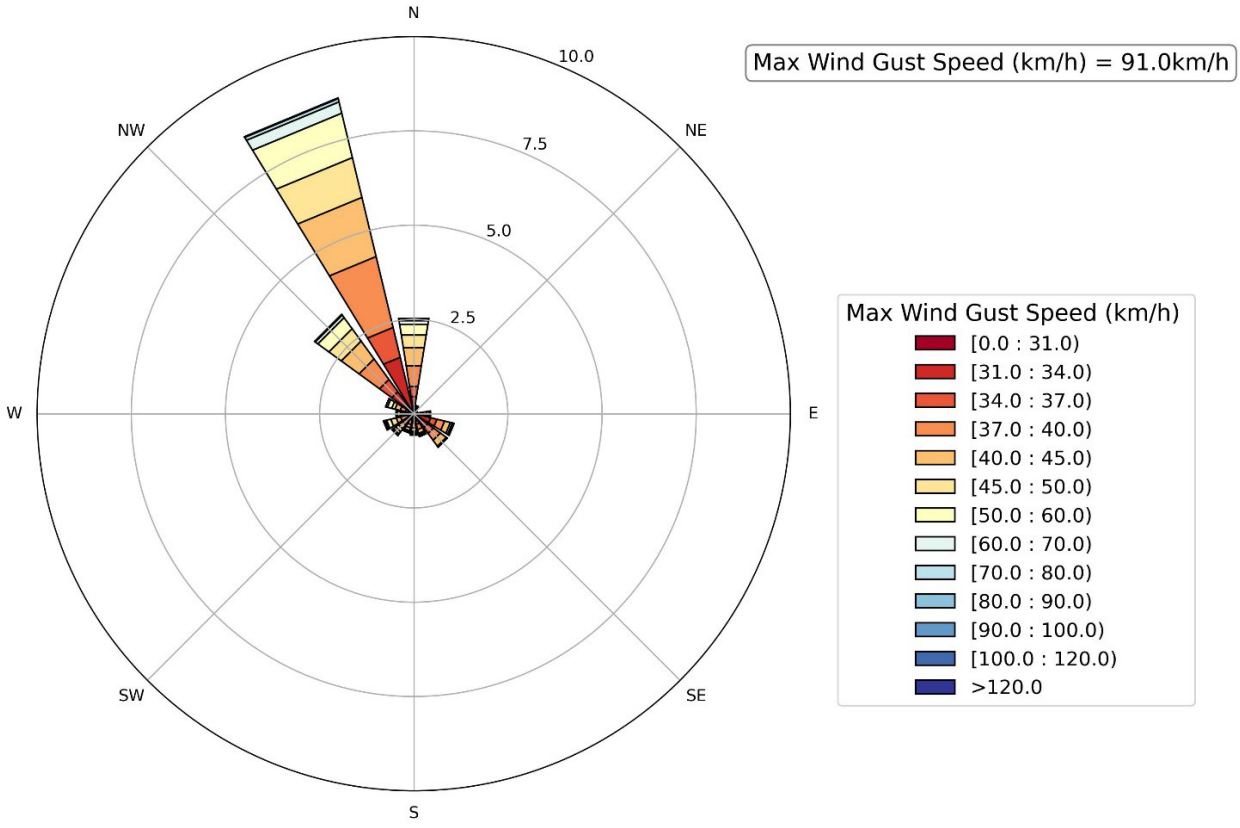
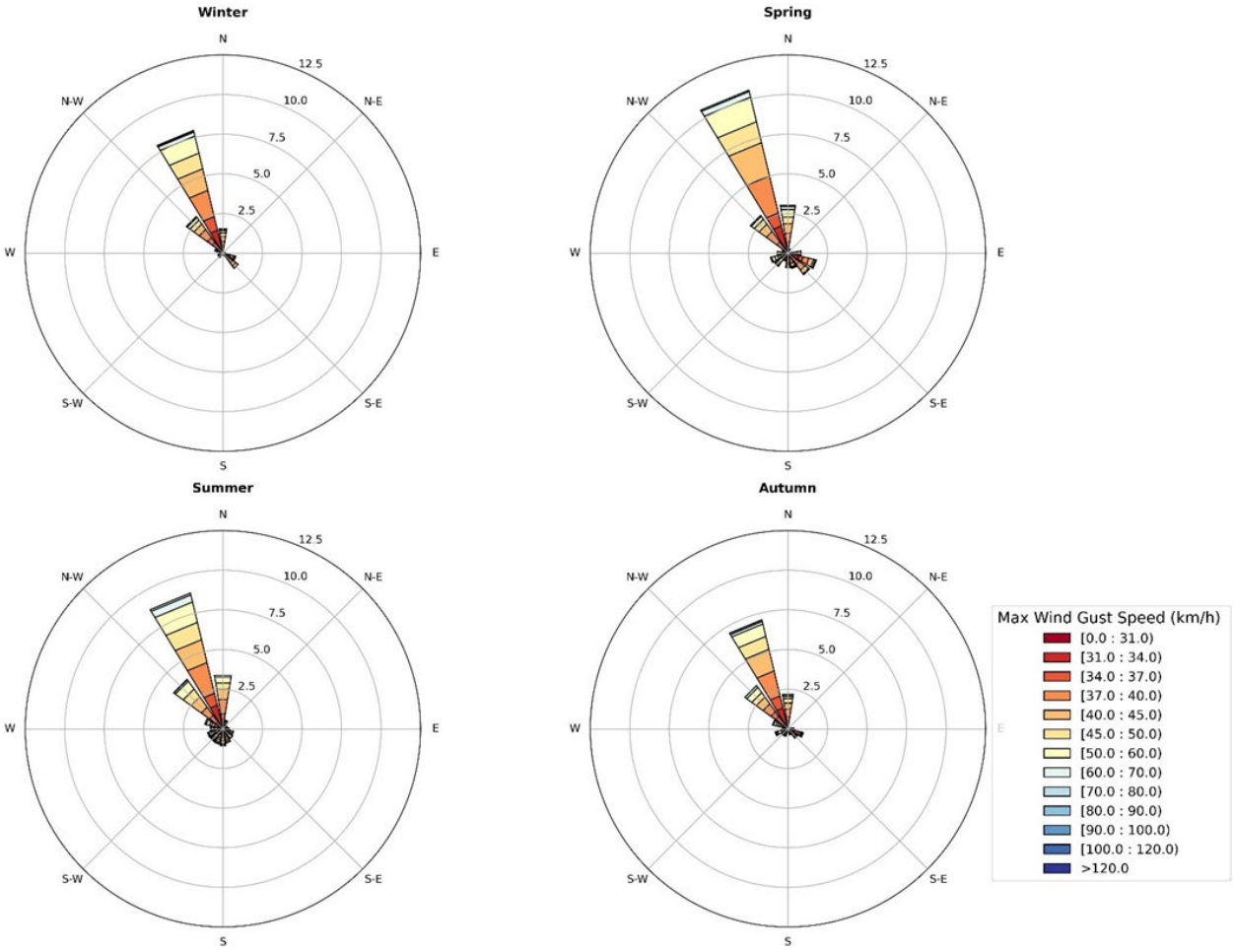


Figure 11 Seasonal Daily Maximum Wind Gust Speed and Direction From 1963-2024 Observed at the Fort Simpson A



The projected changes in wind frequency and intensity have considerable uncertainty compared to other climate variables such as average temperature. However, some general trends have been estimated from specialized research. For example, an analysis of 57 years (1953-2009) of wind gusts at 104 weather stations across Canada indicated that for every 1°C increase in the daily temperature anomaly, the speed of daily wind gust events (≥ 50 km/hr) increased by more than 0.2 km/hr over most regions in Canada (Cheng, 2014). Chang et al. (2014) provides projected percentage changes in the frequency of future daily wind gust events of ≥ 50 km/hr and ≥ 90 km/hr under the SRES A2 scenario (roughly corresponds with RCP8.5 and SSP5-8.5). Cheng et al. (2014) provides regional projections, with Norman Wells located in region N2 and Fort Simpson located in region W1 (Figure 12). Table 24 presents the projected changes for the N2 and W1 regions. Cheng et al. (2014) also indicate that, for the Northwest Territories, the largest projected percentage increases in future daily wind gusts events are expected to occur in the summer (June-July-August) season, suggesting potentially more localized convective windstorms due to warming temperatures.

Figure 12 Wind Gust Regions and Selected Stations Utilized in Cheng et al., 2014 (Figure Source: Cheng et al., 2014)

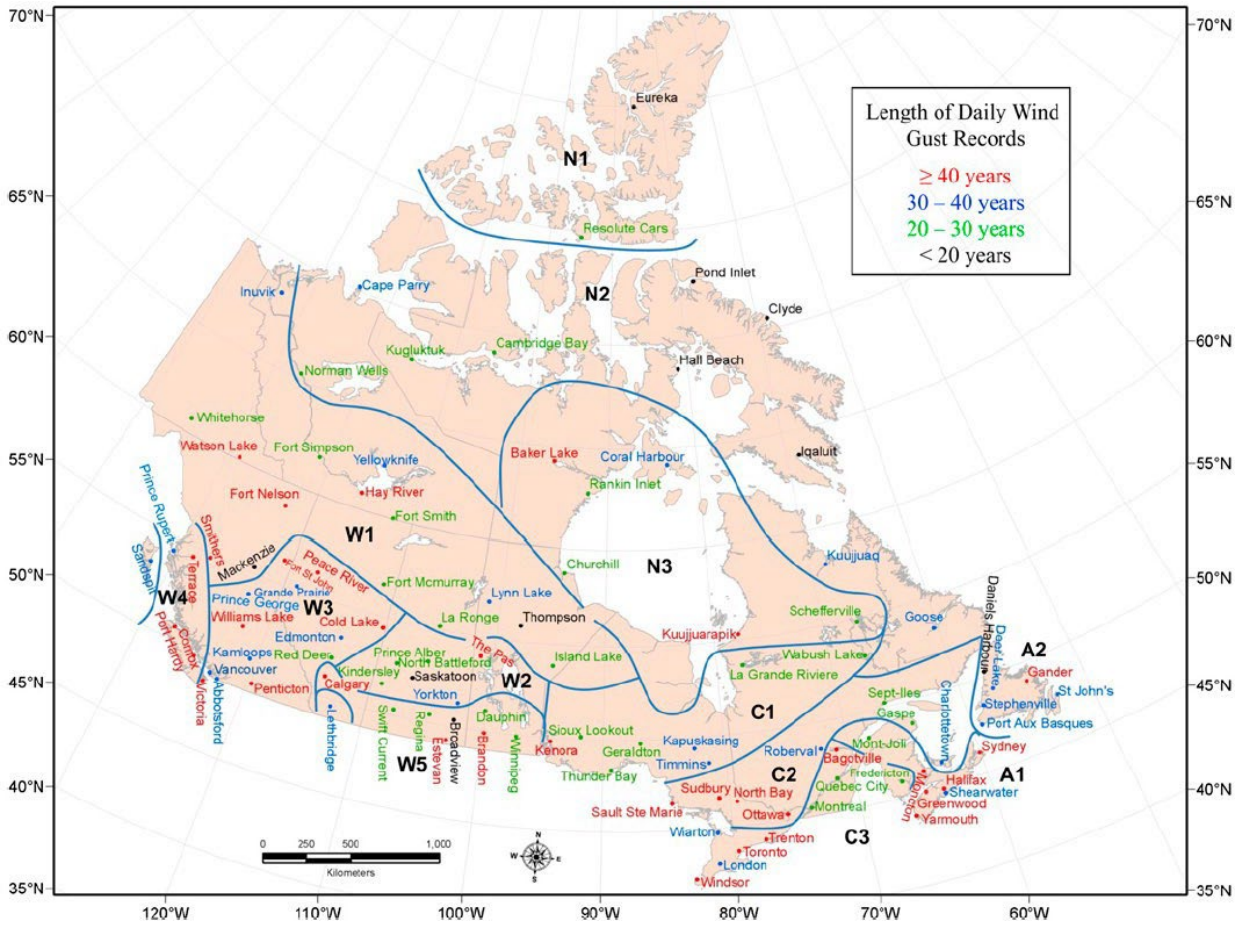


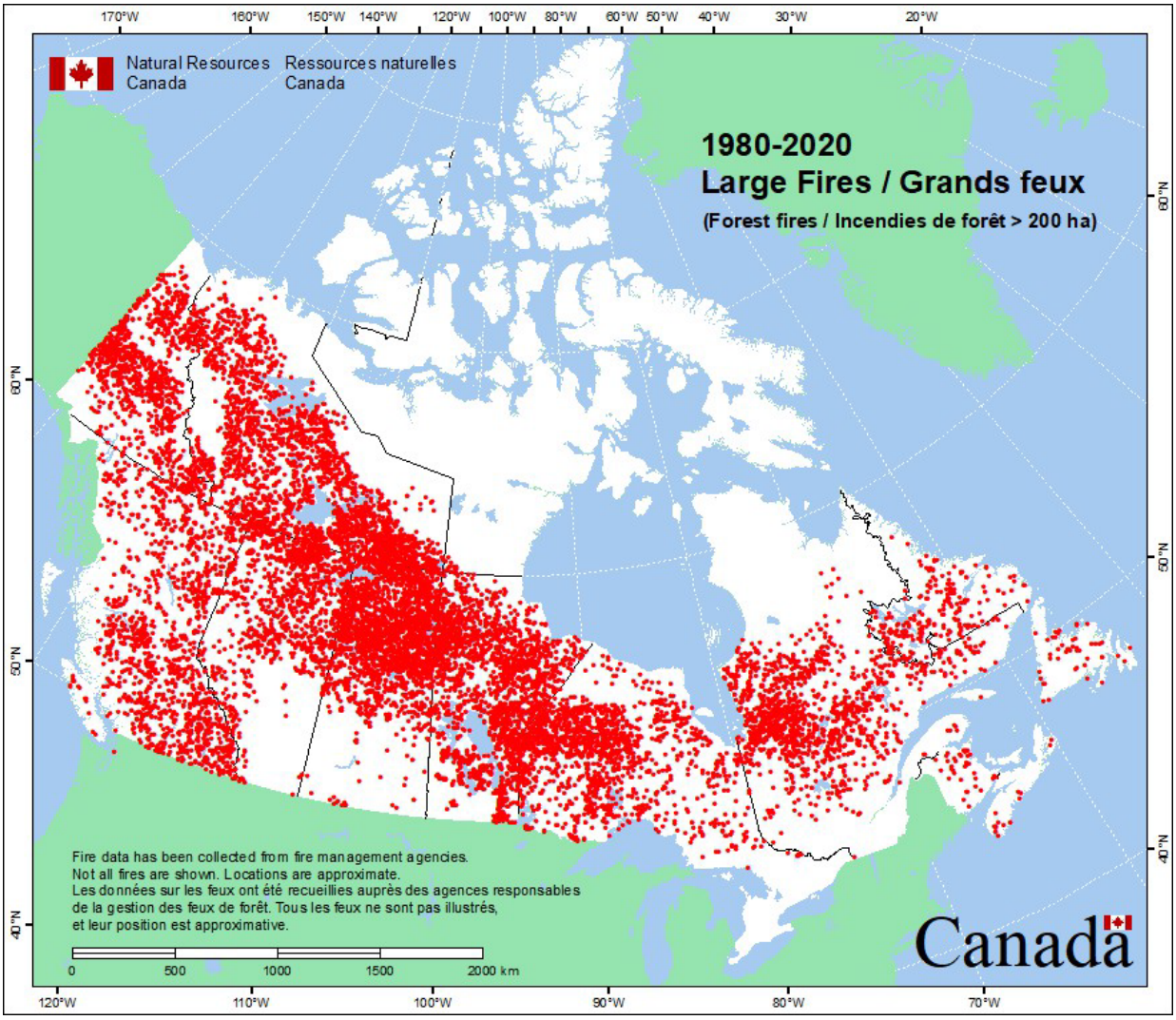
Table 24 Percent Change in Daily Wind Gust Event Frequency (Data source: Cheng et al., 2014)

Climate Zone	Region	Approximate Percent Change in Daily Wind Event Frequency (relative to 1955-2009 baseline)			
		Gusts ≥ 70 km/hr		Gusts ≥ 90 km/hr	
		2050s (2046-2065)	2080s (2081-2100)	2050s (2046-2065)	2080s (2081-2100)
Norman Wells-Tulita	N2	6	22	15	45
Wrigley-Fort Simpson	W1	30	33	95	120

8 Wildfire

The Canadian National Fire Database (CNFDB) provides historical occurrences of large fires (≥ 200 ha) across Canada for the period of 1950 to 2020 (Canadian Forest Service, 2021). Figure 13 presents large fire locations for the 1981-2020 time period.

Figure 13 1980-2020 Large Fire (> 200 ha) Locations (Figure source: Canadian Forest Service)



The Mackenzie Valley Highway region is located in the Taiga Plains (TP) ecozone and the Great Bear Lake (GBL) homogeneous fire regime (HFR). During the 2011-2020 period, the average annual total number of fires in the Taiga Plains ecozone was approximately 375 fires (Stewart et al., 2023), with an average of ~26 large (> 200 ha) fires annually during the 1981-1999 period (Huberman et al., 2022). The average annual number of large (> 200 ha) fires occurrence was 5 to 10 fires annually per 100,000 km2 in the Great Bear Lake HFR during the 1961-1990 period (Boulanger et al., 2014; Huberman et al., 2022). The number of fires annually, as well as the average annual area burned and fire size, is projected to increase under climate change (Boulanger et al., 2014; Blyth et al., 2016; Wang et al., 2022; Stewart et al., 2023). Projected changes in fire occurrence (FireOcc) for the Great Bear Lake HFR under the SRES A2 emissions scenario (which is roughly comparable to RCP8.5 and SSP5-8.5) are presented in Figure 14 (Boulanger et al., 2014). Projected changes in annual area burned (AAB) are also presented in Figure 14 (Boulanger et al., 2014). Similar changes are projected for the larger Taiga Plains ecozone (Wang et al., 2022) – projected changes in annual number of fires (ANF), annual area burned (AAB), and the maximum fire size (MFS) under the RCP8.5 scenario are presented in Figure 15. Projected changes in wildfire occurrence for the Mackenzie Valley Highway region are summarized in Table 25.

Figure 14 Projected Changes in Annual Area Burned (AAB) and Fire Occurrence (FireOcc) Compared with the Baseline (1961-1990) Time Period. (Figure source: Boulanger et al., 2014)

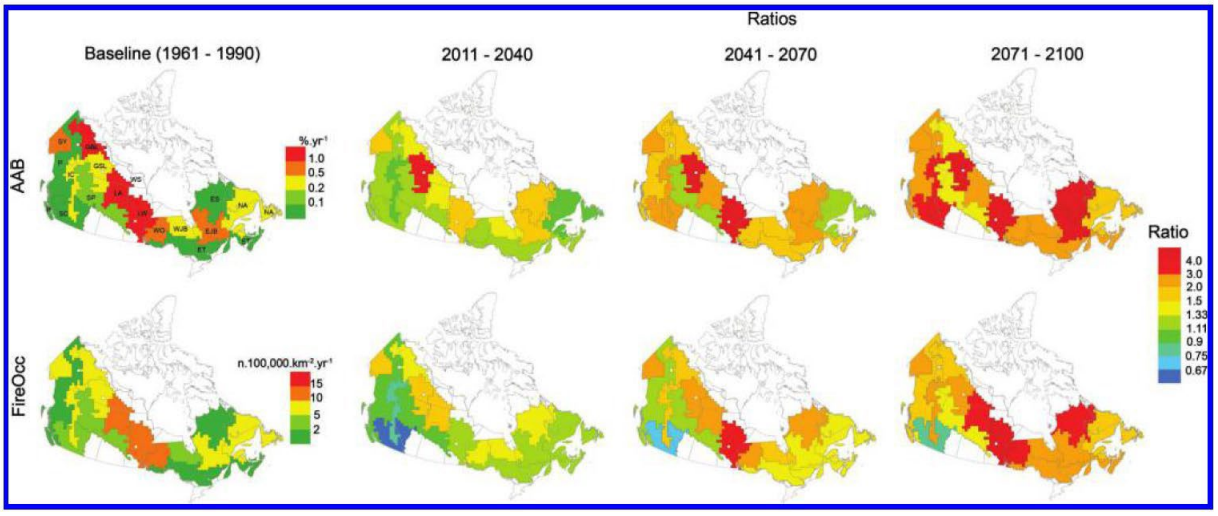


Figure 15 **Ratio of Shift (relative to 1981-2010 baseline) for Annual Area Burned (AAB), Annual Number of Fires (ANF), and Maximum Fire Size (MFS) by Ecozone Under RCP8.5 (Figure source: Wang et al., 2022)**

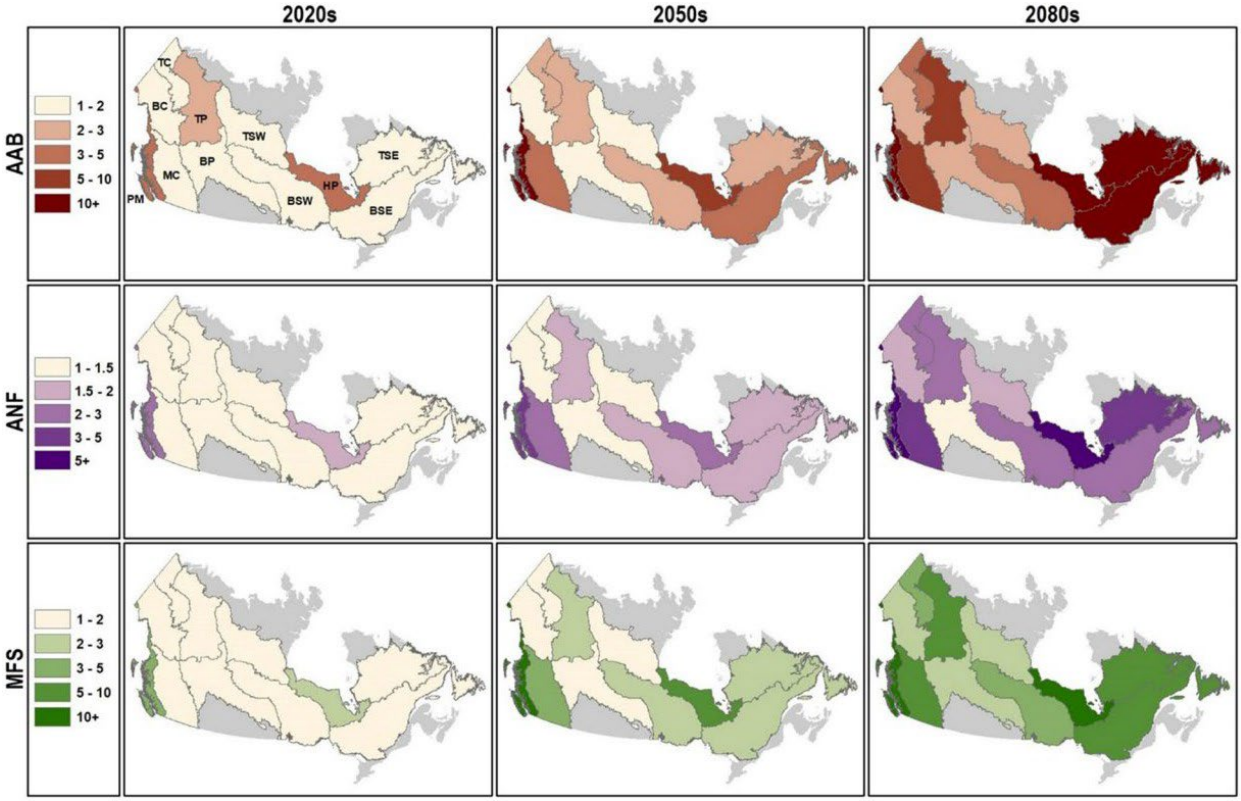


Table 25 **Summary of Projected Changes in Large (> 200 ha) Fire Occurrence (Data sources: Boulanger et al., 2014; Wang et al., 2022)**

Region	Average Annual Fire Occurrence (per 100,000 km^2)	Projected Change in Fire Occurrence (ratio of projected fire occurrence under a high emission scenario) (Fire Occurrence Equivalent)		
	Baseline (1961-1990)	2020s (2011-2040)	2050s (2041-2070)	2080s (2071-2100)
Mackenzie Valley Highway	5 to 10 fires/yr	1 to 1.5-fold (up to 15 fires/yr)	1.5 to 2.0 (up to 20 fires/yr)	2.0 to 3.0 (up to 30 fires/yr)

In addition to changing frequency of occurrence, wildfire severity (intensity), fire size, and area burned are projected to increase under a warming climate (Wang et al., 2015; 2017; 2020). Furthermore, the fire season length is projected to increase under a warming climate (Gaur et al., 2021; Jones et al., 2022).

The Canadian Forest Fire Weather Index (FWI) system can also be used to evaluate the future fire risk in the region. The FWI represents the potential fire intensity and is based on the Initial Spread Index (ISI) and Build-up Index (BUI). The ISI represents the potential rate of spread of fire without the influence of fuel and BUI represents the availability of total fuel (Whitman et al., 2015). The projected change annual 95th percentile of the FWI (represented extreme fire weather events) for the Great Bear Lake HFR are presented in Table 26. Values in Table 26 reflect combined projected changes for the SRES A2 (roughly comparable to RCP8.5, A1B (halfway between RCP8.5 and RCP4.5), and B1 (roughly comparable to RCP4.5) emissions scenarios (Wang et al., 2015).

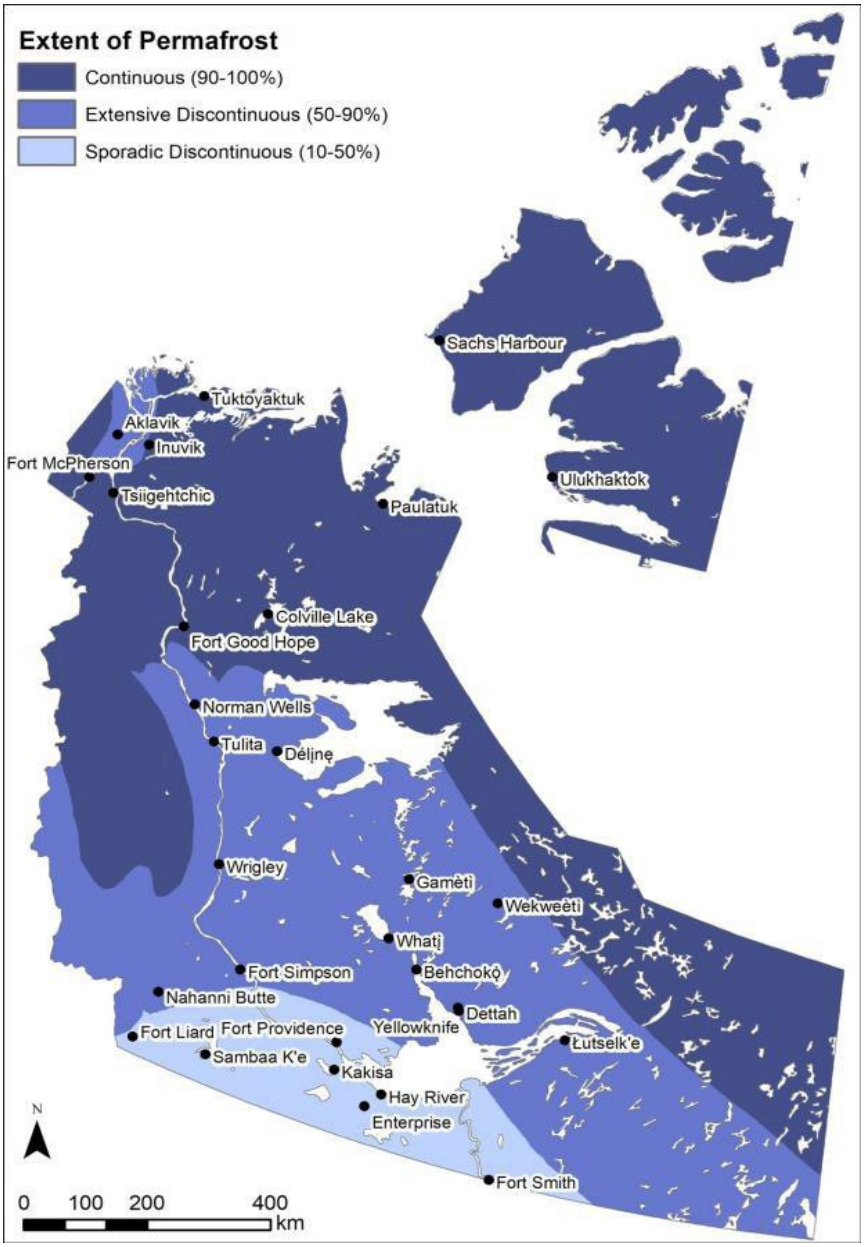
Table 26 Projected Change in the Fire Weather Index (Data source: Wang et al., 2015)

	Projected Percent Change (%) of the 95th Percentile of the FWI Relative to the 1981-2010 Baseline (SRES A2, A1B, and B1 Combined) Median (5th percentile, 95th percentile)		
Homogeneous Fire Regime	**2020s (2001-2030)**	**2050s (2031-2060)**	**2080s (2061-2090)**
Great Bear Lake	8.7 (1.4, 33.9)	14.5 (0.6, 55.9)	21.7 (7.0, 91.3)

9 Permafrost

The Mackenzie Valley Highway project region is located in the extensive discontinuous (50-90%) permafrost zone (Figure 16) (NWT SOE Report, 2022). Community sensitivity to permafrost is identified as moderate risk in Norman Wells and Tulita and as low risk in Wrigley (GNWT, 2015).

Figure 16 Permafrost Zones in the Northwest Territories (Figure source: NWT SOE Report, 2022)



Permafrost thaw typically occurs through an increase in the depth of the active layer, which decreases the overall thickness of the permafrost, and could result in loss of permafrost entirely. Permafrost thaw is strongly related to increases in air temperature, with increases in precipitation also contributing to the thaw. Permafrost is also vulnerable to other short- and long-term environmental conditions, such as wildfires, changing hydrology, and localized disturbances to organic ground cover, and can thaw rapidly once it is disturbed.

Increases in the permafrost active layer have been observed in the Northwest Territories (NWT SOE Report, 2022). Analysis by Peng et al. (2018) indicates the permafrost in the Mackenzie Valley Highway project region had an active layer thickness (ALT) of 40 to 80 cm during the 1971-2000 baseline period (Figure 17). Work by Garibaldi et al. (2022) indicates that mean ALT in the Boreal and Taiga Cordillera ecological region was approximately 65 cm in the early 2000s, and ALT was approximately 90 cm at that time in the Taiga Plains Low Subarctic (LS) ecological region. These are the primary ecological regions in which the Mackenzie Valley Highway Project is situated (Figure 18) (Ecosystem Classification Group 2007, 2010). Garibaldi et al.'s work also indicates that the ALT has remained generally steady, with limited response to warming air temperatures, at sites in the Project area during the 1993-2014 period. However, the active layer is projected to increase in thickness as permafrost thaws under a warming climate (Peng et al., 2018; CCCR, 2019; NWT SOE Report, 2022). The active layer in the Mackenzie Valley Highway project region is projected to increase 20 to 40 cm by the end of the century (2071-2100) under the RCP8.5 emission scenario (Figure 19) (Peng et al., 2018). Furthermore, studies indicate permafrost will no longer be present in the Mackenzie Valley Highway project region by the end of the century under the RCP8.5 emissions scenario (Figure 20) (Slater and Lawrence, 2013; Guo and Wang, 2016; Cannon et al., 2020).

Figure 17 **Spatial Distribution of Multiyear Average in-situ Active Layer Thickness Across the Northern Hemisphere (Figure source: Peng et al., 2018)**

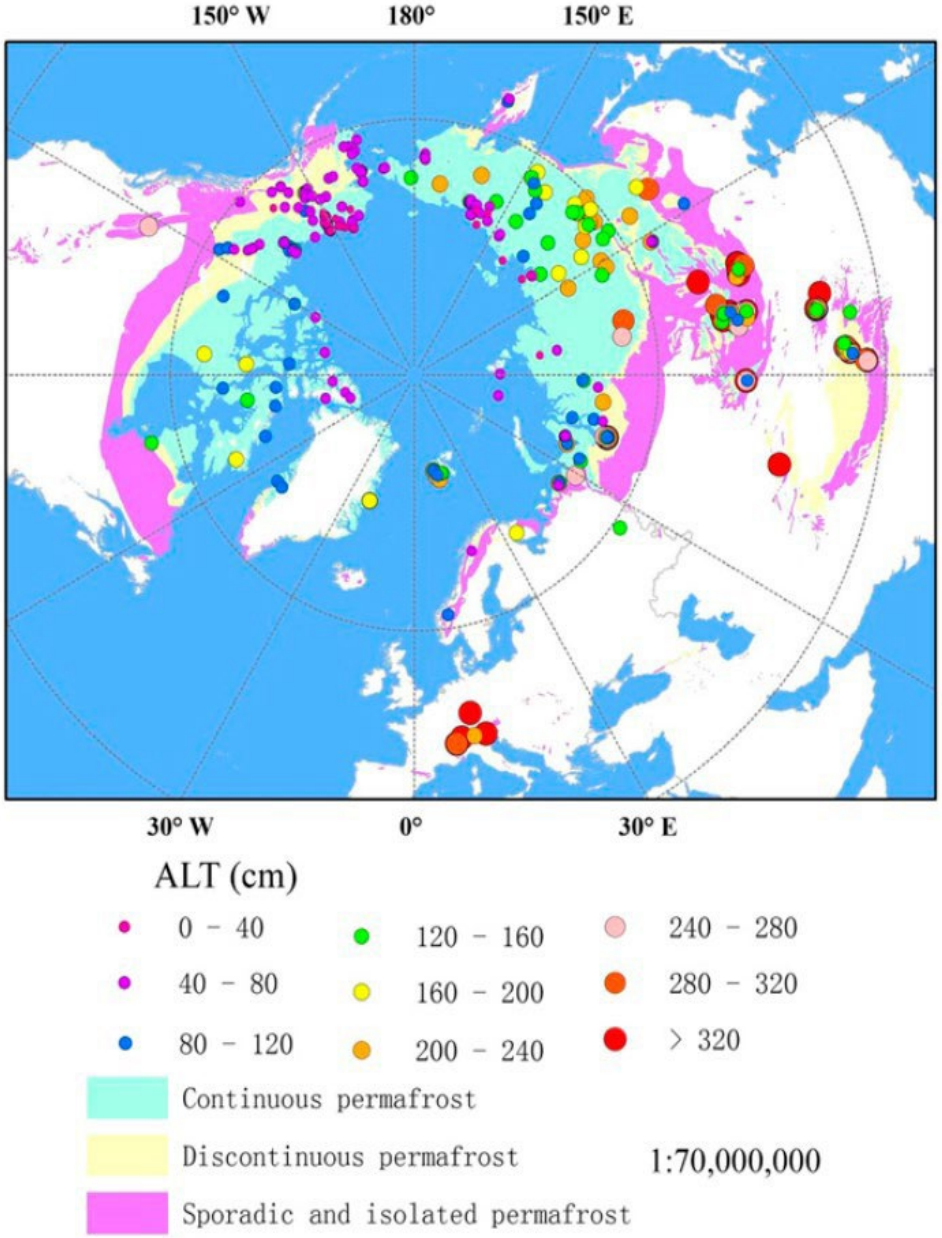


Figure 18 Mackenzie Valley Ecoregions and Permafrost Active Layer Monitoring Sites (Figure Source: Garibaldi et al., 2022)

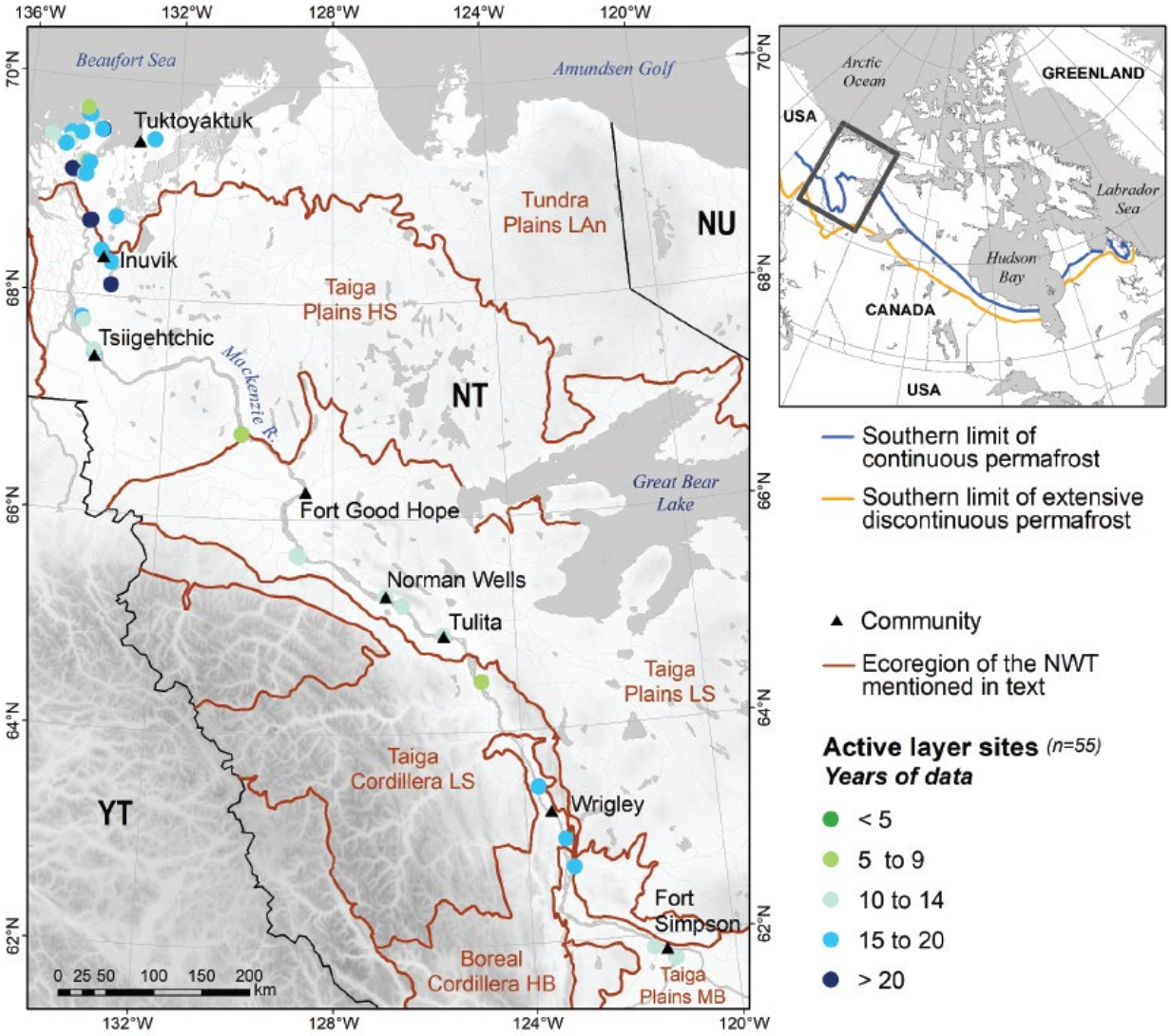


Figure 19 **Projected Change in Active Layer Thickness Between the 2071-2100 Climatology Under the RCP8.5 Emissions Scenario and the Historical 1971-2000 Simulation (Figure source: Peng et al., 2018)**

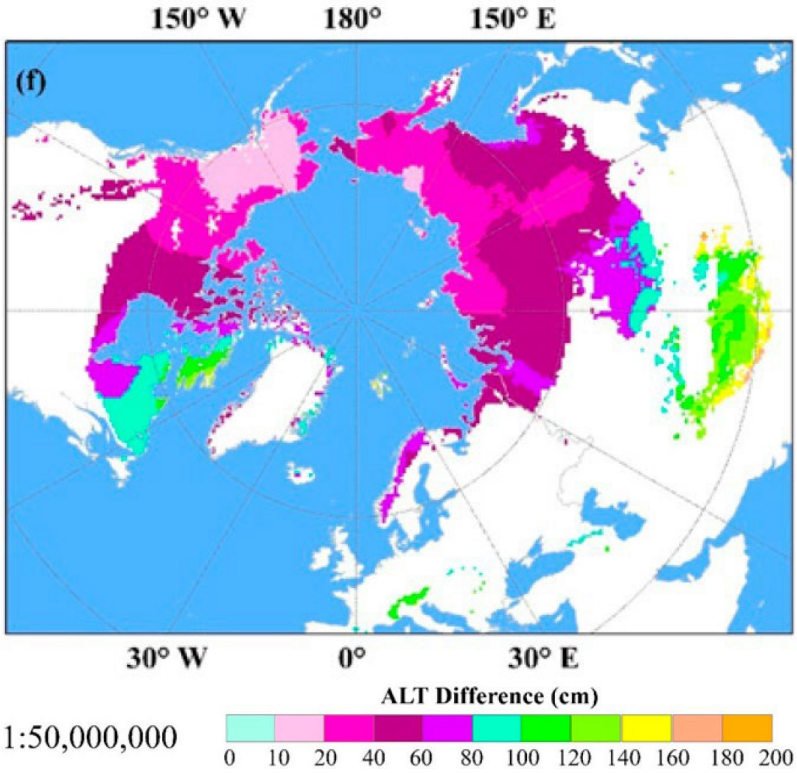
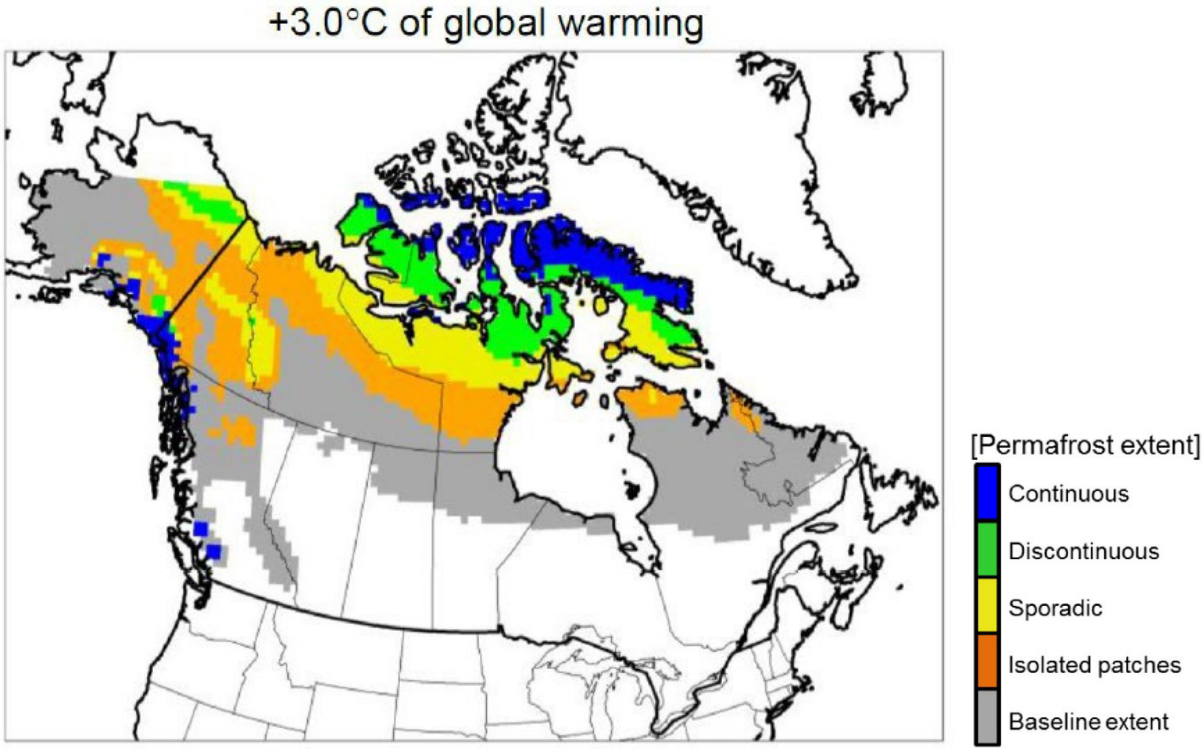


Figure 20 **Projected change in permafrost extent under +3°C of global warming (Figure source: Cannon et al., 2020)**



10 References

Barbero, R., H.J. Fowler, G. Lenderink and S. Blenkinsop. 2017. Is the intensification of precipitation extremes with global warming better detected at hourly than daily resolutions? Geophysical Research Letters, 44: 974-983. doi:10.1002/2016GL071917.

Blyth, C.A., D. Daust, B. Armitage, D. Cichowski, S. Alexander and K. Price. 2016. Landscape projections on boreal caribou habitat in NWT. Prepared for Government of Northwest Territories, Yellowknife, NWT. https://www.cclmportal.ca/sites/default/files/2022-12/GNWT_CaribouHabitat_Projections_SummaryReport_August2016_0.pdf

Boulanger, Y., S. Gauthier and P.J. Burton. 2014. A refinement of models projecting future Canadian fire regimes using homogeneous fire regime zones. Canadian Journal of Forest Research, 44: 365-376. doi:10.1139/cjfr-2013-0372

Canadian Forest Service. 2021. Canadian National Fire Database – Agency Fire Data. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, Edmonton, Alberta. https://cwfis.cfs.nrcan.gc.ca/ha/nfdb

Cannon, A. J. 2015. Selecting GCM Scenarios that Span the Range of Changes in a Multimodel Ensemble: Application to CMIP5 Climate Extreme Indices. Journal of Climate, 28: 1260-1267. doi:10.1175/JCLI-D-14-00636.1

Cannon, A.J., S.R. Sobie, and T.Q. Murdock. 2015. Bias Correction of GCM Precipitation by Quantile Mapping: How Well Do Methods Preserve Changes in Quantiles and Extremes? Journal of Climate, 28: 6938-6959. doi:10.1175/JCLI-D-14-00754.1

Cannon, A.J., D.I. Jeong, X. Zhang and F.W. Zwiers. 2020. Climate-Resilient Buildings and Core Public Infrastructure: An Assessment of the Impact of Climate Change on Climatic Design Data in Canada. Government of Canada, Ottawa, ON. 160 p. https://publications.gc.ca/collections/collection_2021/eccc/En4-415-2020-eng.pdf

CCCR. 2019. Canada's Changing Climate Report. Bush, E. and D.S. Lemmen, editors; Government of Canada, Ottawa, ON, Canada. 444 p. Available at https://changingclimate.ca/CCCR2019/

Chen, C.-T. and R. Knutson. 2008. On the Verification and Comparison of Extreme Rainfall Indices from Climate Models. Journal of Climate, 21: 1605-1621. doi:10.1175/2007JCLI1494.1

Cheng, C.S. 2014. Evidence from the Historical Record to Support Projection of Future Wind Regimes: An Application to Canada. Atmosphere-Ocean, 52: 232-241. doi:10.1080/07055900.2014.902803.

Cheng, C.S., E. Lopes, C. Fu, and Z. Huang. 2014. Possible Impacts of Climate Change on Wind Gusts under Downscaled Future Climate Conditions: Updated for Canada. Journal of Climate, 27:1255-1270. doi:10.1175/JCLI-D-13-00020.1.

CSA (Canadian Standards Association). 2019. Technical guide: Development, interpretation and use of rainfall intensity-duration-frequency (IDF) information: Guideline for Canadian water resources practitioners. CSA Group, p. 125. https://www.csagroup.org/store/product/CSA%20PLUS%204013:19/

Ecosystem Classification Group. 2007 (rev. 2009). Ecological Regions of the Northwest Territories – Taiga Plains. Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT, Canada. viii + 173 pp. + folded insert map.

Ecosystem Classification Group. 2010. Ecological Regions of the Northwest Territories – Cordillera. Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT, Canada. x + 245 pp. + insert map.

Eyring, V., S. Bony, G.A. Meehl, C.A. Senior, B. Stevens, R.J. Stouffer and K.E. Taylor. 2016. Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization. Geoscientific Model Development, 9: 1937-1958. doi:10.5194/gmd-9-1937-2016

Gaur, A., N. Bénichou, M. Armstrong and F. Hill. 2021. Potential future changes in wildfire weather and behavior around 11 Canadian cities. Urban Climate, 35: 100735. doi:10.1016/j.uclim.2020.100735

GNWT. 2015. A Homeowner's Guide to Permafrost in the Northwest Territories. Environment Division, Department of Environment and Natural Resources, Government of the Northwest Territories. Yellowknife, NWT. Available at: https://www.gov.nt.ca/sites/ecc/files/permafrost-homeowners-guide.pdf

Garibaldi, M.C., P.P. Bonnaventure, S.L. Smith and C. Duchesne. 2022. Active layer variability and change in the Mackenzie Valley, Northwest Territories between 1991-2014: An ecoregional assessment. Arctic, Antarctic, and Alpine Research, 54: 274–293. doi:10.1080/15230430.2022.2097156

Guo, D. and H. Wang. 2016. CMIP5 permafrost degradation projection: A comparison among different regions. Journal of Geophysical Research: Atmospheres, 121: 4499-4517. doi:10.1002/2015JD024108

Hausfather, Z. and G.P. Peters. 2020. Emissions – the 'business as usual' story is misleading. Nature, 577: 618-620. doi:10.1038/d41586-020-00177-3

Hopkinson, R.F., D.W. McKenney, E.J. Milewska, M.F. Hutchinson, P. Papadopol, and L.W. Vincent. 2011. Impact of Aligning Climatological Day on Gridding Daily Maximum-Minimum Temperature and Precipitation over Canada. Journal of Applied Meteorology and Climatology, 50: 1654-1665. doi:10.1175/2011JAMC2684.1

Huberman, Y., J. Beckers, R. Brett, G. Castilla, R. Errington, E.C. Fraser-Reid, D. Goodsman, E.H. Hogg, J. Metsaranta, E. Neilson, J. Olesinski, M.-A. Parisien, D. Price, T. Ramsfield, C. Shaw, D. Thompson, M.F. Voicu, E. Whitman and J. Edwards. 2022 The State of Northwest Territories Forests in the Wake of Climate Change: Baseline Conditions and Observed Changes to Forest Ecosystems. Natural Resources Canada, Canadian Forest Service, Northern Forest Centre. Edmonton, AB. Information Report NOR-X-430. https://publications.gc.ca/collections/collection_2022/rncan-nrcan/Fo133-1-430-eng.pdf

Hutchinson, M.F., D.W. McKenney, K. Lawrence, J.H. Pedlar, R.F. Hopkinson, E. Milewska, and P. Papadopol. 2009. Development and Testing of Canada-Wide Interpolated Spatial Models of Daily Minimum-Maximum Temperature and Precipitation for 1961-2003. Journal of Applied Meteorology and Climatology, 48: 725-741. doi:10.1175/2008JAMC1979.1

IPCC. 2013. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.

IPCC. 2021. Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. [Masson-Delmotte,

V. P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. doi:10.1017/9781009157896

IPCC. 2022. Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Balkacemi, A. Hasija, G. Lisboa, S. Luz, and J. Malley (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi:10.1017/9781009157926

Jones, M.W., J.T. Abatzoglou, S. Veraverbeke, N. Andela, G. Lasslop, M. Forkel, A.J.P. Smith, C. Burton, R.A. Betts, G.R. van der Werf, S. Sitch, J.G. Canadell, C. Santín, C. Kolden, S.H. Doerr and C.L. Quéré. 2022. Global and Regional Trends and Drivers of Fire Under Climate Change. Reviews of Geophysics, 60: e2020RG000726. doi:10.1029/2020RG000726

Kochtubajda, B., C. Mooney and R. Stewart. 2017. Characteristics, atmospheric drivers and occurrence patterns of freezing precipitation and ice pellets over the Prairie Provinces and Arctic Territories of Canada: 1964-2005. Atmospheric Research, 191: 115-127. doi:10.1016/j.atmosres.2017.03.005

McCray, C.D., D. Paquin, J.M. Thériault and É. Bresson. 2022. A Multi-Algorithm Analysis of Projected Changes to Freezing Rain Over North America in an Ensemble of Regional Climate Model Simulations. Journal of Geophysical Research: Atmospheres, 127: e2022JD036935. doi:10.1029/2022JD036935

McKenney, D.W., M.F. Hutchinson, P. Papadopol, K. Lawrence, J. Pedlar, K. Campbell, E. Milewska,

R.F. Hopkinson, D. Price, and T. Owen. 2011. Customized Spatial Climate Models for North America. Bulletin of the American Meteorological Society, 92: 1611-1622. doi:10.1175/2011BAMS3132.1

Mekis, E., N. Donaldson, J. Reid, A. Zucconi, J. Hoover, Q. Li, R. Nitu and S. Melo. 2018. An Overview of Surface-Based Precipitation Observations at Environment and Climate Change Canada. Atmosphere-Ocean, 56: 71-95. doi:10.1080/07055900.2018.1433627

Mekis, E., R.E. Stewart, J.M. Theriault, B. Kochtubajda, B.R. Bonsal and Z. Liu. 2020. Near-0 °C surface temperature and precipitation type patterns across Canada. Hydrology and Earth System Sciences, 24: 1741-1761. doi:10.5194/hess-24-1741-2020

Mudryk, L.R., C. Derksen, S. Howell, F. Laliberté, C. Thackeray, R. Sospedra-Alfonso, V. Vionnet, P.J. Kushner and R. Brown. 2018. Canadian snow and sea ice: historical trends and projections. The Cryosphere, 12: 1157-1176. doi:10.5194/tc-12-1157-2018

NWT SOE Report. 2022. NWT State of the Environment Report 2022. Government of Northwest Territories, Yellowknife, NWT. Available at: https://www.gov.nt.ca/ecc/sites/ecc/files/resources/wt_state_of_the_environment_report_2022.pdf

Panthou, G., A. Mailhot, E. Laurence, and G. Talbot. 2014. Relationship between Surface Temperature and Extreme Rainfalls: A Multi-Time-Scale and Event-Based Analysis. Journal of Hydrometeorology, 15:1999-2011. doi:10.1175/JHM-D-14-0020.1.

Pedersen, J.S.T., D.P. van Vuuren, B.A. Aparício, R. Swart, J. Gupta and F.D. Santos. 2020. Variability in historical emissions trends suggests a need for a wide range of global scenarios and regional analyses. Communications Earth & Environment, 1: 1-7, doi:10.1038/s43247-020-00045-y

Peng, X. T. Zhang, O.W. Frauenfeld, K. Wang, D. Luo, B. Cao, H. Su, H. Jin and Q. Wu. 2018. Spatiotemporal Changes in Active Layer Thickness under Contemporary and Projected Climate in the Northern Hemisphere. Journal of Climate, 31: 251-266. doi:10.1175/JCLI-D-16-0721.1

Prein, A.F., R.M. Rasmussen, K. Ikeda, C. Liu, M.P. Clark and G.J. Holland. 2016. The future intensification of hourly precipitation extremes. Nature Climate Change, 7: 48-52. doi:10.1038/nclimate3168.

Riahi, K., D.P. van Vuuren, E. Kriegler, J. Edmonds, B.C. O'Neill, S. Fujimori, N. Bauer, K. Calvin, R. Dellink, O. Fricko, W. Lutz, A. Popp, J.Crespo Cuaresma, Samir KC, M. Leimbach, L. Jiang, T. Kram, S. Rao, J. Emmerling, K. Ebi, T. Hasegawa, P. Havlik, F. Humpenöder, L. Aleluia Da Silva,

S. Smith, E. Stehfest, V. Bosetti, J. Eom, D. Gernaat, T. Masui, J. Rogelj, J. Strefler, L. Drouet, V. Krey, G. Luderer, M. Harmsen, K. Takahashi, L. Baumstark, J.C. Doelman, M. Kainuma, Z. Klimont, G. Marangoni, H. Lotze-Campen, M. Obersteiner, A. Tabeau and M. Tavoni. 2016. The Shared Socioeconomic Pathways and their energy land use, and greenhouse gas emissions implications: An overview. Global Environmental Change, 42: 153-168. Doi:10.1016/j.gloenvcha.2016.05.009

Schwalm, C.R., S. Glendon and P.B. Duffy. RCP8.5 tracks cumulative CO2 emission. Proceedings of the National Academy of Sciences, 117: 19656-19657. Doi:10.1073/pnas.2007117117

Seneviratne, S.I., N. Nicholls, D. Easterling, C.M. Goodess, S. Kanae, J. Kossin, Y. Luo, J. Marengo, K. McInnes, M. Rahimi, M. Reichstein, A. Sorteberg, C. Vera and X. Zhang. 2012. Changes in Climate Extremes and their Impacts on the Natural Physical Environment. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Group I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 109-230. https://www.ipcc.ch/site/assets/uploads/2018/03/SREX-Chap3_FINAL-1.pdf

Shi, H.X. and C.H. Wang. 2015. Projected 21st century changes in snow water equivalent over Northern Hemisphere landmasses from the CMIP5 model ensemble. The Cryosphere, 9: 1943-1953. doi:10.5194/tc-9-1943-2015

Slater, A.G. and D.M. Lawrence. 2013. Diagnosing Present and Future Permafrost from Climate Models. Journal of Climate, 26: 5608-5623. doi:10.1175/JCLI-D-12-00341.1

Smith, M.R. and S.S. Myers. 2018. Impact of anthropogenic CO2 emissions on global human nutrition. Natural Climate Change, 8: 834-839. doi:10.1038/s41558-018-0253-3

Stewart, F.E.C., T. Micheletti, S.G. Cumming, C. Barros, A.M. Chubaty, A.L. Dookie, I. Duclos, I. Eddy, S. Haché, J. Hodson, J. Hughes, C.A. Johnson, M. Leblond, F.K.A. Schmiegelow, J.A. Tremblay and E.J.B. McIntire. 2023. Climate-infomred forecasts reveal dramatic local habitat shifts and population uncertainty for northern boreal caribou. Ecological Applications, 33: e2816. doi:10.1002/eap.2816

Taylor, K.E., R.J. Stouffer, and G.A. Meehl. 2012. An Overview of CMIP5 and the Experiment Design. Bulletin of the American Meteorological Society, 93: 485-498. doi:10.1175/BAMS-D-11-00094.1

van Vuuren, D.P, J. Edmonds, M. Kainuma, K. Riahi, A. Thomson, K. Hibbard, G.C. Hurtt, T. Kram, V. Krey, J.-F. Lamarque, T. Masui, M. Meinshausen, N. Nakicenovic, S.J. Smith, and S.K. Rose. 2011. The representative concentration pathways: an overview. Climatic Change, 109:5-31. doi:10.1007/s10584-011-0148-z

Wan, H., X. Zhang and M. Kirchmeier-Young. 2023. Representativeness of the Precipitation Observing Network for Monitoring Precipitation Change and Variability in Canada. Atmosphere-Ocean, 61: 69-83. doi:10.1080/07055900.2022.2144111

Wang, X., D.K. Thompson, G.A. Marshall, C. Tymstra, R. Carr and M.D. Flannigan. 2015. Increasing frequency of extreme fire weather in Canada with climate change. Climatic Change, 130: 573-586. doi: 10.1007/s10584-015-1375-5

Wang, X., M.A. Parisien, S.W. Taylor, J.N. Candau, D. Stralberg, G.A. Marshall, J.M. Little, and M.D. Flannigan. 2017. Projected changes in daily fire spread across Canada over the next century. Environmental Research Letters, 12: 025005. doi:10.1088/1748-9326/aa5835

Wang, X., K. Studens, M.-A. Parisien, S.W. Taylor, J.-N. Candau, Y. Boulanger and M.D. Flannigan. 2020. Projected changes in fire size from daily spread potential in Canada over the 21st century. Environmental Research Letters, 15: 104048. doi:10.1088/1748-9326/aba101

Wang, X., T. Swystun and M.D. Flannigan. 2022. Future wildfire extent and frequency determined by the longest fire-conductive weather spell. Science of the Total Environment, 830: 154752. doi:10.1016/j.scitotenv.2022.154752

Westra, S., L.V. Alexander and F.W. Zwiers. 2013. Global Increasing Trends in Annual Maximum Daily Precipitation. Journal of Climate, 26: 3904-3918. doi:10.1175/JCLI-D-12-00502.1.

Whitman, E., K. Sherren, and E. Rapaport. 2015. Increasing daily wildfire risk in the Acadian Forest Region of Nova Scotia, Canada, under future climate change. Regional Environmental Change, 15:1447-1459. doi:10.1007/s10113-014-0698-5

Woo, M-K, P. Modeste, L. Martz, J. Blondin, B. Kochtubajda, D. Tutcho, J. Gyakum, A. Takazo, C. Spence, J. Tutcho, M. Modeste, B. Kenny, and W. Modeste. 2007, Science Meets Traditional Knowledge: Water and Climate in the Sahtu (Great Bear Lake) Region, Northwest Territories, Canada. Arctic 60(1): 37-46.

Topic: Lessons Learned Tłı̨chǫ Highway

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board): On February 27, 2024, the Review Board released a Notice of Proceeding indicating it plans to transfer relevant materials from the Tłı̨chǫ All Season Road EA (EA1617-01) to the Mackenzie Valley Highway EA (EA1213-02). This information request builds on the Notice of Proceeding by asking the GNWT to analyse existing information and provide additional information about the actual and impacts, and the effectiveness of mitigation measures relating to the Tłı̨chǫ highway. In the future, the Review Board may ask additional questions about lessons learned that are specific to individual valued components.

Many of the predicted impacts for the proposed MVH are the same or similar to the impacts that were predicted and occurred during the assessment, construction and initial operations of the Tłı̨chǫ highway. During that environmental assessment for the Tłı̨chǫ highway, the GNWT relied on existing programs and plans to mitigate many of the impacts. Similarly, in the MVH DAR the GNWT appears to rely heavily on existing programs and plans to mitigate impacts of the proposed MVH. Some engagement participants noted that GNWT programs are not adequate to deal with existing social impacts in communities along the route.

When the predicted impacts of the Tłı̨chǫ highway happened, existing programs sometimes proved slow and only partially effective to mitigate the impacts. In addition, experience has shown that the predicted "spike" of social impacts has lasted longer than predicted and some of the impacts have been difficult to detect, monitor, and adaptively manage in a timely and effective manner. Because the Tłı̨chǫ highway project precedes the MVH, it offers an excellent opportunity for lessons that may be applicable for this EA, based on the experiences of Tłı̨chǫ communities and GNWT monitoring and management plans.

Request from the Review Board:

A. Please describe which plans and programs for the Tłı̨chǫ highway were effective in efficiently mitigating impacts when they occurred, and which were not and why not.

B. Please describe how effectively GNWT programs are addressing current and existing impacts on communities and on wildlife that will be affected by the construction and operation of the MVH.

C. For any impacts that were not efficiently or effectively mitigated when they happened during construction and operation of the Tłı̨chǫ highway, please justify:

   i. how GNWT programs will effectively deal with similar impacts on communities and on wildlife caused by or associated with the MVH (referencing key performance indicators where possible)
   ii. why the GNWT believes existing plans and programs are appropriate to mitigate additional impacts caused by or associated with the MVH
   iii. why the GNWT expects that the same or other proposed mitigation measures will work better for the MVH than for the Tłı̨chǫ highway.

Response from the Government of the Northwest Territories:

In its role as a public government, the Government of the Northwest Territories (GNWT) provides programs and services[1] to residents across the territory. Programs and services are executed at local, regional, and territorial levels and evolve in response to the diverse needs of residents, modifications to legislation and guidelines, or other legal requirements. Many of the GNWT's programs and services have also been developed in collaboration with Indigenous governments and community governments and as a result, these programs and services reflect their interests and priorities.

Similar to the approach to mitigating impacts of the Tłı̨chǫ Highway, the GNWT is proposing to leverage existing programs and services, and create collaborative working groups similar to those which have seen success in the Tłı̨cho Highway to mitigate impacts of the Mackenzie Valley Highway (MVH) project. As outlined in Section 9.15.1 of the Developer's Assessment Report (DAR), the mitigations proposed by the GNWT are founded on community readiness and preparedness, collaboration and continued engagement with local peoples to facilitate the integration of local knowledge into the project and develop monitoring approaches collaboratively.

The GNWT understands that the Review Board is attempting to better understand the effectiveness and limitations of this approach. The GNWT has not completed a systematic review of the effectiveness and limitations of each of its programs and plans as they relate to the Tłı̨cho Highway for several reasons including:

1) **GNWT Programs and services are continually evolving**

   The GNWT programs and services are designed to change over time to meet the needs of residents and are regularly adapted to reflect environmental and socio-economic conditions. Programs and services are implemented at territorial, regional, and community levels by the GNWT, Indigenous governments, Indigenous organizations and/or community governments. This approach allows for Indigenous governments and community governments to provide programs and services that people need in their communities and adaptively respond to changing needs. The GNWT provides funding under broad programming areas to provide the greatest flexibility to support defined priorities and objectives[2].

[1] The IR posed by the Review Board states, "existing plans and programs". The GNWT has interpreted this to mean programs and plans that are associated with the GNWT's role as a public government and not project specific.

[2] Examples include Community Wellness and Addictions Recovery Fund (this funding has replaced the One the Land Healing Fund, the Addictions Recovery Peer Support Fund, and the Gender-Based Violence Community Initiatives Fund). A list of GNWT's programs can be found here.

2) Social and wellbeing impacts in communities associated with the Tłı̨chǫ Highway are not experienced in isolation.

The Tłı̨chǫ Highway project was constructed between September 2019 to October 2021 and officially opened in November 2021. During that time, the NWT, along with the rest of the world, experienced the COVID-19 pandemic which impacted the territory in several ways including:

- Reported measures of mental wellness were reported to have declined throughout the pandemic and measures of mental wellness began to recover slightly in 2022[3].
- Alcohol consumption also increased during the pandemic across the NWT and Canada. Alcohol consumption has been documented to exacerbate feelings of loneliness associated with the imposed physical distancing during the pandemic, increase symptoms of anxiety and depression, and increase the risk of intimate partner violence and child neglect[4].
- Closure and/or reduction in access to programs and services due to pandemic related isolation requirements.

With the impacts of COVID-19 and COVID-19 restrictions easing in 2022, it was expected that the pandemic related impacts would decrease (though some experts expect to see impacts of COVID-19 for a decade, if not more[5]). However, 2023 brought other stressors to the Tłı̨chǫ (and other) region(s). Wildfires resulted in the evacuation of Behchokǫ̀ as well as other communities around the territory. The long-term effects of the 2023 wildfire season on territorial residents are not yet fully understood; however, the effects of wildfires in other areas have been documented to:

- Increase rates of post-traumatic stress disorder, depression, generalized anxiety, often in combination with substance abuse and substance use disorder[6]
- Increases in hypertension, gastrointestinal disorders, diabetes, chronic obstructive pulmonary disease, and asthma exacerbations[7].

When considering these impacts associated with the pandemic and the wildfires together, it is clear that there are factors affecting community wellbeing within the Tłı̨chǫ region that are not solely attributable to the Tłı̨chǫ Highway project.

---

[3] https://www.hss.gov.nt.ca/sites/hss/files/resources/social-indicators-covid-19-pandemic-june-2022.pdf
[4] World Health Organisation Europe. Alcohol and COVID-19: what you need to know. WHO 2020. http://www.euro.who.int/__data/assets/pdf_file/0010/437608/Alcohol-and-COVID-19-what-you-need-toknow.pdf?ua=1
[5] British Academy. The COVID Decade: Understanding the long-term societal impacts of COVID-19. 2021. doi.org/10.5871/ bac19stf/9780856726583.001
[6] To, P., Eboreime, E., and Agyapong, V.I.O. The Impact of Wildfires on Mental Health: A Scoping Review. Behav. Sci. **2021**,11, 126. https://doi.org/10.3390/bs11090126
[7] Doerr, S.H.; Santín, C. Global trends in wildfire and its impacts: Perceptions versus realities in a changing world. Philos. Trans. R. Soc. B Biol. Sci. 2016, 371, 20150345.

The GNWT does not complete formal project-specific (resource development, large infrastructure project) evaluation of its programs and plans. However, when indicators are trending in a way that is unanticipated, regardless of the cause of the trend, programs can be responsive, or have additional mitigations put in place. Indicator trends may not only be related to project-specific impacts rather they may be connected to broader trends that may be present across the region and/or territory.

In the preamble of the Information Request, the Review Board stated that "*existing programs sometimes proved slow and only partially effective to mitigate the impacts. In addition, experience has shown that the predicted "spike" of social impacts has lasted longer than predicted and some of the impacts have been difficult to detect, monitor, and adaptively manage in a timely and effective manner*". There is preliminary information collected that indicates concerning changes in social indicators are occurring, and while this might suggest that existing programs were unable to mitigate the impacts of the Tłı̨chǫ Highway as predicted, there were other unanticipated factors that may have contributed to these observations. The COVID-19 pandemic and its related restrictions, wildfires and evacuations, etc. occurred at approximately the same time and are likely contributing to the observations of the "spike" extending. As well, it is important to note that not all changes in indicators of concern are directly related only to the Tłı̨chǫ Highway as trends in some of the indicators were observed before construction of the highway began and similar trends are being observed in other regions of the NWT.

3) From an environmental perspective, the Projects fundamentally differ and therefore direct comparisons are difficult.

The GNWT has, where appropriate, considered the Tłı̨chǫ Highway project in its design of adaptive management. That being said, there are important differences between the MVH and Tłı̨chǫ Highway projects which make direct comparisons challenging. These differences include:

- The disturbance to the landscape is not the same. The all-season road proposed as part of the MVH project will generally follow the existing Mackenzie Valley winter road which has been in use for many years. The Tłı̨chǫ Highway replaced a winter road that traversed a lake for a significant portion of its length with an all-season road that followed an older winter road alignment that had not been in use for quite some time.
- From a wildlife perspective the MVH is changing from an area where wildlife was already exposed to seasonal winter traffic to a proposed year-round highway but the Tłı̨chǫ Highway was a new road with year-round traffic being established in an area where there was essentially no traffic disturbance at any time of the year at baseline.
- Communities impacted by the MVH are different from the Tłı̨chǫ communities given some of the regional development in the area (e.g. Norman Wells). Further, they have different histories, governance structures, interests, and needs.

As a result of these differences, the baseline conditions for wildlife and socio-economic conditions were/are notably different. For example, the amount of undisturbed caribou habitat in the Sahtu is greater than in the Wek'èezhìı region and the amount of boreal caribou collar information available to inform baseline information is greater for the MVH than for the Tłı̨chǫ Highway environmental assessment (EA). All of the above being considered, it is true that the physical construction activities for the road will be similar. Note, specific regulatory plans will be developed for the MVH as part of regulatory permitting for the highway.

4) The GNWT is working to improve programs and services.

Throughout the COVID-19 pandemic, the 2023 wildfire season, and the opening of the Tłı̨chǫ Highway, the GNWT used existing programs to adaptively manage impacts to the extent possible. There will always be capacity and resource constraints in providing services to diverse people and regions, experiencing different stressors, compounded by the history of imposed colonialism and the residential school system, across the NWT. The legacies of colonization and residential schools have impacted health outcomes of Indigenous residents and shaped the way services are delivered in the territory. The GNWT is working to address these concerns and improve the health outcomes of Indigenous residents.

At the same time, the GNWT is committed to supporting the expansion and diversification of our economy, the strength of which is dependant upon reliable, sustainable and resilient infrastructure such as the proposed Mackenzie Valley Highway, which among other outcomes is intended to improve the quality of life for NWT residents.

Below, the GNWT has provided information, where possible, on select programs and plans from the Tłı̨chǫ Highway project that are relevant to this EA. This information includes examples of:

- Existing GNWT programs and plans relevant to mitigating impacts of the Tłı̨chǫ Highway project (Appendix A, item i).
- Existing GNWT programs and plans that have been adapted in response to commitments and measures resulting from the Tłı̨chǫ All Season Road (TASR) EA as well as from impacts observed during the construction and operation and maintenance of the Tłı̨chǫ Highway (Appendix A, item ii).
- Existing GNWT programs and plans relevant to the MVH Project (Appendix A, item iii).

A. Please describe which plans and programs for the Tłı̨chǫ Highway were effective in efficiently mitigating impacts when they occurred, and which were not and why not.

The GNWT relied on existing plans, programs, and services to mitigate impacts of the Tłı̨chǫ Highway project construction (complete) and operation and maintenance (ongoing), on local communities and the environment. In response to requests from communities and/or the region, the plans, programs, and services were supplemented as appropriate and possible. In addition to the plans, programs, and

services, there were actions taken during the project planning phase that resulted in mitigations not being required. These include employment and contracting initiatives put in place through the P3 operator (North Star Infrastructure) that resulted in benefits for the Tłı̨chǫ Government. Safety and awareness training, development of gender-specific employment policies, etc.

It is important to note that GNWT plans and programs that mitigate impacts of the Tłı̨chǫ Highway do not operate in isolation but in conjunction with measures from the TASR EA directed to the GNWT both as the Developer and as a Government and Regulatory Authority, and measures directed to Tłı̨chǫ Government. In the case of the Tłı̨chǫ Highway, the GNWT and Tłı̨chǫ Government worked collaboratively to advance measure implementation.

Measure 14-3 in the Report of EA for the TASR required the GNWT establish the Tłı̨chǫ All Season Road Corridor Working Group (THCWG) "To mitigate significant adverse impacts from the Project to the environment and *people* [emphasis added], the developer will implement the TASR Corridor Working Group…". The THCWG provides a forum for information exchange, with the specific objectives to review and provide comment on the design of the GNWT's Tłı̨chǫ Highway project specific monitoring programs, review and comment on project specific monitoring program annual reports and providing advice on monitoring and mitigation results that may contribute to adaptive management and/or regional cumulative effects monitoring programs. The GNWT's Annual EA Measures Report is guided by and reflects feedback from the THCWG and the other working groups.

Socio-Economic Related Impact Mitigation

As part of the implementation of EA Measure 5-1, the GNWT, Tłı̨chǫ Government, Tłı̨chǫ Community Services Agency, and the Community Governments of Behchoko and Whati, established the Tłı̨chǫ Highway Socio-Economic Working Group (formally referred to as the Health and Well-being Working Group). This working group provides a forum for information exchange specific to identifying trends in indicators being monitored for community health and well-being and provide advice on monitoring and mitigation results that may contribute to adaptive management. The working group began in 2019 and has worked collaboratively to develop, monitor, and collect important health and well-being indicators.

The collaborative work of the working group is critical to adaptively managing negative trends. For instance, when the working group identified a need to improve road safety, the GNWT provided satellite phones to Tłı̨chǫ Community Service Agency workers, and Road Safety and Trauma Kits to the Tłı̨cho Government in 2023. The working group also provided information regarding the ongoing syphilis outbreak that resulted in additional work being undertaken by the Tłı̨chǫ Community Service Agency and the GNWT (further details provided in the appendix). As well, GNWT-HSS held a youth painting night in Whati, as a way to engage youth and continue to build relationships that started at the mental health and substance use information session held in the school during the day.

Wildlife Related Impact Mitigation

A Wildlife Management and Monitoring Plan (WMMP) for the Tłı̨chǫ Highway was required under s.95(1) of the *Wildlife Act* and under Measure 10-2 of MVEIRB's Report of EA and Reasons for Decision (Report of EA) for the Tłı̨chǫ Highway. The GNWT's WMMP for the Tłı̨chǫ Highway project was informed by feedback from the THCWG and from the annual public review of the WMMP. The GNWT is compiling findings and results of the monitoring programs advanced under the WMMP during the Tłı̨chǫ Highway project construction, which is anticipated to be complete in the fall of 2024. This report will include an assessment of which mitigation measures and monitoring programs have been effective at mitigating impacts on wildlife and habitat during the construction of the highway and will be made available to the public.

As part of Measure 6-1 of the EA, the GNWT was required to develop and implement a range planning for boreal caribou. Through the Wek'èezhìı range planning working group developed in response to the EA measure, the regional boreal caribou range plans began in 2019, and an interim range plan for the Wek'èezhìı region was completed in February 2022. Development of range plans in the other four regions is still in progress. A range plan for the Bathurst barren-ground caribou herd was completed in August 2019. Outcomes of the monitoring activities completed as part of the project are outlined in the GNWTs Annual EA Measures Report[8].

A specific example of a program that could have been more effective on the Tłı̨chǫ Highway project is related to the ground temperature monitoring installations along the Tłı̨chǫ Highway. Many of the thermistors along the Tłı̨chǫ Highway were unintentionally destroyed during road construction. On the MVH project, the GNWT will incorporate the learnings from the Tłı̨chǫ Highway and ensure that the thermistor installation along the MVH is protected to ensure that ground temperature can be effectively monitored from pre-construction through to operations.

WMMP for MVH Project

A Minister-approved WMMP will be required for the MVH project under s.95 of the *Wildlife Act*. The DAR included a draft WMMP (Volume 5 – Management Plans), with descriptions of new positions and programs (e.g., for harvest monitoring) that will be needed for the MVH project. The draft WMMP for the MVH project was largely based on the WMMP for the Tłı̨chǫ Highway. It is intended that the draft WMMP will be updated and added to during the course of the EA to reflect new developer commitments, measures of EA, and post-EA to reflect the results of a public review of the WMMP before its final approval by GNWT-ECC.

With respect to existing wildlife monitoring and management programs implemented by the GNWT, or in partnership with renewable resources boards and other Indigenous governments and Indigenous organizations, the DAR for the MVH acknowledges that they may need to be expanded upon or enhanced to specifically address impacts from the MVH, and that this will require additional resources. There are several examples including:

[8] GNWT 2022 Annual Measures Report Tlicho All-season Road Project (EA1617-01).pdf (reviewboard.ca)

For example, Section 10.7.2 - Gaps and Uncertainties of the DAR states that:

> *"The GNWT will work with SRRB and other resource managers to address uncertainty regarding the effects of improved access created by the Project on harvested resources in the study areas. This would include monitoring of harvest that can be used to identify the need for management actions to be taken by the appropriate resource management organization."*
>
> *"It is expected that there will be a time lag associated with the implementation of enhancements into exiting harvest management programs to effectively respond to increased harvest pressures on caribou and moose (e.g., new staff would need to be hired, monitoring and enforcement protocols would need to be developed and applied)."*

For example, Section 10.8 – Follow-up Monitoring, and Management states that:

> *"Existing monitoring programs can/will receive support early on to expand and modify them to address questions/provide more information about species near the Project. The programs will require long-term financial and staffing and resource commitment to obtain and analyze results."*

Section 10.2.2.2 of the DAR describes existing monitoring and management plans that are in place for barren-ground caribou. For boreal caribou, a new collar-based monitoring program was initiated to provide baseline data for the MVH DAR, and as proposed in the draft WMMP, this program may continue through the construction phase of the project and into the operations phase, similar to the approach taken in the WMMP for the Tłı̨chǫ Highway.

B. Please describe how effectively GNWT programs are addressing current and existing impacts on communities and on wildlife that will be affected by the construction and operation of the MVH.

The DAR submitted for the MVH EA provides a snapshot of the existing baseline conditions, including existing program and services, and emphasizes ongoing collaboration with Indigenous governments and Indigenous organizations in communities anticipated to be impacted by the project. Where appropriate, the DAR identifies where gaps may exist, and which GNWT programs and plans may need to be augmented to mitigate anticipated impacts, or where monitoring and adaptive management is proposed. Further, as noted above, a project specific WMMP will be developed for the MVH that will be revied and refined as part of the regulatory/public review process prior to permitting, for both the construction and operation phases.

C. For any impacts that were not efficiently or effectively mitigated when they happened during construction and operation of the Tłı̨chǫ Highway, please justify:

a. How GNWT programs will effectively deal with similar impacts on communities and on wildlife caused by or associated with the MVH (referencing key performance indicators where possible)

b. Why the GNWT believes existing plans and programs are appropriate to mitigate additional impacts caused by or associated with the MVH

c. Why the GNWT expects that the same or other proposed mitigation measures will work better for the MVH than for the Tłı̨chǫ Highway.

Learnings from the Tłı̨chǫ Highway project will be integrated into the MVH project based on the outcomes of the Tłı̨chǫ Highway project (e.g. the construction phase WMMP Report anticipated in fall of 2024), the needs/wants of communities, input from Indigenous Governments and Indigenous organizations, resource managers, etc.

The GNWT considers that having a specific WMMP in place for the MVH project, in combination with existing programs, will be effective in mitigating impacts to wildlife and habitat from construction and operations of the MVH. Additional information on the WMMP is provided in Appendix A.

The GNWT is committed to adapting its plans and programs to ensure effectiveness and looks forward to hearing from intervenors during the EA process on ways in which they think impacts to wildlife and communities can be mitigated.

Appendix A –

i. Examples of Existing GNWT Plans and Programs Relevant to Mitigating impacts of the Tłı̨chǫ Highway Project

Project Specific Wildlife Management and Monitoring Plan

A Wildlife Management and Monitoring Plan (WMMP) for the Tłı̨chǫ Highway was required under s.95(1) of the *Wildlife Act* and under Measure 10-2 of MVEIRB's Report of EA and Reasons for Decision (Report of EA) for the Tłı̨chǫ Highway.

The process to prepare the Tłı̨chǫ Highway WMMP[9] was iterative. Since its initial submission in 2016, the WMMP underwent several updates to incorporate developer commitments, address measures from the Report of EA, and integrate feedback from regulators, independent third-party reviewers, and the public. ECC works with the Wek'èezhìı Land and Water Board (WLWB) and the Wek'èezhìı Renewable Resources Board to coordinate an annual public review of the WMMP.

The WMMP will be implemented for the first five years of operations of the Tłı̨chǫ Highway (until 2026), at which time the need for continuing the WMMP programs will be re-evaluated. The GNWT is required to provide annual reports through the WMMP and the annual water licence reports. These are shared with the THCWG, are publicly available on ECC's WMMP Resources website and are submitted to and the WLWB.

A comprehensive report summarizing the findings of the monitoring programs advanced under the WMMP during the construction phase of the TASR is anticipated to be issued in the fall of 2024. This report will include an assessment of which mitigation measures and monitoring programs have been effective at mitigating impacts on wildlife and habitat during the construction of the highway.

Other Northwest Territories Wide Wildlife Related Programs and Plans

The Big Game Hunting Regulations

The Big Game Hunting Regulations set seasons and limits on wildlife harvest. These regulations were amended in 2019 to split mountain woodland caribou and boreal woodland caribou into separate tags to allow for better estimation of Resident and General Hunting Licence (GHL) holder harvest on boreal caribou. The hunting season for boreal caribou for Resident hunters and GHLs was shortened, and Residents were limited to male-only harvesting.

[9] WMMP is available on GNWT-ECC's WMMP Resources website

Resident Hunter Surveys and Enforcement

The annual Resident Hunter Survey program provides regional-scale information about resident hunter harvest levels. To assist with harvest monitoring and enforcement specific to the Tłı̨chǫ Highway, a new Renewable Resources Officer position was created in Whatì.

Caribou Range Planning

The regional boreal caribou range plans began in 2019, and an interim range plan for the Wek'èezhìı region was completed in February 2022. Development of range plans in the other four regions is still in progress. A range plan for the Bathurst barren-ground caribou herd was completed in August 2019.

Other Programs advanced by GNWT Partners (Tłı̨chǫ Government)

GNWT annually provides funding to the Tłı̨chǫ Government (TG) to support the implementation of TASR EA Measures 7-1 and 9-1, both of which are related to the WMMP. The GNWT also provides contribution agreement funding to the TG to help in the implementation of Measures 5-1 and 5-2 as it relates to monitoring and adaptively management of adverse health and well-being impacts to the Community of Whati.

ii. Examples of existing GNWT Programs and Plans that have been adapted in response to commitments and measures from the TASR EA and community needs

- Wildlife surveys including regional bison and moose population surveys are conducted every three to five years and the survey areas have been expanded to include the area of the Tłı̨chǫ Highway corridor.
- In response to the opioid crisis, the Health Promotion Division of the GNWT has sent 70 naloxone kits to Tłı̨chǫ as part of the GNWT surge response activities since 2023. This is over and above the normal naloxone kits made available by the Health Authority (2000 kits were sent out across the territory in response to the opioid crisis; training was also provided in the use of the kits).
- In response to the ongoing syphilis outbreak in the NWT, the GNWT has sent 35 condom dispensers to the Tłı̨chǫ region since March 2023 as surge programming (266 dispensers were distributed across the territory).
    - Tłı̨cho Government,̨ GNWT-HSS, TCSA and the Office of the Chief Public Health Officer met in October 2022 to identify health related mitigative actions based on initial changes identified through the monitoring program and qualitative reports from the community. Workshops were held in the Tłı̨chǫ region in May 2023 to provide additional supports and training for community health centre workers. This mitigation was developed based on surveillance by the GNWT and Tłı̨chǫ Government, as well as ongoing discussions within the Tłı̨chǫ Highway Socio-Economic Working Group regarding the outbreak of Sexually Transmitted Infections across the north.

iii. Examples of Existing GNWT Programs and Plans Relevant to the MVH Project

Socio-Economic Related GNWT Programs and Plans Relevant to the MVH Project

The GNWT works closely with communities to provide annual funding for plans, programs, and services based on established community needs. For instance:

- Department of Infrastructure
  - Provides financial contributions to communities toward the construction or maintenance of access roads, trails, docks and wharves as part of the Community Access Program.
- Department of Education, Culture and Employment
  - Provides funding directly to Indigenous Governments, communities, and non-governmental organizations to support Indigenous Language programming, communications, and mentorship programs.
  - Provides support for early learning and childcare throughout the territory and is working to create more high-quality, affordable, and regulated childcare spaces, primarily through support for the not-for-profit and public childcare providers.
- Department of Justice
  - Ministerial Policing Priorities (MPP) are built from community priorities sent to the Department of Justice annually.
    - Communities can consider incoming and completed projects and other issues when establishing their priorities. This allows MPPs to act as adaptive management for project issues.
- Industry, Tourism and Investment (ITI)
  - ITI collaborates with Northwest Territories Tourism to provide marketing for tourism specific to each region in the NWT.
  - Communities have the opportunity to access ITI programming and establish their own priorities. This includes the development of Tourism Plans.
    - These plans and priorities can consider incoming and completed projects which allow them to act to adaptively manage project issues and/or retain benefits.
  - Within the MVH Project Local Assessment Area:
    - Norman Wells has an economic development strategy, community plan, and recreation master plan that speaks to tourism and to develop it in Norman Wells.
    - Tulita has put together an informal community strategic plan and has a community campground plan. A new Economic Development Officer (EDO) was hired and is working with ITI's Regional Office on future plans for the community.
    - Wrigley has an old Tourism Development Plan from 1990. ITI is interested in following up with Wrigley's leadership to update the plan as conditions change.
- Department of Health and Social Services:
  - Provides health promotion funding:

- Community Wellness and Addictions Recovery fund provides funding for Regional and Community Indigenous Governments, Community Governing Authorities (Band Councils, Metis Locals, Charter Community or municipal council) and Non-government Indigenous organizations to deliver culturally relevant, community-based options for individuals living with mental health and addictions in the NWT,
- Community Suicide Prevention fund provides funding for community-based suicide prevention activities in the NWT,
- Gender-Based Violence Community Initiatives Fund provides funding for community-based initiatives across the Northwest Territories that support the implementation of the National Action Plan to End Gender Based Violence.

Preventative Programming

The GNWT completes health and well-being promotion and preventative programming which supports the adaptive management of negative social issues, including:

- Housing – Public Housing, Assistance to Homeowners (Homeownership Initiative), Assistance for individuals experiencing homelessness (Homelessness Assistance Fund, Small Communities Homeless Fund, Shelter Enhancement Fund, Northern Pathways to Housing).
- MACA – Sports Funding Programs (Recreational and Sport Contribution Program, Regional Youth Sport Events, After School Physical Activity Program, etc.), Youth Support Programs (Youth Contributions, Youth Centres Initiative Program, NWT Youth Corps Program, etc.), and NWT Outstanding Volunteer awards.
- ECE – Income Assistance program provides financial assistance to NWT residents to help them meet their basic and enhanced needs. Benefits are aligned with the Northern Basket Measure and ECE has developed a performance measurement plan to evaluate the effectiveness of the program. The program also provides assistance with shelter (accommodations) and utilities, based on actual amounts, and additional allowances for persons with permanent disabilities and seniors (e.g., Senior Home Heating Subsidy).
- Justice – Assistance to crime victims (Victim Services, Victim Notification Program, Victim of Crime Emergency fund, etc.), Ministerial Policing Policies, First Nations and Inuit Policing Program[10].
- HSS – Health promotion (Healthy Choices Fund, online information and resource catalogues, surge responses to key public health priorities, etc.), mental health and addictions recovery, online resources addressing addiction recovery and community mental health supports and the 811 Nurse Advice Line which provides 24/7 nurse advice, mental health and wellness supports, and tobacco cessation supports for residents of the NWT. These programs and initiatives are likely to support the mitigation of adverse changes in residents mental and physical health as part of an incoming highway project. A new standard of practice for Child and Family Services

[10] Agreement with Canada and the DOJ to contract more RCMP to provide policing services that reflect the needs and values of - First Nation and Inuit communities.

was implemented in 2021, where extended family can enter in a Voluntary Support Agreement to receive the financial supports without requiring children to come into care. This aligns with the principles of keeping children with family, community, and culture. As well, in response to the overrepresentation of Indigenous children and youth in Child and Family Services, the Family Preservation Program was expanded across the NWT between 2019 and 2021, and expanded support for youth in 2022-2023.

There are other examples of programming that is preventative more so than mitigative. These are designed to help communities take advantage of potential benefits of the project. These include programs such as:

- The Department of Industry, Tourism and Investment:
    - Programs for Entrepreneurs and business owners under the Support for Entrepreneurs and Economic Development (SEED) Policy (https://www.iti.gov.nt.ca/en/services/sector-support-seed).
    - Tourism Programs (including the Tourism Business Mentorship Program, Youth Mentorship for Tourism Program, Tourism Training Fund etc.).
- The Department of Education, Culture and Employment
    - Small Communities Employment Program is a GNWT funded program that supports small communities and regional centres in developing regional employment and training opportunities. Regional ECE Service Centres engage with communities to provide information, tools and supports towards accessing Small Community Employment Support (SCES) program funding and develop multi-year community labour market development plans.

Community Wellness

From a community health and well-being perspective, as part of the Northwest Territories Northern Wellness Agreement (NWA), communities and the GNWT-HSS work together to develop Community Wellness Plans annually based on current needs and future considerations. These Community Wellness Plans include Community Wellness Initiatives (CWI) which are then funded by the GNWT. The GNWT and communities consider incoming and completed projects, along with changes in monitored indicators when building initiatives and allocating funding. This allows CWIs to act as adaptive management and mitigate for project issues. Two-hundred and twenty-four programs and initiatives in communities were funded in the 2022-23. While Tłı̨chǫ communities are not covered by the NWA, Norman Wells, Tulita, Wrigley and other communities which may be impacted by the MVH will be covered.

Topic: 4-Socio-economic: Use of Parameters (DAR Section 9.3)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board):

"Several of the parameters in Table 9.3 are not measurable due to insufficient data and so cannot be carried through the analysis. For example, the parameters used to measure social pressures (and the significant effect that is described) are specific but community-level data is lacking. This insufficiency is noted by the developer in several sections of the assessment. Some parameters are not specifically evaluated in the effects discussions. The assessment results and conclusions are at a higher level than is implied by the identified parameters.

In responding to this IR, the Review Board requires analysis from Health and Social Services (HSS) and any other relevant expert departments. Please make it clear what information was provided by each department and how that information was used in the developer's response."

Request from the Review Board:

"Please review the parameters and describe which are measurable and can be analyzed during the assessment and monitored into the future to validate the assessment. For those that are not measurable, please describe how a qualitative approach could be used."

Response from the Government of the Northwest Territories:

Identifying and reporting on community-level data related to human health and community wellness is challenging, especially in northern and remote regions (Fellows et al., 2022; Jones & Bradshaw, 2015), for projects involving marginalized populations (MacKellar et al., 2023) and those focused on mitigating Indigenous health and wellbeing impacts (Jones & Bradshaw, 2015; Salerno et al., 2021). The small population of the Northwest Territories (NWT) exacerbates these challenges as, for example, crime reporting and trends may lack the same level of certainty that larger sample sizes provide. This limited population also heightens privacy concerns, necessitating careful handling and distribution of data to ensure confidentiality.

Human health and community wellness measures are often subjective and driven by complex experiences that cannot be captured by simple metrics (Jones & Bradshaw, 2015; MacKellar et al., 2023; Salerno et al., 2021). Consequently, best practices in socioeconomic impact assessment have shifted from predictive models to participatory processes (McGuigan, 2015) that prioritize the unique experiences and needs of communities and Indigenous people (Jones & Bradshaw, 2015; Salerno et al., 2021). Such best practices, along with the professional expertise and experience of GNWT's team, underpin the approach to the assessment of potential socio-economic effects of the Project.

Quantitative measures remain crucial for establishing baselines and assessing certain aspects of human health and community wellness (Fellows et al., 2022; Jones & Bradshaw, 2015; MacKellar et al., 2023; Salerno et al., 2021). The Department of Health and Social Services (HSS) has confirmed there are existing datasets on the following parameters, but many have limitations on their public release or sharing of community-level data or how it may be used. Parameter selection and availability will be discussed with all parties during the development of the Social Monitoring Plan and the Well-Being Adaptive Management Plan, taking into account the unique context of the NWT and the critical importance of data handling.

- Communicable diseases
- Mental health status
- Physical health status
- Teen pregnancies
- Certain crimes involving drugs and alcohol
- Collisions and victims involving alcohol
- Violent crimes
- Property crime
- Reported collisions, injuries, and fatalities by year
- Community/family social ties
- Food security
- Social determinants of health

- JK-12 education data
- Capacity and demand for educational/training institutions and facilities
- Employment/unemployment rates

The specifics of how indicators could be used in monitoring or reporting would require discussions with the Social Monitoring and Adaptive Management Sub-Working Group to ensure that data is being used and interpreted appropriately with regard to monitoring potential effects of the Project. If additional datasets become available, they will be shared with the Social Monitoring and Adaptive Management Sub-Working Group to inform the development and implementation of monitoring for the Project.

The GNWT recognizes the sensitivities and challenges of collecting health data, justice data, educational data, and data related to Indigenous communities. The GNWT must abide by the guidance of the NWT *Access to Information and Protection of Privacy Act* in determining how information is shared. As such, the GNWT takes a collaborative approach to the sharing and collection of data where possible. For example, to address privacy considerations and data availability related to monitoring these parameters, the GNWT is open to exploring the development of data sharing agreements with communities. HSS has indicated that this approach has been used with communities in the NWT for other projects or initiatives. This approach is also aligned with the GNWT's commitment to implementing the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), which reaffirms the rights of Indigenous Peoples to access and control data about their Peoples, territories, lifeways, and resources. Qualitative measures, which capture parameters not easily quantified, may involve various approaches. Generally, the GNWT's approach to incorporating qualitative measures is and will remain rooted in socio-economic assessment best practices, employing participatory, engagement-led methods that include a diverse range of stakeholders and historically underrepresented groups (e.g., women) (Manning et al., 2018). This approach ensures that methods align with the unique values and priorities of these groups. To maintain effective monitoring in the future, the GNWT is committed to an adaptive management approach that aligns with best practices and supports communities addressing the impacts that matter to them most. Importantly, any qualitative methods for monitoring Project effects on human health and community wellness will be guided by the needs and direction provided through the Social Monitoring and Adaptive Management Sub-Working Group.

The response to this Information Request has been prepared in accordance with the Government of the Northwest Territories' Whole of Government Approach to the Mackenzie Valley Highway Environmental Assessment. Subject matter expertise from all relevant line departments has been considered in the drafting, review, and approval of this response. The GNWT is confident that all line departments are contributing to efforts to minimize negative social, cultural, and environmental impacts, while maximizing benefits for NWT residents from this project.

The following departments have been specifically involved in the drafting, review and approval of this response:

- Department of Infrastructure
- Department of Health and Social Services
- Department of Justice
- Department of Education, Culture and Employment

References

Fellows, K. G., Munzur, A., Winter, J. (2022). A socio-economic review of the impacts of Northwest Territories' Inuvik to Tuktoyaktuk Highway 10. *Canadian Journal of Regional Science 45*(3), 137-149. https://doi.org/10.7202/1094686ar

Jones, J. & Bradshaw, B. (2015). Addressing historical impacts through impact and benefit agreements and health impact assessment: Why it matters for Indigenous well-being. Northern Review, 41, 81–109. https://doi.org/10.22584/nr41.2015.004.

Manning, S. et al. (2018). *Strengthening Impact Assessments for Indigenous Women.* Prepared on behalf of the Canadian Research Institute for the Advancement of Women for the Canadian Environmental Assessment Agency. https://www.criaw-icref.ca/wp-content/uploads/2021/04/Strengthening-Impact-Assessments-for-Indigenous-Women.pdf

MacKellar, A., Klenk, K., B.C.S, B. B., Grant, S., Aylesworth, A., Mines, S., Ellingwood, H.N., & Westwood, A.R. (2023). *Queers, closets, and man camps: Setting a foundation to understand the impacts of major infrastructure and natural resource extraction projects on marginalized communities.* Prepared for the Impact Assessment Agency of Canada. Westwood Lab, Dalhousie University, Halifax.

McGuigan, E. K. (2015). *Social impact assessment in rural and small-town British Columbia (Doctoral Dissertation)*. University of British Columbia. Retrieved from https://open.library.ubc.ca/collections/ubctheses/24/items/1.0166191

Salerno T, Tam, J, Page J, Gosling. S, & Firelight Research Inc. (2021). *Indigenous mental wellness and major project development guidance for impact assessment professionals and indigenous communities*. Prepared for the Impact Assessment Agency of Canada. https://www.canada.ca/content/dam/iaac-acei/documents/research/indigenous-mental-wellness-and-ia-en.pdf

United Nations. (2007). *United Nations Declaration on the Rights of Indigenous Peoples*. https://www.un.org/development/desa/indigenouspeoples/wp-content/uploads/sites/19/2018/11/UNDRIP_E_web.pdf

Topic: 5-Socio-economic: Methods – definitions (DAR Section 9.4)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board):

"The definitions of direct, indirect, and induced effects in 9.4 do not align with the Review Board Socio-economic Impact Assessment Guidelines (see pg.31)."

Request from the Review Board:

"Please clarify and, if necessary, revise the definitions provided and confirm that potential socio-economic effects have been identified and characterized in a way that aligns with the Guidelines."

Response from the Government of the Northwest Territories:

The Review Board's Socio-economic Impact Assessment Guidelines were published in 2007, and the practice of socio-economic impact assessment has continued to evolve in that time. The GNWT's definitions of direct, indirect and induced potential socio-economic effects provided in the Developer's Assessment Report (DAR) align with these definitions, and also incorporate a broader interpretation of effects to enable a more holistic assessment. The definitions used in the DAR align with the call for "continuous learning and improvement, fostering an environment of innovation and adaptation" (p.8) in the Review Board's Evolving Environmental Impact Assessments in the Mackenzie Valley and Beyond (2020) perspective paper, reflecting more recent literature on best practices in social impact assessment (Golder, 2019).

The GNWT's and the Guidelines' definitions of **direct effects/impacts**[1] align in the sense that direct effects occur as a direct consequence of a project. The Guidelines define these impacts as the "direct consequences of a proposed development location, construction, or operation," which aligns with the GNWT's definition that a direct effect "occurs at the same time and place and exhibits no intermediate effects." Furthermore, the Guidelines' focus on immediate socio-economic changes, such as employment opportunities or income levels, is consistent with the GNWT's emphasis on the absence of intermediary steps in the effects pathway(s).

The GNWT and the Guidelines' definitions of **indirect effects/impacts** agree that indirect indicates a separation in time, space, or through intermediate steps. The Guidelines describe indirect impacts as "secondary consequences of direct impacts," such as changes in consumption patterns or business opportunities. This aligns with the GNWT's definition of indirect effects as interactions that "occur at a later time and space with intermediary steps".

The Guidelines do not explicitly define **induced effects**. The GNWT included a definition for this term, which is an effect that is "partly attributable" to the project, in order to provide more information on those economic changes that result in the production of goods and services and jobs that are associated with direct and indirect requirements and expenditures. Induced effects result from the direct and indirect employees of the directly and indirectly affected businesses purchasing goods and services. In the DAR, induced effects are only described in the assessment of potential effects on the Employment and Economy Valued Component (see Section 9.7). This includes an assessment of induced employment, wages and salaries, benefits, Gross Domestic Product (GDP) and government revenues.

Overall, the GNWT's definitions of effects/impacts align with those provided in the Guidelines. Therefore, the potential socio-economic effects have been identified and characterized in a way that aligns with the Guidelines.

References

Golder Associates Ltd. (2019). *Good practice in social impact assessment*. Prepared for the Canadian Environmental Assessment Agency. https://www.canada.ca/content/dam/iaac-acei/documents/research/Good-Practices-in-Social-Impact-Assessment-Golder-March-2019.pdf

[1] The Guidelines use the term "impacts." The Developer's Assessment Report for the Project uses the term "effects."

Topic: MVEIRB IR 6-Socio-economic: Spatial boundaries need clarifying (DAR Sections 9.2.5.1, 9.4)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board): "The Local Assessment Area and Regional Assessment Area for socio-economic effects are not well-defined. Section 9.2.5.1 defines the Local Assessment Area as communities that will be directly connected by the project and are therefore most likely to experience direct, indirect, and induced effects. The Regional Assessment Area is defined as communities in the region that may also experience direct, indirect, or induced effects but which are outside the Local Assessment Area.

Typically, a Local Assessment Area includes the area where direct and indirect effects are expected, which should include the communities in the Local Assessment Area and Regional Assessment Area for socio-economic effects, as theoretically any of these could supply labour or goods and services for project construction. The Regional Assessment Area, as typically defined for socio-economic topics, includes the Local Assessment Area, and provides regional context for the assessment of potential effects and for the cumulative effects assessment. However, in the DAR, the Local Assessment Area and Regional Assessment Area for the Project are mutually exclusive. It is also not clear why the study areas are the same for all socio-economic valued components.

In responding to this IR, the Review Board requires analysis from HSS and any other relevant expert departments. Please make it clear what information was provided by each department and how that information was used in the developer's response."

Request from the Review Board:

"A. Please clarify study areas (Local Assessment Area and Regional Assessment Area) for all socio-economic valued components and provide rationales for the selection.

B. Please clarify the study areas used for the assessment of regional and cumulative effects for all socio-economic valued components."

Response from the Government of the Northwest Territories:

The GNWT's responses to requests A and B have been combined. The definitions of the LAA and RAA are provided in Section 9.2.5.1 of the DAR, and are the same for all of the socio-economic valued components (VCs) and apply to the assessment of both residual and cumulative effects:

Project Development Area (PDA): The area of direct Project disturbance within which physical works and activities will occur (footprint). This includes a new two-lane gravel highway, 60 metres (m) wide highway right-of-way (ROW), laydown and staging areas, maintenance yards, construction camps, and quarry/borrow sources with access roads on a 30 m ROW.

Local Assessment Area (LAA): The LAA is established to assess the potential direct, indirect and

induced effects of the Project on the socio-economic environment for the communities to be directly connected by the Project. The LAA for socio-economic VCs consists of the communities of Wrigley, Tulita and Norman Wells.

Regional Assessment Area (RAA): The RAA is established to assess the potential direct, indirect and induced effects of the Project on three communities in the Sahtu Region outside of the LAA and one community in the Dehcho. The RAA includes the communities of Fort Simpson, Fort Good Hope, Délįnę and Colville Lake.

As outlined in the Spatial Boundaries Section of the DAR (S 9.2.5.1), the potential effects of the Project are not necessarily bound by or limited to a localized spatial location. Some potential effects of the Project are instead more appropriately assessed at a community level. While some of the potential socio-economic effects may occur at spatial locations outside the PDA/LAA/RAA communities (e.g. some of those identified in the Non-Traditional Land and Resource; see Section 9.9), it is community members (who generally reside within the LAA and RAA communities) who will experience the effects. The LAA and RAA have been defined as mutually exclusive assessment areas, allowing for a more appropriate assessment of the variation in types, direction, and magnitude of potential Project effects – including residual and cumulative effects – on communities. As outlined in Section 9.4 of the DAR, potential effects on socio-economic VCs – in terms of type, direction, and magnitude – is linked to the proximity of a community to the Project construction sites and the Project itself. Communities within the LAA are comprised of those located along the proposed route and are more likely to experience direct, indirect, and induced effects of the Project during both the construction and operational phases. While there may be some differences between communities in the LAA depending on whether or not they become connected to all-season road access for the first time (e.g., Norman Wells and Tulita compared to Wrigley), generally the potential effects of the Project would be more pronounced than in the RAA due to their proximity to construction sites/activities and the Project. Conversely, the four RAA communities are less likely than those in the LAA to experience direct effects of the Project due to their farther distance from the construction sites /activities and the Project. Additionally, none of the RAA communities will experience a change in all-season road access as a result of the Project:

- Fort Good Hope, Délįnę and Colville Lake currently do not have all-season road access. This will not change as a result of the Project as they are not located on the proposed route of the Project.
- Fort Simpson already has all-season road access from the south via HWY 1. This will not change or be expanded as Fort Simpson is not located on the proposed route of the Project.

This approach is consistent with the Review Board's Socio-Economic Impact Assessment Guidelines (2007) and best practices in the field of socio-economic impact assessment, which considers community feedback and data collection as an important methodological component for the assessment of a proposed project's effects on socio-economic valued components.

The response to this Information Request has been prepared in accordance with the Government of the Northwest Territories' Whole of Government Approach to the Mackenzie Valley Highway Environmental Assessment. Subject matter expertise from all relevant line departments has been considered in the drafting, review, and approval of this response. The GNWT is confident that all line departments are contributing to efforts to minimize negative social, cultural, and environmental impacts, while

maximizing benefits for NWT residents from this project.

The following departments have been specifically involved in the drafting, review and approval of this response:

- Department of Environment and Climate Change
- Department of Health and Social Services
- Department of Industry, Tourism and Investment

Topic: MVEIRB IR 7-Socio-economic: Overall Determination of Significance for Human Health and Community Wellness (DAR sections 9.5.6.4, 9.5.9.4, 9.5.12)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board): "The significant effects described for the Human Health valued component are associated with public safety and social pressures. It is clear from the engagement results, and from similar projects completed in the Northwest Territories, that the presence of a road construction workforce could negatively affect public safety in small, isolated communities, particularly for small Indigenous communities. It is also clear that the effect would likely be focused on the safety of women, girls and 2SLGBTQQIA+ people in these communities.

The developer has identified these as significant effects. They are also identified as a key line of inquiry in the Terms of Reference and these findings are informed by community concerns, evidence from other similar projects (e.g., Tłı̨chǫ Highway) and the developer's own analysis. However, the conclusion in the summaries and in Chapter 9 is that, overall, the project's adverse effects on human health and community wellness are not significant. Since these effects are clearly of high importance to the communities and are identified as significant after mitigation is applied, the evidence and rationale for this conclusion appear to be missing.

In responding to this IR, the Review Board requires analysis from HSS and any other relevant expert departments. Please make it clear what information was provided by each department and how that information was used in the developer's response."

Request from the Review Board:
"Please resolve the discrepancy between the findings of significant effects to social pressures and public safety, and the overall conclusion that the adverse effects on the human health valued component are not significant."

Response from the Government of the Northwest Territories:

The Human Health and Community Wellness Valued Component (VC) was assessed based on potential effects of the Project on the physical, mental and social health of residents and the support systems and programs available to address human health and community wellness in communities potentially affected by the Project. A total of nine potential effects were assessed for the Human Health and Community Wellness VC:

- Change in population composition and migration (in/out of communities)
- Change in population health
- Change in community/family and social ties
- Change in food security
- Change in social pressures
- Change in nuisance (air quality, noise)

- Change in drinking and recreational water quality
- Change in public safety
- Change in social determinants of health (SDOH)

The overall determination of effects on Human Health and Wellbeing VC was determined based on the residual effects determinations for all nine potential effects outlined above. As such, the adverse effects related to social pressures and public safety were not considered in isolation of other potential effects, effect pathways, and indicators linked to Human Health and Community Wellness.

The determination that overall effects on Human Health and Community Wellness are not significant is supported by the full scope of assessment of potential effects. Across the nine potential effects identified for Human Health and Community Wellness:

- Two were assessed as having neutral or positive effects;
- Five were assessed as adverse effects that are not significant; and
- Two were assessed as adverse effects that are significant.

In summary, while the potential effects on public safety and social pressures reflect important contributions to the overall effects on the Human Health and Community Wellness VC, they are not the only factors considered in assessing overall socio-economic effects of the Project. The overall conclusion of the assessment that potential Project effects on the VC are not significant is supported by the majority of potential effects (7 out of 9) being either positive, neutral, or adverse but lacking significance. In turn, drawing a conclusion that the overall effects are significant based solely on adverse effects for public safety and social pressure would not be appropriate. This is summarized in Table 9.30 in the Developer's Assessment Report (DAR). An adapted version of Table 9.30 identifying residual effects assessment for Human Health and Community Wellness is included below.

Socio-Economic VC	Effect	Significance Determination
Human Health and Community Wellness	Population Composition and Migration	Not Applicable (Effects characterized as only neutral or positive)
	Population Health	Includes positive effects and adverse effects that are not significant
	Community/Family and Social Ties	Includes positive effects and adverse effects that are not significant
	Food Security	Includes adverse effects that are not significant
	Social Pressures	Adverse effects that are significant
	Nuisance	Includes adverse effects that are not significant
	Drinking and Recreational Water Quality	Includes neutral effects and adverse effects that are not significant
	Public Safety	Adverse effects that are significant
	Social Determinants of Health	Not Applicable (Effects characterized as only neutral or positive)

Although the assessment finds that the overall potential effects of the Project on Human Health and

Community Wellness are not significant, the significant adverse effects related to social pressures and public safety are the focus of several proposed mitigations for the Project. In response to the concerns shared by community members related to existing conditions in communities, and lessons learned from similar projects (e.g. Tłı̨chǫ Highway), a Community Readiness Strategy, which includes a Well-Being Adaptive Management Plan and a Social Monitoring Plan will be developed and implemented to address the adverse effects of the Project and include focus areas related to social pressures and public safety. A similar adaptive management approach has been employed for the Tłı̨chǫ Highway. Strong collaboration and communication amongst the GNWT, Tłı̨chǫ Government, and contractor established via the formation of the Tlicho All-Season Road Working Group has been an important element for monitoring and responding to potential social pressure and public safety effects anticipated during both the construction and post-construction period for the Tłı̨chǫ Highway.

The Well-Being Adaptive Management Plan will be collaboratively developed by the GNWT and communities to address the potential significant adverse effects related to social pressures and public safety including risks to community safety for at-risk segments of the population and substance abuse. A full description of focus areas to be included in the Well-Being Adaptive Management Plan is provided in Section 9.16.2.3.1 of the DAR. In tandem with this, the Social Monitoring Plan will monitor socio-economic and well-being indicators to track the implementation of the activities identified in the Well-Being Adaptive Management Plan to ensure that mitigations are responsive to adverse changes in socio-economic conditions as a result of the Project.

The response to this Information Request has been prepared in accordance with the Government of the Northwest Territories' Whole of Government Approach to the Mackenzie Valley Highway Environmental Assessment. Subject matter expertise from all relevant line departments has been considered in the drafting, review, and approval of this response. The GNWT is confident that all line departments are contributing to efforts to minimize negative social, cultural, and environmental impacts, while maximizing benefits for NWT residents from this project.

The following departments have been specifically involved in the drafting, review and approval of this response:

- The Department of Education, Culture and Employment
- The Department of Health and Social Services
- The Department of Infrastructure
- The Department of Environment and Climate Change

MVEIRB-08

Topic: Socio-economic: Confirm workforce estimate information source (DAR section 9.7.2.1.1)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board):
The developer's estimate that 50% of the construction workforce will come from local communities and from elsewhere in the Northwest Territories was taken from the developer's own 2022 draft Developer's Assessment Report. Referring to a draft Developer's Assessment Report is not a suitable source of information for the estimated construction workforce.

Acho Dene Koe First Nation asked GNWT to make firm commitments regarding Indigenous members' training, employment, and contracting (ADKFN, comment #6). The GNWT responded that this information would be provided in the Contractor Training and Employment Plan. While details will be provided in the plan, robust estimates at this stage will help clarify the employment benefits of the construction phase.

In responding to this IR, the Review Board requires analysis from any relevant expert departments such as Education, Culture and Employment (ECE), Industry, Tourism and Investment (ITI). Please make it clear what information was provided by each department and how that information was used in the developer's response.

Request from the Review Board:

A. Please provide a final current reference for the workforce estimate, including greater detail regarding the 50% Northwest Territories workforce estimate.

B. Please confirm the number of induced direct and indirect jobs (estimated at 14,000 in 2015; Appendix 1A).

Answers to these questions should consider GNWT's optimal schedule of 3-4 years as well as the conceptual timeline of 20 years of construction presented in the DAR.

Response from the Government of the Northwest Territories:

A. – The assessment carried out in the Developer's Assessment Report (DAR)was based on currently available figures at the time of drafting. The requested analysis of percentage of northern workforce is not available for a 3–4-year construction schedule as this schedule is an alternative method of construction. The GNWT is submitting a supplemental filing (Supplement to the Developer's Assessment Report Chapter 7: Assessment of Alternatives) to be posted on the public registry, which will provide a qualitative assessment of the accelerated construction timeline.

The GNWT remains committed to maximizing local participation in the project. As stated in section 5.4.14.2 in the DAR, the 50% northern workforce is assumed based on a conceptual construction schedule.

B- As a correction, the reference to 14, 000 induced direct and indirect jobs created as result of this Project stem from Appendix 5 of Appendix 1A which is the Mackenzie Valley All-Weather Road Economic Analysis (2009). This document is an Economic analysis of a road from Wrigley to Tuktoyaktuk. From the Final Nichols Report (2017), that was submitted as response to ORS-3, the number of Direct jobs for a 10 year design and construction project is estimated at 1,970 for the Northwest Territories. Indirect jobs are estimated at 2,195 jobs and 2,470 induced jobs are estimated (all job estimates are for full time equivalent).

The assessment carried out in the DAR was based on currently available figures at the time of drafting. A revised cost estimate and updated business case for the Mackenzie Valley Highway Project is under development and anticipated to be completed in early 2025.

Upon receipt of the revised cost estimate and business case, INF will work with our consultants to prepare a public facing document for submission to the Board as some of the financial components may be sensitive and could negatively impact future procurement activities.

The response to this Information Request has been prepared in accordance with the Government of the Northwest Territories' Whole of Government Approach to the Mackenzie Valley Highway Environmental Assessment. Subject matter expertise from all relevant line departments has been considered in the drafting, review, and approval of this response. The GNWT is confident that all line departments are contributing to efforts to minimize negative social, cultural, and environmental impacts, while maximizing benefits for NWT residents from this project.

The following departments have been specifically involved in the drafting, review and approval of this response: Infrastructure, Environment and Climate Change, Health and Social Services, Justice, Industry, Tourism and Investment, Education, Culture and Employment

Topic: MVEIRB IR 9-Socio-economic: Types of employment (DAR section 9.7)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board): "The Terms of Reference require a description of "Employment opportunities for every year of construction and operation, with reference to length of employment, form of employment, skill category". Chapter 9 mentions that this information will be provided in the Contractor Training and Employment Plan. While details will be provided in the plan in the future, robust estimates at this stage will help clarify the employment benefits of the construction phase. "

Request from the Review Board: "Please provide the employment opportunities for every year of construction and operation, with reference to length of employment, form of employment, skill category.

Please answer this question for both the optimal schedule of 3-4 years as well as the conceptual timeline of 20 years of construction presented in the DAR."

Response from the Government of the Northwest Territories:

Construction planning has not advanced to the stage where firm employment requirements or schedules are available, and so additional information beyond what is currently outlined in the Developer's Assessment Report (DAR) is unavailable. However, a general timeline and total annual workforce requirement has been determined for the purpose of assessment. As outlined in Sections 5.4.14 and 9.7.2.1.1 of the DAR, the estimated number of direct jobs expected to be created by the construction of the Project is approximately 200-330 full-time employees (FTEs) for each year of construction activity. This includes approximately:

- 160-280 construction personnel (40-70 persons plus cross-shift at two work camps);
- 8-10 supervisors (4-5 supervisory personnel per cross-shift)
- 6 environmental / wildlife monitors (three per cross-shift)
- 24-30 camp services personnel (cooks, first aid, cleaning, and others per camp plus cross-shift)
- Construction administration and management personnel

It is expected that 50% of the estimated 200-330 person construction workforce will come from the local Sahtu and Dehcho communities and from elsewhere in the NWT, with the remainder of the workforce coming from outside the NWT.

In addition to direct construction employment, anticipated indirect jobs related to supply and resupply, waste haul, equipment and material supply, and personnel transport are also expected. The estimated number of indirect jobs is between 84 – 126 FTEs per year of construction, and estimated number of induced jobs is between 40.5 to 60 FTEs per year of construction.

The 'optimal timeline' of 3-4 years referenced in the response to MVEIRB IR#1 does not replace the GNWT's proposed project and project construction schedule of 10 years of construction over a 20-year period, that is described in the Developer's Assessment Report (DAR). Rather, the GNWT considers the 3–4-year construction timeline an alternative method to construction.

The GNWT is submitting a supplemental filing (Supplement to the Developer's Assessment Report Chapter 7: Assessment of Alternatives) to be posted on the public registry, which will provide a qualitative assessment of the accelerated construction timeline. Section 2.2 of the Supplemental Filing provides the following estimates for the workforce associated with the accelerated construction alternative:

- 400-700 contractor's construction personnel (40-70 persons per crew at four work camps per cross-shift)
- 50 contractor's camp services personnel (includes 4-5 per camp per cross-shift)
- 10 environmental/wildlife monitors (5 per cross-shift)
- 12-16 contractor's supervisors (includes 6-8 supervisory personnel per cross-shift)

The comparative evaluation contained in the Supplemental Filing indicates that under the accelerated construction schedule, it is anticipated that there will continue to be potential positive effects on employment, but the level of positive effect may be reduced as a result of the shorter construction period. This will lead to less time for people to prepare for both construction and operations related jobs for the Project. Additional details are available in Section 3.2.7.15 of the Supplemental Filing.

Topic: MVEIRB IR 10-Socio-economic: Effects on the cost of living and consumer prices (DAR section 9.7.5)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board): "The Terms of Reference refer to 'Cost of living and consumer prices for different types of goods'. The in the DAR section 9.7.5, it is stated that "effect of the Project on the cost of living and consumer prices is expected to be positive" (p.9-164). The Review Board would like more details on the effects of the project on cost of living and consumer prices for different types of goods.

In responding to this IR, the Review Board requires analysis from any relevant expert departments. Please make it clear what information was provided by each department and how that information was used in the developer's response."

Request from the Review Board:
"Please provide the cost of living and consumer prices for different types of goods."

Response from the Government of the Northwest Territories:

The NWT Bureau of Statistics has indicated that there is limited community-level data on cost of living and prices of consumer goods. Community-level price data is not collected for many types of goods such as clothing, transportation, household furnishings and equipment. Prices for electricity are available from the NWT Power Corporation, while fuel prices are available for the Local Assessment Area (LAA) and Regional Assessment Area (RAA) communities serviced by the GNWT Petroleum Products Program.

A Consumer Price Index (CPI) and food price indices are provided by NWT Bureau of Statistics for communities in the NWT, but these measures provide a value as compared to values in Yellowknife. While this provides some ability to compare communities to each other in relation to Yellowknife, this type of measure is limited in its use to track price information in communities over time.

Notwithstanding the above, data on food price indices were used in the assessment of potential effects on food security provided in Section 9.5.5.1.2 of the Developer's Assessment Report (DAR). This section includes an assessment of food price indices in communities within the LAA as well as an assessment of food price indices in other communities that have been connected by all-season roads (e.g. Inuvik-Tuktoyaktuk Highway) to assess whether and how food prices may be affected as a result of being connected to an all-season road.

The GNWT has carried out engagement on the proposed mitigations and remains open to working with communities as the project advances to refine them, if needed. The proposed mitigations may complement the GNWT's existing programs and services to prepare communities to participate in economic benefits associated with the project. As required, adaptive management responses will be developed collaboratively with communities. As part of the development of the Social Monitoring Plan for the Project, GNWT will work collaboratively with communities to identify and consider options to collect data and monitor changes to cost of living and consumer prices as a result of the Project. This will be determined in collaboration with communities and with the support of the NWT Bureau of Statistics.

The response to this Information Request has been prepared in accordance with the Government of the Northwest Territories' Whole of Government Approach to the Mackenzie Valley Highway Environmental Assessment. Subject matter expertise from all relevant line departments has been considered in the

drafting, review, and approval of this response. The GNWT is confident that all line departments are contributing to efforts to minimize negative social, cultural, and environmental impacts, while maximizing benefits for NWT residents from this project.

The following department has been specifically involved in the drafting, review and approval of this response:

- NWT Bureau of Statistics
- The Department of Environment and Climate Change

MVEIRB-11

Topic: Socio-economic: Project's contribution to GDP (DAR section 9.7.3)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board):
The Terms of Reference refers to the proposed project's contribution to the GDP, provided separately for direct, indirect, and induced economic activities for the regional and (to the extent possible) territorial and national economies. The developer provided this information in part (territorial and national), but it was based on a 2011 study and does not provide the details requested.

Request from the Review Board:

Please provide the project's contribution to the GDP, provided separately for direct, indirect, and induced economic activities for the regional and (to the extent possible) territorial and national economies.

Please answer the question for both construction schedules: GNWT's optimal schedule of 3-4 years and GNWT's conceptual schedule of 20 years.

Response from the Government of the Northwest Territories:

To answer this question with the most up to date economic information for the project's contribution to gross domestic product (GDP) an updated cost estimate is required. A revised cost estimate and updated business case for the MVH Project is under development and anticipated to be completed in early 2025.

The 'optimal schedule' of 3-4 years referenced in the response to overarching MVEIRB IR#1 does not replace the GNWT's proposed project and project construction schedule of '10 years of construction over a 20-year period' that is described in the Developer's Assessment Report. Rather, the GNWT considers the 3–4-year construction timeline an alternative method to construction. The GNWT is submitting a supplemental filing (Supplement to the Developer's Assessment Report Chapter 7: Assessment of Alternatives) to be posted on the public registry, which will provide a qualitative assessment of the accelerated construction timeline.

MVEIRB-12

Topic: Socio-economic: Increasing access to education and training (DAR Section 9.6 - Education, Training and Skills - p.9-126)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board): "The DAR states that the project will increase interest in education and skills training among local residents, especially during the construction phase (p.9-127). However, residents expressed concerns regarding the GNWT's ability to meet demand for education and training (p.9-129). Residents suggest building a satellite campus of Aurora College to provide improve access to training (p.9-134), which "the GNWT is not committing to" (p.9-196).

In response to residents' concerns and request, the DAR states that a Contractor Training and Employment Plan will be developed, which will include measures to address training and employment needs (p.9-128). However, the DAR also highlights difficulties to meet demand for training, even with future mitigation measures in place (p. 9-140).

As the Review Board does not have the Contractor Training and Employment Plan, it requires clarification on how education and training needs will be addressed in this Plan.

In responding to this IR, the Review Board requires analysis from ECE and any other relevant expert departments. Please make it clear what information was provided by each department and how that information was used in the developer's response."

Request from the Review Board:

"A. Please describe how the GNWT will increase either GNWT or community capacity to educate and train residents; to meet the predicted demand for education and training of residents so they can work on the project. Please include any specific mitigation or approaches that will be in the Contractor Training and Employment Plan.

B. If the developer proceeds with its optimal schedule (3-4 years), can the meet education need before construction?"

Response from the Government of the Northwest Territories:

Part A

The GNWT is using a Whole-of-Government approach on this project, with the Department of Infrastructure (INF) leading this work. The Department of Education, Culture and Employment (ECE) provides information and analysis regarding their mandate area, including: information on programs and services for the development of the Developers Assessment Report (DAR) and the analysis of Information Requests (IRs). ECE is not responsible for developing a Contractor Training and Employment Plan for the project. This is led by INF; ECE will provide support as needed and fulfill their role identified in the Community Readiness Strategy.

The delivery of education and training in the Northwest Territories involves collaboration between the territorial government, public and private education/training institutions, Indigenous governments, non-governmental organizations, communities and industry. ECE provides residents with access to quality programs, services, and supports in order to assist residents in making informed choices for themselves and their families, regarding education, training, careers, child development, language, culture and heritage. The department provides overarching strategic direction and distributes funding to ensure that residents are able to access and obtain education, training and upgrade skills. The department is also responsible for the legislation and regulations that govern the sector. The department is not involved in the direct delivery of education and training programs, but rather supports individuals' and employers' access to training and skills development through the provision of financial supports, development of strategic frameworks and action plans that support the sector, and collaboration with partners, other jurisdictions, and stakeholders.

ECE provides a range of labour market programs for individuals, employers, organizations and communities. This includes:

Programs for Individuals	
Skills Development Program	Provides support for eligible individuals to participate in training opportunities to upgrade skills and knowledge and/or develop essential employability skills.
Self-Employment Program	Provides support to eligible individuals with the opportunity to start a small business.
Programs for Employers	
Wage Subsidy Program	Provides support to an employer to hire and train NWT residents.
Employee Training Program	Assists employers to offset the cost of training for new employees.

Programs for Organizations	
Community Training Partnerships	Provides training/skills development opportunities to improve the subsequent employment prospects of the participants.
Job Creation Partnerships	Provides work experience opportunities to improve the subsequent employment prospects of the participants.
Strategic Workforce Initiatives	Supports community partners in undertaking labour market activities that promote labour force development, workforce adjustments and effective human resources planning.
Employment Assistance Services	Enables Regional ECE Service Centres to enter into arrangements with external service providers to extend the delivery of services throughout their region.
Programs for Communities	
Small Community Employment Support (SCES) Program	Provides funding to small NWT communities to support employment and training opportunities for their residents. SCES provides funding directly to the community through contribution agreements. The program has supported 3,600 jobs since 2018. Under SCES, communities that had or were completing Community Labour Market Development Plans (CLMDPs) are provided the option of entering into multi-year contribution agreements for SCES funding (up to three years) with the GNWT, as a means of encouraging them to develop CLMDPs and to support enhanced labour market planning in communities.

As noted in the NWT Small Communities Employment Strategy, ECE can partner with and provide financial support to communities to support the development of CLMDPs. This means that Designated Community Authorities can plan for and incorporate MVH employment and training needs work into their CLMDPs and once completed, Designated Community Authorities can access multi-year funding under the Small Community Employment Support (SCES) Program to assist in implementing them.

Information on the above is available at https://www.ece.gov.nt.ca/en/services/career-employment-and-training-services/labour-market-program-funding and https://www.ece.gov.nt.ca/sites/ece/files/resources/lds_scesp_fact_sheet_jun18.pdf.

As discussed in Section 9.16 of the Developer's Assessment Report (DAR), a Community Readiness Strategy will be developed to mitigate the potential adverse socio-economic effects of the Project on the

Local Assessment Area (LAA) and Regional Assessment Area (RAA) communities and enhance the potential positive effects. The Community Readiness Strategy will leverage and augment existing programs and services available across the GNWT to address potential effects of the Project.

In implementing the Community Readiness Strategy, the GNWT will focus on addressing any existing issues with education and training capacity and needs for LAA and RAA impacted communities via the Training and Employment Sub-Working Group. This adaptive management approach focuses on leveraging and augmenting existing services and programs and is consistent with the approach taken by GNWT for similar projects. For example, an adaptive management approach was taken for the Tłı̨chǫ Highway which focused on implementing initiatives grounded in existing programming and approaches to respond to socio-economic conditions that were identified through collaborative monitoring activities with communities. The Tłı̨chǫ Highway project is distinct from the Mackenzie Valley Highway, but the goals are aligned. The GNWT will prioritize northern hiring and will include hiring and training targets in contracts. The GNWT will work closely with Indigenous Governments in the LAA and RAA via the Community Readiness Strategy Sub-Working Groups and in step with existing agreements and approaches in an effort to maximize opportunities associated with the construction of the Mackenzie Valley Highway.

As mentioned above, the GNWT regularly works closely with partners in the territory and with Canada to identify and address ongoing labour market needs. Federal labour market funding is essential in ensuring that the GNWT is able to meet the needs of the labour market and close skill gaps. GNWT-ECE works with the federal government and other provinces and territories. In NWT Regions, including the North Slave ECE Regional Service Centres, federal officials, representatives of Indigenous Governments and Organizations, local employers and stakeholders held regular Regional Training Partnership meetings to discuss and address ongoing and emerging labour market needs and priorities. If required, these regional training partnerships can also occur in the Sahtu and Dehcho centres. ECE labour market programs are delivered through Regional ECE Service Centres in Yellowknife, Hay River, Fort Smith, Fort Simpson, Norman Wells and Inuvik by five Regional Managers and 17 Career Development Officers (CDOs). Clients work with CDOs to identify their needs and work towards their goals. For individuals, this includes Career Action Planning, which can include essential skills development, assistance with gaining employment, skills upgrading to maintain or advance in employment, and/or becoming self-employed. Individuals can also access services such as support for resume writing and job searches, mock interviews and employment workshops through community organizations funded under labour market programs or directly with ECE.

As described in section 9.16.2.2 of the DAR, the GNWT has committed to establish a Training and Employment Sub-Working Group to develop and implement a Contractor Training and Employment Plan in collaboration with communities working with Aurora College and other education partners. The Contractor Training and Employment Plan is intended to enhance the anticipated potential positive effects of the Project on education and training and mitigate potential adverse effects, including capacity challenges arising from an increased demand for education and training.

The details of the Contractor Training and Employment Plan have yet to be developed, as the intention is

that the GNWT will work collaboratively with communities to develop the sub-working groups and plans that are part of the Community Readiness Strategy. However, the intended scope of the Contractor Training and Employment Plan includes (amongst other things) the following proposed elements that are intended to maximize the potential positive effects of the Project related to education, training and employment (specific ECE program and service notes have been added to provide additional details):

- Identifies employment opportunities (types, numbers, timing/schedule and employment hiring requirements) during construction and operations, informed by information from the GNWT about the project schedule and well in advance of the beginning of construction.
    - ECE can share some Labour Market Information (LMI), available here: https://www.ece.gov.nt.ca/en/services/labour-market-information/nwt-labour-market-present.
- Identifies availability of and gaps in skilled labour for construction employment opportunities in each of the communities including the creation of skill inventories and seeks to address these to support optimizing training and employment opportunities.
    - ECE can provide some general Labour Market Information during planning and throughout the project and the work of the ECE Regional Service Centres and CDOs will continue throughout.
- Identifies barriers to increasing uptake in education and training courses (e.g., restricted licences in Tulita) and develops potential solutions to implement.
    - ECE Regional Service Centres are positioned to engage with communities to discuss any barriers to accessing labour market programs and options to address them.
- Identifies education, skills and training programs and courses required to address lack of available skilled labour for construction and operations in each of the communities, including sharing information about Labour Market Programs that can support communities, employers and organizations.
- Identifies education and training programs and courses currently available, where (local CLC or campus) and how they are offered (in-person, remote, or blended), and new programs and courses required to meet local need (as well as whether or not additional staffing and space requirements are necessary)
- Identifies potential funding to support education and training prior to construction, during construction and operations
- Explores feasibility of building workshops in each community to support hands-on learning opportunities.
    - ECE labour market programs may be able to provide financial supports to organizations delivering or individuals attending labour market development or employment-related workshops, where program eligibility criteria are met.
- Ensure all communities are supported to prepare the workforce for employment opportunities through coverage of existing ECE programs and positions (e.g., Career Development Officers). ECE serves all communities in the NWT.

- Communities will be encouraged to develop community labour market plans to evaluate their needs in relation to the Project.
    - ECE can provide financial support toward the development of Community Labour Market Development Plans.

Part B

The 'optimal timeline' of 3-4 years referenced in the response to MVEIRB IR#1 does not replace the GNWT's proposed project and project construction schedule of 10 years of construction over a 20-year period, that is described in the Developer's Assessment Report (DAR). Rather, the GNWT considers the 3–4-year construction timeline an alternative method to construction.

The GNWT is submitting a supplemental filing (Supplement to the Developer's Assessment Report Chapter 7: Assessment of Alternatives) to be posted on the public registry, which will provide a qualitative assessment of the accelerated construction timeline.

The response to this Information Request has been prepared in accordance with the Government of the Northwest Territories' Whole of Government Approach to the Mackenzie Valley Highway Environmental Assessment. Subject matter expertise from all relevant line departments has been considered in the drafting, review, and approval of this response. The GNWT is confident that all line departments are contributing to efforts to minimize negative social, cultural, and environmental impacts, while maximizing benefits for NWT residents from this project.

The following departments have been specifically involved in the drafting, review and approval of this response: Education, Culture and Employment, Infrastructure, Environment and Climate Change, Justice, and Health and Social Services.

MVEIRB IR 13

Topic: Socio-economic: Opportunities for training and work (DAR Section 9.6 - Education, Training and Skills - p.9-126)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board): "The developer states in the DAR that a Well-being Adaptive Management Plan would be created under the proposed Community Readiness Strategy. For now, the Review Board does not have the details of the Well-being Adaptive Management Plan.

Indigenous women and other under-represented groups typically face more barriers to employment and are not able to benefit as much from development projects. The DAR does not adequately describe GNWT plans to support and encourage women and other under-represented groups to participate in training and work. These barriers need to be examined by the developer before the project construction begins to consider how they can be avoided or mitigated.

In responding to this IR, the Review Board requires analysis from ECE and any other relevant expert departments. Please make it clear what information was provided by each department and how that information was used in the developer's response."

Request from the Review Board:

"Please describe any strategies the developer intends to use to limit barriers or encourage participation of women and other under-represented groups in training, skills development, and job opportunities."

Response from the Government of the Northwest Territories:

Eliminating barriers to employment and supporting under-represented groups in their pursuit of economic prosperity is important to the GNWT and is the subject of several initiatives and programs. The GNWT has been working to address concerns regarding barriers to employment for Indigenous women and other vulnerable sectors in recent years. For example, the high cost and low availability of child care is often cited as a barrier to employment for women and families in the territory, including Indigenous women. The GNWT and the federal government have worked to address affordability and access to early learning and child care (ELCC) programs in the territory via the implementation of the Canada-Northwest Territories Canada-wide ELCC Agreement 2021 to 2026 and the Canada-Northwest Territories ELCC Agreement – 2021 to 2024, as well as the recent signing of a three-year action plan (2023-2026). This work is focused on improving and expanding licensed ELCC programming across the territory, including in communities in the Local Assessment Area (LAA) and Regional Assessment Area (RAA). Increasing the availability of child care and reducing the costs of childcare throughout the territory to an average of $10 a day will improve employment opportunities and reduce barriers. Another example that the GNWT can draw on internally to inform Project policies and practices around hiring and contract hiring is the work of the GNWT Advisory Committee on Diversity and Inclusion. This group provides advice on improving access to the public service for designated employment equity groups (including Indigenous employees and women) and has worked to remove and prevent barriers faced by these groups as a means to promote, support and increase diversity within the GNWT workforce.

The Department of Education, Culture and Employment (ECE) works via labour market agreements and programming to meet the needs of the labour market and close skill gaps. ECE's Skills 4 Success initiative, serves as the roadmap for ECE's labour market programs and services, and is based on the vision that "NWT residents have the skills, knowledge and attitudes for employment success."

- ECE delivers the Trades and Occupations Wage Subsidy Program (TOWSP), which provides financial support to employers to hire and train skilled apprentices and occupation trainees who are registered with the Apprenticeship, Trade and Occupation Certification Program. Under TOWSP, employers can receive a wage subsidy of $9.00 per hour. However, for female apprentices, a maximum of $16.00 per hour is available (to incentivize the hiring of females in the non-traditional trades and meet the labour demands in the trades).

- ECE Labour Market Programs provide financial assistance that can assist under-represented individuals and families in accessing training and employment opportunities. This includes financial support for tuition; living allowance and living away allowance; books; course materials; software and fees; tools, equipment and clothing; child care; and travel expenses.

- Where required and on a case-by-case basis, ECE Labour Market Programs can provide additional supports to assist persons with disabilities in accessing training and skills development. This can include supports for assistive devices to support individuals' participation in training.

As described in section 9.16.2.2 of the DAR, the GNWT has committed to establish a Training and Employment Sub-Working Group as a part of the Community Readiness Strategy to develop and implement a Contractor Training and Employment Plan in collaboration with communities working with Aurora College and other education partners. Throughout the environmental assessment the GNWT has met with Indigenous Governments and communities to discuss potential issues or concerns resulting from the Project, including barriers to employment. It is the intent of the GNWT to continue to meet and discuss these concerns with all parties and that this continues post-environment assessment via the Training and Employment Sub-Working Group. The Contractor Training and Employment Plan is intended to enhance the anticipated potential positive effects of the Project on education and training and mitigate potential adverse effects, including capacity challenges arising from an increased demand for education and training.

The GNWT has carried out engagement on the proposed mitigations and remains open to working with communities as the project advances to refine them, if needed. The proposed mitigations may complement the GNWT's existing programs and services to prepare communities to participate in economic benefits associated with the project. As required, adaptive management responses will be developed collaboratively with communities.

The adaptive management responses and approach for the Community Readiness Strategy and associated sub-working groups and plans will leverage and augment existing services and programs. Additionally, GNWT programs and services are continually evolving in response to the outcomes of evaluation, program reviews, and ongoing collaboration with communities that lead to improvement. This can support the ability of the working groups and GNWT to use an existing programs and services framework to quickly and effectively respond to existing conditions and potential effects.

The details of the Contractor Training and Employment Plan have yet to be developed, as the intention is that the GNWT will work collaboratively with communities to develop the sub-working groups and plans that are part of the Community Readiness Strategy. However, the scope of the Training and Employment Sub-Working Group includes (amongst other things) the following activities that are supportive of identifying and addressing barriers to education, training and employment:

- Identifies barriers to increasing uptake in education and training courses (e.g., restricted licences in Tulita) and develops potential solutions to implement.
- Identifies education, skills and training programs and courses required to address lack of available skilled labour for construction and operations in each of the communities, including sharing information about Labour Market Programs that can support communities, employers and organizations
    - ECE provides a range of labour market programs for individuals, employers, organizations and communities. Information on the above is available at https://www.ece.gov.nt.ca/en/services/career-employment-and-training-services/labour-market-program-funding.
- Identifies education and training programs and courses currently available, where (local CLC or campus) and how they are offered (in-person, remote, or blended), and new programs and

courses required to meet local need (as well as whether or not additional staffing and space requirements are necessary)

- Identifies potential funding to support education and training prior to construction, during construction and operations

The principles, programs and initiatives outlined above related to removing barriers and supporting participation in education, training and employment will be explored in collaboration with communities and be considered for inclusion into the Contractor Training and Employment Plan as well as other mitigations developed under the Community Readiness Strategy, including the Well-Being Adaptive Management Plan. Further, the GNWT will work through the Social Monitoring and Adaptive Management Sub-Working Group and Social Monitoring Plan to identify appropriate monitoring measures related to employment which could be used to identify additional opportunities to support vulnerable and under-represented groups.

The response to this Information Request has been prepared in accordance with the Government of the Northwest Territories' Whole of Government Approach to the Mackenzie Valley Highway Environmental Assessment. Subject matter expertise from all relevant line departments has been considered in the drafting, review, and approval of this response. The GNWT is confident that all line departments are contributing to efforts to minimize negative social, cultural, and environmental impacts, while maximizing benefits for NWT residents from this project.

The following departments have been specifically involved in the drafting, review and approval of this response:

- Department of Education, Culture and Employment
- Department of Infrastructure
- Department of Finance
- Department of Health and Social Services

MVEIRB-14

Topic: Socio-economic: Economic assessment based on up-to-date models and structure of the Northwest Territories economy (DAR section 9.7.2.1.1, Table 9.16)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board):
The economic effects of the Mackenzie Valley Highway are an important consideration when considering the cost of its construction. It is therefore important that the modelling work provides an appropriate level of confidence and relates to this project. The use of the Inuvik-Tuktoyaktuk Highway (2011) as proof of potential expected employment and income effects arising in the Northwest Territories from construction is inappropriate. Further, with the completion of the Inuvik-Tuktoyaktuk Highway, actual outcomes from that project could have been provided if the point was to feature an example.

Request from the Review Board:
Please provide an assessment of the potential economic effects using up-to-date models based on current structures of the Northwest Territories economy. Please consider both the optimal schedule of 3-4 years as well as the conceptual timeline of 20 years of construction presented in the DAR.

Response from the Government of the Northwest Territories:

To provide an assessment of the potential economic effects on the Northwest Territories economy, updated economic figures are required. A revised cost estimate and updated business case for the MVH Project is under development and anticipated to be completed in early 2025.

As mentioned in the response to MVEIRB IR 11, the 3–4-year construction schedule is an alternative method of construction. The GNWT is submitting a supplemental filing (Supplement to the Developer's Assessment Report Chapter 7: Assessment of Alternatives) to be posted on the public registry, which will provide a qualitative assessment of the accelerated construction timeline. The analysis of the potential economic effects will be carried out for the project construction schedule of 20 years.

Topic: MVEIRB IR 15-Socio-economic: Tourism identified as being an expected driver of induced employment (DAR section 9.7.2.1.2)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board): "The developer reports that during engagement it heard potentially affected parties identify tourism as being an expected driver of induced employment. Is this the developer's expectation? The Developer's Assessment Report does not contain adequate follow up or research into community predictions or expectations. For example, as it relates to tourism, it might be possible to study the experience of Tuktoyaktuk with the Inuvik-Tuktoyaktuk Highway, or Whatì with the recently opened Tłı̨chǫ All-Season Road.

In responding to this IR, the Review Board requires analysis from ITI and any other relevant expert departments. Please make it clear what information was provided by each department and how that information was used in the developer's response."

Request from the Review Board:

"Please clarify and elaborate on predictions for tourism numbers and the economic effect of those tourists on the Local Assessment Area and Regional Assessment Area community economies."

Response from the Government of the Northwest Territories:

RAA Communities
An increase in tourism numbers and economic effects on the Regional Assessment Area (RAA) is not expected as a result of the Project. The Project will not directly change or provide all-season access to the RAA communities, and as a result, no noticeable changes in tourism visits, opportunities, and businesses are anticipated as a result of the Project.

LAA Communities
As discussed in Section 9.14 of the DAR, confidence in residual effect prediction for socio-economic valued components is influenced by a range of factors including available data and prior experiences from similar projects in similar environments. Predictive certainty is also influenced by the temporal boundary of the Project.
As discussed in Section 9.7.2.1.2 and 9.7.4.1.2, engagement findings indicated a shared expectation that the Project will increase access to LAA communities which could result in both a greater number of visitors and an increase in the length of time they spend in the area. An increase in visitors during the operations phase of the Project was seen as increasing the viability of new local businesses related to tourism (e.g. adventure tourism, eco-tourism, hunting/fishing outfitting, hospitality).

Opportunities for tourism will vary amongst LAA communities based on the specific circumstances of each community. For example, Section 9.9.3.1.2 indicates that Tulita currently has limited tourism operators which may limit the ability to attract tourists. However, an all-season road may afford opportunities for new and/or existing tourist operators to establish or expand tourism-based activities in Tulita.

With regard to experiences for other projects that can provide information to assist with addressing potential project effects, the Department of Industry, Tourism and Investment (ITI) has provided data from NWT Parks and other sources indicating that construction of the Inuvik–Tuktoyaktuk Highway has had a demonstrated effect on tourism in the hamlet of Tuktoyaktuk stemming from the community's proximity to the Arctic Ocean. ITI has provided anecdotal observations that the completion of the Tłı̨chǫ Highway

has not brought a significant increase in tourism opportunities for Whatì to date, but also notes that there is a lack of relevant community-level data being collected. A lack of observed effects on tourism to date may also be attributable to the recency of the Tłı̨chǫ Highway project (opened in 2021) and the timing of the project with the onset of the COVID-19 pandemic.

The GNWT has carried out engagement on the proposed mitigations and remains open to working with communities as the project advances to refine them, if needed. The proposed mitigations may complement the GNWT's existing programs and services to prepare communities to participate in economic benefits associated with the project. As required, adaptive management responses will be developed collaboratively with communities. To that end, measures to increase the readiness of communities to maximize benefits of potential tourism opportunities have been included as part of the proposed Community Readiness Strategy for the Project.

Specifically, ITI will make staff available to discuss tourism readiness with communities and has funding available in various programs that can be used to develop community-led initiatives (e.g., tourism plans) as needs are identified in order to maximize benefits and mitigate adverse effects associated with the operation of the Project, including:

- Identifying barriers or gaps in the current context that need to be addressed to fully realize benefits from tourism
- Identifying future potential for tourism development and promotion, and
- Identifying additional needs and supports available to mitigate adverse effects related to tourism as a result of the Project.

The response to this Information Request has been prepared in accordance with the Government of the Northwest Territories' Whole of Government Approach to the Mackenzie Valley Highway Environmental Assessment. Subject matter expertise from all relevant line departments has been considered in the drafting, review, and approval of this response. The GNWT is confident that all line departments are contributing to efforts to minimize negative social, cultural, and environmental impacts, while maximizing benefits for NWT residents from this project.

The following departments have been specifically involved in the drafting, review and approval of this response:

- The Department of Environment and Climate Change
- The Department of Infrastructure
- The Department of Industry, Tourism and Investment.

MVEIRB-16

Topic: Socio-economic: Use actual data from the Inuvik-Tuktoyaktuk (Tuk) Highway or other active and relevant road O&M rather than the predicted effects (DAR section 9.7.2.1.2, Table 9.17)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board):
It is stated that annual employment estimates were derived based on maintenance estimates for the Inuvik-Tuktoyaktuk Highway. These were prepared in 2011 and likely based on modelling of an economy in 2007 (or 2008 at the latest). If the Inuvik-Tuktoyaktuk Highway is the reference, then estimates for the Mackenzie Valley Highway should be based on actual employment records from the Inuvik-Tuktoyaktuk Highway, given that it has been operating for some time.

Alternatively, the developer might want to consider the actual employment and costs associated with operating and maintaining the new Tłı̨chǫ All-Season Road, or use the employment and costs associated with operating and maintaining the highway between Fort Simpson and Wrigley.

Request from the Review Board:

A. Please provide actual (not estimated) employment records experienced by similar roads that are open in the Northwest Territories as part of the employment and operation and maintenance costs, with adjustments that might be needed to account for differences between the highway projects.

B. Please model the economic effects of employment using up-to-date economic data and current structure of the territorial economy.

Response from the Government of the Northwest Territories:

A. In GNWT's response to MVEIRB ORS comment 5, we estimated two to three maintenance yards for the Project and each segment will employ a maintenance supervisor, 3-4 heavy equipment operators and 3-4 casual laborers during the summer.

   Direct comparison between highways for operations and maintenance is not possible. Highways in the Northwest Territories are of varying lengths, and vary in how often they need to be maintained and how many people are required (Table 1). Operations and maintenance varies by conditions, which are not entirely predictable, and we are likely to see increased maintenance going forward as a result of climate change, eg. 2023 fire season.

   Each region of the Northwest Territories employs contractors for highway operations and maintenance, to a varying degree. As an example, the Dehcho and Beaufort-Delta exclusively hire contractors and the South Slave does a substantial amount of work internally. Contactor information available at the time of response is provided in the Table below. It is assumed that each contracted employee may have other duties.

   The Dehcho Regional highway system has 667.3 km of highway that is overseen by a regional

superintendent, a highway manager and three highway maintenance supervisors. The maintenance of the highways is done under three separate contracts (specific employee numbers not available) and one maintenance camp is used.

The South Slave Region has 1,277 kilometers of highway, four maintenance camps and a central equipment repair facility. A regional superintendent oversees the region and there is a highways manager. Each camp employs a maintenance supervisor and 5-8 maintenance staff in various positions. Two of the camps also employ mechanical support positions due to their distance from the central equipment repair facility. As well, two camps also do airport maintenance.

The central repair facility employs a maintenance facility supervisor, reporting to the highway operations manager. The supervisor oversees 12 repair staff in various positions.

The North Slave Region maintains 330.8 kilometers of highway and has two maintenance camps. A regional superintendent oversees the region and there is a manager of highway operations. Each camp employees a highway maintenance supervisor and 8-10 maintenance staff in various positions.

The camps in the North Slave and South Slave and the repair facility employ some casual labour, including summer students each fiscal year.

The Beaufort-Delta Region has 414.4 kilometers of highway and is overseen by a regional superintendent, a highway manager, two project officers and three project technicians. The maintenance of Highway 8 is done by two different contractors. Each contractor employs a supervisor, 0-2 heavy equipment mechanics, 5-8 maintenance staff and 4-22 part-time and casual staff.

Highway 10 is maintained by one contractor that employs four supervisors, two heavy equipment mechanics, ten maintenance staff and four part-time and casual staff.

Highway 9 in the North Slave is maintained by P3 partnership which employs a similar number of staff: a heavy equipment mechanic on contract, five full time operators, two part-time operators and two labourers over the summer.

Table 1. Highway Maintenance Employee numbers for highways in the Northwest Territories.

Highway #	Region	Camp	Total kilometers (KM)	Highway Maintenance Supervisor	Heavy Duty Mechanic	Full time operators	Part Time Operators (6 months)	Labourers (4-5 months)
1 & 7	Dehcho	0	310.3	3	n/a	n/a	n/a	n/a
1	Dehcho	0	219		n/a	n/a	n/a	n/a
1	Dehcho North	1	138.3		n/a	n/a	n/a	n/a
3	North Slave	1	132.7	1	1	8	1	2
3	North Slave	1	95.4	1	1	10	0	4
4	North Slave		102.2 (plus 6.3 km of Ice Road)					
Sections of 1, 2, 3, 5 and 6	South Slave	4	1,277	1 (per camp)	0-1 (per camp)	3-7 (per camp)	1-3 (per camp)	0-3 (per camp)
	South Slave	Central Equipment Repair Facility	-	1	10	2	0	
8	Beaufort-Delta	1	178.2	1	2	5	4	0
8	Beaufort-Delta	1	94.3	1	0	8	22	0
9 (GNWT and P3)	North Slave	1	107	1	As required (contract)	5	2	2
10	Beaufort-Delta	0	138.9	4	2	10	4	0

Red- externally contracted positions

n/a – not available

B. The assessment carried out in the DAR was based on currently available figures at the time of drafting. A revised cost estimate and updated business case for the MVH Project is under development and anticipated to be completed in early 2025.

Upon receipt of the revised cost estimate and business case, INF will work with our consultants to prepare a public facing document for submission to the Board as some of the financial components may be sensitive and could negatively impact future procurement activities.

Topic: MVEIRB IR 17-Socio-economic: Mitigation verification (DAR sections 9.7.2.2, 9.16.2.2.1)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board): "The developer has proposed a Community Readiness Strategy and a Community Readiness and Wellbeing Adaptive Management Plan that appears to be centered on government's core activities such as education services, economic development offices, college courses, and communication of these services. The Strategy proposes a series of committees or plans focused on the communication of these existing government services.

It is unclear if and how these proposed mitigation measures will be modified or adapted specifically for the Mackenzie Valley Highway or if the services will continue as usual. In the absence of the Community Readiness Strategy and a Community Readiness and Wellbeing Adaptive Management Plan, is the developer proposing new or unique mitigation related to the GNWT's core activities to respond to additional impacts and pressures resulting from the MVH? A distinction or explanation is required as otherwise, the outcome of the proposed mitigation does not extend beyond baseline conditions.

In responding to this IR, the Review Board requires analysis from HSS and any other relevant expert departments. Please make it clear what information was provided by each department and how that information was used in the developer's response."

Request from the Review Board:

"Please provide an explanation as to the content of Community Readiness Strategy and a Community Readiness and Wellbeing Adaptive Management Plan. Include:
- whether the proposed mitigations (in the plans) are additional or just existing government programs and services
- how quickly those mitigations can be implemented and take effect
-if the plan will be ready before construction"

Response from the Government of the Northwest Territories:

As discussed in Section 9.16 of the Developer's Assessment Report (DAR), a Community Readiness Strategy will be developed to mitigate the potential adverse socio-economic effects of the Project on the LAA and RAA communities and enhance the potential positive effects. The Community Readiness Strategy will be developed and overseen by the Mackenzie Valley Highway Corridor Working Group (MVHCWG). The foundation of the mitigation approach for the Project is community readiness and preparedness, continued engagement, and collaboration.

The Community Readiness Strategy will leverage and augment existing programs and services available across the GNWT to mitigate potential adverse effects/enhance positive effects of the Project. A Social Monitoring and Adaptive Management Sub-Working Group reporting to the MVHCWG will be established. This Group will develop and implement a Social Monitoring Plan and a Well-Being Adaptive Management Plan. The Social Monitoring and Adaptive Management Sub-Working Group will be responsible for annually monitoring changes in community well-being indicators related to project activities and/or effects and responding with appropriate adaptive management measures.

This adaptive management approach focused on leveraging and augmenting existing services and programs is consistent with the approach taken by GNWT for similar projects. For example, the adaptive management approach taken for the Tłı̨chǫ Highway focused on implementing initiatives grounded in existing programming and approaches to respond to socio-economic conditions that were identified through collaborative monitoring activities with communities and standard monitoring activities that are undertaken by the Department of Health and Social Services (HSS). Through this approach, programs and services have been successfully adapted to respond to the needs of communities. Examples include:

- Wildlife surveys including regional bison and moose population surveys are conducted every three to five years and the survey areas have been expanded to include the area of the Tłı̨chǫ Highway corridor.

- In response to the opioid crisis, the Office of the Chief Public Health Officer (OCPHO) of the GNWT sent 70 naloxone kits to Tłı̨chǫ Territory as part of the GNWT surge response activities since 2023. This is over and above the normal naloxone kits made available by the Health and Social Services Authority (2000 kits were sent out by the OCPHO across the territory in response to the opioid crisis; training was also provided in the use of the kits).

- The OCPHO Health Promotion unit of the GNWT sent 35 condom dispensers to the Tłı̨chǫ region since March 2023. This was part of a wider Community Condom Access Pilot Program that the Department of Health and Social Services initiated in response to a territory wide syphilis outbreak; 308 free condom dispensers were distributed and installed in public locations across the NWT.

- When the Tłı̨chǫ Highway Socio-Economic Working Group identified a need to improve road safety,

the GNWT provided satellite phones to Tłı̨chǫ Community Service Agency workers, and Road Safety and Trauma Kits to the Tłı̨cho Government in 2023.

These examples highlight the ability of an adaptive management approach used within the framework of existing programs and services to quickly respond to evolving existing conditions and potential Project effects.

Additionally, GNWT programs and services are continually evolving in response to the outcomes of evaluation, program reviews, and ongoing collaboration with communities that lead to improvement. The Department of Health and Social Services (HSS) has provided some examples of program responsiveness and engagement focused on improving programs and outcomes:

- In 2022, the Minister of Health and Social Services noted the distressing surge in suicide rates. The following year, an additional $500,000 was allocated to the Community Suicide Prevention Fund, which is accessible by communities and non-government organizations. When the Inuvialuit Regional Corporation released its suicide prevention strategy (September 2022), officials from HSS as well as the Northwest Territories Health and Social Services Authority traveled to Inuvik to meet with Inuvialuit Regional Corporation staff to offer support for their work. This resulted in the identification of tangible and practical opportunities to reduce barriers in the health and social services system to support the Inuvialuit Regional Corporation in helping individuals and families.

- The Department's Community, Culture and Innovation division hosted Weaving our Wisdom Gathering in February 2024 to share Indigenous health and community wellness wise practices and identify shared wellness priorities, in particular for Indigenous youth, Elders and Indigenous men. Community Wellness Plans are currently under review and can be found here: https://www.hss.gov.nt.ca/en/services/community-wellness-plans The Department is identifying ways to support Indigenous communities in achieving their wellness goals and priorities.

- HSS is also continually engaging with the Mental Wellness and Addictions Recovery Advisory Group and the Indigenous Advisory Body, learning from previous consultations/engagements (e.g. Ministers forum, Cultural Safety and Anti-Racism unit, and other departmental engagements) to gain a better understanding of mental wellness and addictions recovery needs on an ongoing basis.

Aligned with the principles of adaptive management and community collaboration, the details that will be included in the Community Readiness Strategy and associated plans (i.e. Road Safety Plan, Safety and Security Plan for Vulnerable Community Members, Contractor Training and Employment Plan, Social Monitoring Plan, Well-Being Adaptive Management Plan) have not yet been determined. These will be developed in collaboration with communities. As stated in Section 9.16.2 of the DAR, the GNWT is proposing to advance development of the Corridor Working Group one year prior to the start of construction. The purpose of this action is to ensure that communities are able to benefit from the training, employment, and business opportunities associated with the project, as well as adapt or prepare for other project impacts. The GNWT has heard a desire from communities to commence this work as soon as possible. The GNWT would like to clarify our commitment, in that we commit to establishing these

working groups and related sub-committees a minimum of one year prior to construction. Specific commencement dates will be established through further discussions with communities.

The response to this Information Request has been prepared in accordance with the Government of the Northwest Territories' Whole of Government Approach to the Mackenzie Valley Highway Environmental Assessment. Subject matter expertise from all relevant line departments has been considered in the drafting, review, and approval of this response. The GNWT is confident that all line departments are contributing to efforts to minimize negative social, cultural, and environmental impacts, while maximizing benefits for NWT residents from this project.

The following departments have been specifically involved in the drafting, review and approval of this response:

- Department of Health and Social Services
- Department of Infrastructure

MVEIRB-18

Topic: Socio-economic: GNWT's Business Case projects a cost of $700 million (DAR section 9.7.3.1.1)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board):
The developer acknowledges that the cost of the project will have increased since the estimate was produced in 2015. It would be important to have an estimate that is based on more recent prices.

Changing climate conditions could substantially affect highway operations and maintenance costs.

Request from the Review Board:
A. Based on recent prices, please provide a new estimate of the project's cost of construction and annual O and;M cost.

B. Please predict how operations and maintenance costs would vary for the different climate change scenarios described in the Review Board's overarching IR#2.

Response from the Government of the Northwest Territories:

A. and B.
The assessment carried out in the Developer's Assessment Report (DAR) was based on currently available figures at the time of drafting. A revised cost estimate and updated business case for the MVH project is under development and anticipated to be completed in early 2025. The updated estimates will be provided for the costs of construction and operations and maintenance (O&M), and how O&M costs might vary for the climate change scenarios mentioned.

MVEIRB IR 19

Topic: Socio-economic: Annual cost of O&M is unclear (DAR section 9.7.3.1.2)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board):
Table 9.19 provides the estimated effect of annual operations and maintenance (O&M) expenditure on GDP but does not provide an estimate of expenditures that was used to determine these results. The Nichols Draft Economic Study of the Mackenzie Valley Highway Upgrade provides estimates, but that report is not referenced in Chapter 9. That report states annual O&M will be $1.7 million, replacing $0.6 million from the winter road O&M. It is not clear what numbers are being used in the Developer's Assessment Report.

Request from the Review Board:
Please provide the annual cost of O&M used to determine the economic effects estimates in the DAR.

Response from the Government of the Northwest Territories:
Table 9.19 in the DAR models annual operating and maintenance Project effects in the form of total government revenue. Total government revenue is derived from estimated wages, salaries, and benefits costs for full-time equivalent (FTE) employment for estimated direct, indirect, and induced employment for the Operations and Maintenance phase of the Project.

The estimated FTEs for direct, indirect, and induced FTEs are described in Section 9.7.2.1.2 and also described below. As indicated in the DAR, only a basic estimate of direct jobs required for operations and maintenance has been developed at this time.

> "The GNWT estimates that there would be a total of one supervisor, three or four operators and three or four casual positions required per maintenance camp along the Project, and that there would be a total of three camps once the Project is operational. In the winter, the numbers of jobs would be reduced to one supervisor and three or four operators. This is an estimated total of 21 to 27 positions in the summer and 12 to 15 positions in the winter, for an overall total of 33 to 42 positions. These new positions may result in changes to the local employment rates in each community, but given the small number of jobs, it may not be possible to see measurable changes in employment rates due to project-related operational jobs.
>
> For the purposes of assessment, annual employment estimates were derived based on the maintenance estimates for the Inuvik-Tuktoyaktuk highway construction and are presented in Table 9.17. Annual employment effects are estimated at 35.3 jobs and over $2 million in salaries and wages. This may be reflected in higher family income levels in communities over a longer period, although given the small number of jobs associated with project operations, the change may not be possible to measure."

The wages, salaries, and benefits figures that are contained in Table 9.17 in this section were what was used to estimate the total government revenue figure contained in Table 9.19.

The assessment carried out in the DAR was based on currently available figures at the time of drafting. A revised cost estimate and updated business case for the MVH Project is under development and anticipated to be completed in early 2025.

Upon receipt of the revised cost estimate and business case, INF will work with our consultants to prepare a public facing document for submission to the Board as some of the financial components may be sensitive and could negatively impact future procurement activities.

MVEIRB-20

Topic: Socio-economic: The economic effects related to the loss of winter road (DAR section 9.7.3.1.2)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board):

The DAR states that economic effects related to the loss of winter road construction and maintenance are "not estimated at this point pending information on their current costs". The developer has not indicated when it will provide these economic effects evaluations.

The DAR states that "much of the [capital expenditures] are expected to be spent on local sources of goods, services, and labour", without identifying which goods and services. The developer has not provided additional information to support the statement.

In responding to this IR, the Review Board requires analysis from Finance and any other relevant expert departments. Please make it clear what information was provided by each department and how that information was used in the developer's response.

Request from the Review Board:

Please provide the overall net effects on the economy, considering the loss of annual winter road construction and operation and maintenance.

Response from the Government of the Northwest Territories:

The GNWT is unable to answer this question in full at this time. As of 2023, the current Mackenzie Valley Winter Road from Wrigley to Norman Wells, including the Tulita ice crossing, cost approximately $1.1 M to construct and operate and maintain. Without knowing the estimated cost of operating and maintaining the Mackenzie Valley Highway the net effect on the economy cannot be determined.

The assessment carried out in the DAR was based on currently available figures at the time of drafting. A revised cost estimate and updated business case for the MVH Project is under development and anticipated to be completed in early 2025.

The response to this Information Request has been prepared in accordance with the Government of the Northwest Territories' Whole of Government Approach to the Mackenzie Valley Highway Environmental Assessment. Subject matter expertise from all relevant line departments has been considered in the drafting, review, and approval of this response. The GNWT is confident that all line departments are contributing to efforts to minimize negative social, cultural, and environmental impacts, while maximizing benefits for NWT residents from this project.

The following departments have been specifically involved in the drafting, review, and approval of this response: Environment and Climate Change, Finance, Infrastructure, and Justice.

Topic: 21-Socio-economic: Increase in contracts for businesses (DAR section 9.7.4.1.1)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board):
"The DAR states that "much of the [capital expenditures] are expected to be spent on local sources of goods, services, and labour", without identifying which goods and services. The developer has not provided additional information to support the statement.

In responding to this IR, the Review Board requires analysis from any relevant expert departments. Please make it clear what information was provided by each department and how that information was used in the developer's response."

Request from the Review Board:
"Please describe, in general terms, the goods and services that can be provided by local sources."

Response from the Government of the Northwest Territories:

Information on businesses operating in Tulita and Norman Wells is outlined in Section 5.2.2.2.2, Section 5.2.2.3.2 and Figure 7 of the Existing Socioeconomic Conditions Report provided in Appendix 9C of the Developers Assessment Report (DAR). This information was shared by municipal staff in each community. Similar information for other communities was not provided or was otherwise not available.

A further review of available information indicates that there are a number of goods and services that could be provided by local sources in the Local Assessment Area (LAA) and Regional Assessment Area (RAA). Locally available goods and services may include[1]:

- Construction materials and equipment including fuel, gas, oil, gravel, cement, hardware, and tools;
- Construction services and labour (including general contracting, excavation, sand blasting, drilling, concrete and cement work; and road construction/maintenance);
- Accommodation and catering;
- Ground transportation (including bulk trucking for sand, gravel and other construction materials);
- Skilled trades (e.g. carpentry, electrical, welding and plumbing);
- Land Surveying and mapping;
- Vehicle and heavy equipment leasing, rental and repairs;
- Cleaning and janitorial services;
- Environmental and wildlife monitoring; and,
- Environmental and engineering remediation services.

As discussed in 9.16.2.2.1 of the DAR, a Contractor Training and Employment Plan will be developed as part of the Community Readiness Strategy to enhance positive effects from the Project for LAA and RAA communities. The Contractor Training and Employment Plan will identify local contracting and employment opportunities associated with the Project and appropriate strategies to enhance opportunities for local businesses and workers. This Plan – including the approach to procurement of goods and services – will be developed in collaboration with communities to ensure strategies and actions are responsive to the needs and resources available in the LAA and RAA.

The response to this Information Request has been prepared in accordance with the Government of the Northwest Territories' Whole of Government Approach to the Mackenzie Valley Highway Environmental Assessment. Subject matter expertise from all relevant line departments has been considered in the drafting, review, and approval of this response. The GNWT is confident that all line departments are contributing to efforts to minimize negative social, cultural, and environmental impacts, while maximizing benefits for NWT residents from this project.

[1] This listing is based on information available through the GNWT's Business Incentive Policy (BIP) Registry.

The following departments have been specifically involved in the drafting, review and approval of this response:

- Department of Industry, Tourism, and Investment
- Department of Infrastructure
- Department of Health and Social Services

Topic: MVEIRB IR 22-Socio-economic: Increase access to harvesting will reduce the availability of traditional foods (DAR section 9.7.6.1.2)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board): "The developer states that "the project may increase access to harvesting and trapping areas that were previously more difficult to access outside of the winter road season. Increased competition for wildlife could in turn reduce the availability of traditional foods for community consumption and increase reliance on store-bought foods to supplement diets." This effect was reiterated in the GNWT's answer to Review Board's comment #7. This is an assumption without supporting information and analysis, such as from the Tłı̨chǫ Highway or Inuvik-Tuktoyaktuk Road.

In responding to this IR, the Review Board requires analysis from ECC and any other relevant expert departments. Please make it clear what information was provided by each department and how that information was used in the developer's response."

Request from the Review Board:

"Please clarify how an increased distribution of harvesters will result in a reduction of traditional foods and increase reliance on store-bought foods."

Response from the Government of the Northwest Territories:

To clarify, the potential effect on food security noted in Section 9.7.6.1.2 of the Developer's Assessment Report (DAR) is not related to a greater distribution of harvesters along the route of the Project. Rather, the potential effect on food security would be due to an increase in the overall number of hunters and their increased all-season access to harvesting areas currently relied upon by members of communities in the Local Assessment Area (LAA). As identified in Sections 9.5.1 and 9.5.5.2 of the DAR, feedback collected from LAA communities included concerns that the Project may facilitate increased access/visits by non-residents which could place additional pressure on hunting and fishing sites that in turn may lead to a decreased availability of traditional foods for local residents. Increased competition in acquiring traditional foods that may result due to improved access for non-residents to access harvesting sites may lead to residents in LAA communities needing to supplement their traditional food intake with store-bought foods.

The Department of Environment and Climate Change (ECC) and NWT Bureau of Statistics have indicated that some community level data exists related to harvesting levels generally. However, this data is limited due to:

- the infrequency of collection (only every 5-10 years); and,
- the nature of most of the data itself being based on wildlife levels generally rather than specific harvesting levels.

Together, these considerations limit the ability to leverage data collected and held by the GNWT to draw conclusions on potential pressures on harvesting areas that could be attributed to the effects of the

Project.

With regard to similar effects being seen in other communities that have been connected by or proximate to an all-season road, ECC indicated that limited data exists. Given the relatively recent completion of the Tłı̨chǫ Highway project (opened in 2021), it is too early to assess whether and how the road may be affecting harvesting levels, access by non-residents and any associated increased pressure on hunting and fishing sites. ECC provided a report commissioned as part of the Wildlife Effects Monitoring Program for the Inuvik-Tuktoyaktuk Highway (d'Eon-Eggertson, 2023). The report examines changes in patterns of harvest of wolves, wolverine and grizzly bears before, during and after the construction of the Inuvik-Tuktoyaktuk Highway. The key conclusions of the report include:

- Local harvesting rates have not increased since the opening of the highway;
- Hunters report seeing similar amounts of animals in the region over the past decade;
- The average distance of harvest from the highway has not increased since opening of the highway; and,
- The proportion of harvests close to the highway have not changed substantially since the opening of the highway.

While the conclusions of this study indicate that the Inuvik-Tuktoyaktuk Highway does not appear to have increased local harvesting rates, the study has limitations:

- There is no distinction made between local and outside hunters in the study;
- The study does not include all sources of wildlife harvested by hunters for consumption;
- The data used for the study is based on successful hunts and thus does not include unsuccessful hunts which would accurately reflect hunting effort in the region surrounding the highway; and,
- There may be indirect effects related to longer-term changes in hunting and harvesting areas that are delayed and should be assessed as part of follow up studies.

Following the precautionary principle, potential adverse effects on harvesting activities have been identified as a potential effect to be mitigated through the development and implementation of a Wildlife Management and Monitoring Plan (WMMP). The WMMP will be developed in collaboration with community governments and organizations – including the Sahtu Renewable Resources Board and other resources managers – to implement monitoring activities that can be used to identify the need for management actions related to pressures on harvesting. This in turn will help address potential adverse effects of the Project on access to and availability of traditional foods connected to any increase in outside hunters within harvest areas used by LAA communities.

The response to this Information Request has been prepared in accordance with the Government of the Northwest Territories' Whole of Government Approach to the Mackenzie Valley Highway Environmental Assessment. Subject matter expertise from all relevant line departments has been considered in the

drafting, review, and approval of this response. The GNWT is confident that all line departments are contributing to efforts to minimize negative social, cultural, and environmental impacts, while maximizing benefits for NWT residents from this project.

The following departments have been specifically involved in the drafting, review and approval of this response:

- The Department of Education, Culture, and Employment
- The Department of Environment and Climate Change
- The Department of Health and Social Services
- The Department of Infrastructure
- NWT Bureau of Statistics

MVEIRB IR 23

Topic: Socio-economic: Confirm construction costs and payment arrangements between the GNWT and Canada (DAR Volume 1 (Introduction and Project Description) (2 of 3); Project Description)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board):
The project description suggests the construction cost of the Mackenzie Valley Highway will be shared 75%/25% between Canada and the Northwest Territories, respectively. This assumption was put forward based on an estimated $700 million Project cost. The cost of the project has risen since 2015 when it was first estimated. It is not clear from the project description if these arrangements still pertain or if cost increases bring into question the affordability and cost-benefit considerations.

Request from the Review Board:

A. Please provide an update on how GWNT intends to finance the project construction based on up-to-date project cost estimates.

B. Please describe how GNWT intends to fund annual operations and maintenance, and what effect this would have on annual operations and maintenance budgets for existing highways.

Response from the Government of the Northwest Territories:

A. The funding model and sources for the construction of the Project are not yet determined. The approximately 75%/25% federal to territorial government funding ratio was the standard funding ratio used across multiple federal funding programs for GNWT projects and initiatives at the time the project description was developed. However, federal funding programs and specific funding ratios are continually evolving through time, with some federal programs offering higher percentages towards projects. As large transformative projects such as the MVH may not necessarily fit within an established funding program, there will likely be a need to pursue special arrangements with Canada for financial support, and/or obtain support across multiple programs.

B. As stated in the information request, the cost of the Project has increased since the 2015 estimates that are used in the Developer's Assessment Report. The assessment carried out in the DAR was based on currently available figures at the time of drafting. A revised cost estimate and updated business case for the MVH Project is under development and anticipated to be completed in early 2025.

   Upon receipt of the revised cost estimate and business case, INF will work with our consultants to prepare a public facing document for submission to the Board as some of the financial components may be sensitive and could negatively impact future procurement activities.

   The operations and maintenance (O&M) phase of the MVH will commence in a staged manner as construction of each segment of highway is completed (See DAR Section 4.3.3.2). At that time the completed road sections will be opened to the public and operated and maintained by the GNWT Department of Infrastructure (INF) as part of the NWT highway system. New appropriations would be sought through the annual GNWT budget cycle that reflect expected operations and maintenance requirements for the new all-season road, no different than how appropriations are requested for O&M for other regional highways through that process. These allocations are subject to the review

and approval of the Legislative Assembly.

Topic: 24-Socio-economic: Indirect and induced effects presented appear to be inflated (DAR Volume 1 (Introduction and Project Description) (2 of 3); Appendix 4)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board):

"The Nichols 2014 Draft Economic Study of the Mackenzie Valley Highway Upgrade presents results that appear exaggerated by a significant amount when compared to the latest Input-Output Tables for the Northwest Territories. The draft report is also mentioned in the Appendices but not in Section 9.7 of Chapter 9. It is not clear how the results of this study influenced the Developer's Assessment Report or the developer's expectations regarding the economic effects of the proposed project."

Request from the Review Board:

"Please provide a detailed explanation of the economic model and how its results were incorporated into the assessment."

Response from the Government of the Northwest Territories:

The Nichols 2014 Draft Economic Study of the Mackenzie Valley Highway Upgrade was not used in the assessment contained in the Developer's Assessment Report. The draft Nichols report was included as an appendix to the DAR submission for the purpose of completeness, and not as a reference that informed the assessment of potential economic effects associated with the Project.

As stated in Section 9.7.3 of the DAR, the model used to assess the economic effects of the Project was the NWT Bureau of Statistics Input/Output model that was used for the Environmental Impact Statement for the Construction of the Inuvik – Tuktoyaktuk Highway. This model was used to determine estimates for GDP and government revenue due to the Project. The output of this economic model was supplemented with other data sources including census data provided by the NWT Bureau of Statistics, qualitative feedback from communities, and data on experiences from similar projects in similar environments.

The assessment carried out in the DAR was based on currently available figures at the time of drafting. A revised cost estimate and updated business case for the MVH Project is under development and anticipated to be completed in early 2025.

Upon receipt of the revised cost estimate and business case, INF will work with our consultants to prepare a public facing document for submission to the Board as some of the financial components may be sensitive and could negatively impact future procurement activities.

MVEIRB-25

Topic: Socio-economic: Approval to use community services (DAR section 9.8)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board):
The developer mentions that it "will obtain approval and agreement from the Town of Norman Wells, the Hamlet of Tulita and Wrigley to use their community water supplies, their sewage lagoon and solid waste disposal facilities." The developer has not indicated what it would do if community infrastructure or services are unavailable, for example if they are already at capacity.

Request from the Review Board:

A. Do the communities of Wrigley, Tulita, and Norman Wells have the capacity to support the use of water, sewage, and solid waste infrastructure for the highway?

B. Please describe how GNWT will manage water, sewage, and solid waste if it is not feasible or acceptable to use communities' infrastructure and services.

Response from the Government of the Northwest Territories:

A. While the communities of Wrigley, Tulita, and Norman Wells have waste management facilities, the GNWT is yet to determine the capacity of each community to support the management of wastes generated by the Project. The GNWT intends to engage with each respective community government to establish the capacity of their waste management facilities and will then negotiate agreements for provision of potable water and to receive project wastes accordingly (Section 5.4).

B. Waste in excess of community capacities and waste that cannot be accepted by community facilities will be disposed of in accordance with acceptable industry standards and the approved Waste Management and Incinerator Management Plans for the Project.

   If municipal facilities are unable to accept solid waste, containerized waste will be transported by road to an alternate accredited facility approved to accept the wastes. As mentioned in Section 5.4.12 of the DAR, there are currently no facilities in the Sahtu or Dehcho regions licensed to accept and manage recyclables or hazardous wastes from commercial operations. Recyclable wastes and hazardous wastes will be backhauled for disposal and/or recycling at accredited facilities capable of accepting such wastes within or outside of the NWT.

   After construction, any remaining equipment, scrap materials, and waste that cannot be disposed locally could be demobilized by truck and disposed of in an approved facility at the end of construction.
   Each camp will include waste transfer and temporary waste management facilities. The management of solid waste from camps and construction activities may also include incineration. Wastes suitable

for incineration, such as food waste and cardboard, will be incinerated on site following applicable guidelines and the approved Incinerator Management Plan.

Reviewer Preamble

To understand the effectiveness of current GNWT health and wellness programs, it would help to compare indicators of health and wellbeing in the communities along the project against Canadian averages. Looking at what is already working, and what is not, can help indicate which existing issues are already significant and how well GNWT programs may mitigate additional impacts, such as cumulative impacts that may arise from the MVH.

In responding to this IR, the Review Board requires analysis from HSS and any other relevant expert departments. Please make it clear what information was provided by each department and how that information was used in the developer's response.

Reviewer Request

Please provide a comparison of human health and community wellness indicators in the Local Assessment Area against the Canadian averages.

Response to MVEIRB IR26

Comparing "human health and community wellness" indicators in the Local Assessment Area (LAA) against Canadian averages will not identify how successful the Government of the Northwest Territories (GNWT) programs are at mitigating additional impacts. Comparisons of territorial, and to a greater extent, LAA community indicators to Canadian averages is difficult and in some instances not possible. There are privacy concerns with the collection and sharing of community-level data, differences in data collection methodology between jurisdictions, and small sample sizes in the LAA limit the effectiveness of such comparisons.

Communities within the LAA have health and wellbeing challenges that are unique from other Canadian jurisdictions. Much of this is rooted in colonialism and the legacy of residential schools, which has directly impacted Indigenous health outcomes of Indigenous People, including those in LAA communities. Indigenous People make up 49.6% of the population of the Northwest Territories (NWT) compared to 5.0% of Canada as a whole. Partially as a by-product of colonialism, LAA communities are also challenged by their remoteness, and isolation. They are small communities and tend to have less access to services and facilities that larger, more connected communities would have access to. The GNWT is working to improve health outcomes of all Indigenous residents.

The Canadian Institute for Health Information (CIHI) does make some comparisons of health-related indicators, including a comparison of Northwest Territories (NWT) indicators to national averages. This comparison is of limited use as it does not look at community level data, and does not analyze why differences exist between the NWT and the rest of Canada. Community level wellness indicators for the LAA are available, but they are often not standardized with broader Canadian and CIHI indicators, which can make comparison with similar CIHI and Canadian indicators misleading.

Sensitivities in collecting health data and data related to Indigenous communities include general concerns with privacy, especially in small communities like those in the LAA (i.e. Norman Wells, Tulita, and Pehdzeh Ki). The priority of the NWT Health and Social Services System is to ensure the protection of personal health information, embedding privacy practices in services, policies, procedures and processes.

The Health Information Act includes privacy and security safeguard requirements to ensure protection of patient information. This means that at the community level, there is very little public reporting of health data that could be used to provide information on human health and the wellbeing of communities generally. Additionally, there is also variation in the data sources, time periods for which data is collected, method of collecting data, and the indicators used to measure health and wellbeing in jurisdictions across Canada.

In conclusion, considering all of the information provided above, there is a limited efficacy of comparison between LAA health and community wellness indicators and the national averages.

The response to this Information Request has been prepared in accordance with the Government of the Northwest Territories' Whole of Government Approach to the Mackenzie Valley Highway Environmental Assessment. Subject matter expertise from all relevant line departments has been considered in the drafting, review, and approval of this response. The GNWT is confident that all line departments are contributing to efforts to minimize negative social, cultural, and environmental impacts, while maximizing benefits for NWT residents from this project.

The following departments have been specifically involved in the drafting, review and approval of this response:

- The Department of Health and Social Services
- The Department of Infrastructure
- The Department of Environment and Climate Change

Topic: MVEIRB IR 27-Socio-economic: Increasing resilience to face health issues (DAR section 9.5.3.2)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board):

"The developer acknowledges that the project will exacerbate existing health and wellbeing issues (about population health, community/family and social ties, food security, social pressure, nuisance, water quality, public safety, and social determinants of health (Table 9.10)). Engagement mentioned the need to resolve existing health needs and health services issues before the project becomes operational (p.9-79). The developer also acknowledges an upcoming increase in demand for counselling, emergency services, and protective services (p.9-182). Residents of Norman Wells and Tulita stated during engagement that health services are already at maximum capacity (p.9-180).

For example, Tulita residents note the risk of increased drugs and alcohol in the community, and the resulting increase in demand for counselling, facility-based treatment, emergency services, and protective services (p.9-182). Tulita and Norman Wells residents also point out that health services already are at maximum capacity, and that the community lacks mental health, suicide prevention, addictions, or social workers (p.9-180). The DAR highlights that the project will make these existing issues worse (p.9-182).

Although the GNWT has identified a variety of plans, programs, and working groups that will be used to address problems, there are potential challenges with the time lag that may occur for these plans, programs, and working groups to identify the problem, come up with mitigation, put the mitigation into action, and reduce impacts. Initial experience with the Tłı̨chǫ highway demonstrates this. In some cases, there are already services that are at capacity in the communities, and this project may further increase demand. For the Tłı̨chǫ highway, it has sometimes taken time to adjust to the increase in demand (such as by getting another RCMP officer).

Additionally, the Acho Dene Koe First Nation noted that "There is a serious concern that [the Well-Being and Adaptive Management Plan] will not be a satisfactory form of mitigation," "it is unclear whether it will appropriately address all effects associated with community well-being," and "This Plan must be co-developed with affected communities and be developed before final approval of this project" (ADKFN comment #3). The GNWT has stated, in its answer to ADKFN comment #3, that the Mackenzie Valley Highway Corridor Working Group will develop the Community Readiness Strategy's plans beginning one year before construction and ending after five years of operations. The timeframe for the Community Readiness Strategy and the development of the associated plans has not been determined, but they will not be finalized before the end of the EA. GNWT will engage communities about the timeframe in 2024.

In responding to this IR, the Review Board requires analysis from HSS and any other relevant expert departments. Please make it clear what information was provided by each department and how that information was used in the developer's response."

Request from the Review Board:

A. "Please summarize any existing social or health services that are at or near capacity in the communities, and if this project might increase demand for those services, resulting in adverse impacts.

B. Are there ways the GNWT could increase capacity or community resilience to help prevent impacts before the impacts occur, rather than waiting to respond to them after they happen?

C. Based on "lessons learned" from the Tłı̨chǫ Highway, please describe which mitigation measures will be considered suitable for the Mackenzie Highway project and can be expected to be reflected in the Well-Being Adaptive Management Plan addressing social and health services

D. Even though the timeline is currently uncertain, does the developer plan to have the Well-Being Adaptive Management Plan ready before construction?"

Response from the Government of the Northwest Territories:

Request A

Current Health and Social Services Capacity in Local Assessment Area (LAA) Communities

The health and social services system ('the HSS system') in the NWT is complex and subject to many pressures, including cost pressures, increasing demand for programs and services, and changing patient and provider needs. The HSS system is responsible for providing programs and services to 33 communities (nearly 45,000 people) over one million square kilometers. Of those communities, 10 have less than 200 residents, and only six have over 1,000 residents. Additionally, four communities are completely without road access, and 10 have winter road access only. As a result, delivery of health and social services is particularly challenging in smaller communities with limited staff and capacity, and further strained during unexpected increases in demand (e.g., COVID-19 pandemic).

The HSS system continues to face pressures and service impacts related to a shortage of health care providers in the NWT, and several Community Health Centres incur staff shortages that impact the ability to provide usual service levels. Required coverage is often provided by managers, staff from other communities/regions, or additional resources where possible. Alternative solutions, such as the use of paramedics, relief staff, locums, and agency professionals are pursued as needed to maintain service.

As of early September 2024, the deficits in staffing levels within the Northwest Territories Health and Social Services Authority (NTHSSA)[1] (i.e., reduced services) included:

- Four (4) Nurse Health Centres: Staffing at 3 RNs (75%) or 2 RNs (50%)
- Three (3) Nurse Health Centres: Staffing at 2 RNs (66%)
- Two (2) Nurse Health Centres: Staffing at 1 RN (50%)

[1] Established August 1, 2016, the NTHSSA is one of three health and social services authorities in the NWT. It serves the Beaufort-Delta, Sahtu, Dehcho, Yellowknife, and Fort Smith regions of the Northwest Territories, and is responsible for the operation of the Stanton Territorial Hospital.

Like other jurisdictions across Canada, the NWT is challenged in recruiting and retaining skilled and qualified staff. Additionally, it is a priority for the NWT health and social services system to maintain a stable and representative workforce. To be competitive, the GNWT offers a competitive wage and benefits package to its professionals, as well as targeted measures such as incentives to help retain and recruit staff. Even with these competitive measures, the HSS system is still challenged by unique factors associated with recruitment and retention of health care providers such as lack of housing in communities (a challenge faced by all GNWT departments) (GNWT HSS, 2023).

As a result of the complexity and ongoing challenges in the HSS system, the NWT has one of the highest per capita costs for healthcare delivery in Canada (with the 2021 total health care per capita spending over 2.5 times higher than the average cost per Canadian) (GNWT, 2023). With a small tax base, and reliance on federal and third party funding, ensuring long-term sustainability of the NWT HSS system remains a challenge and priority area. More specific details on the challenges faced by the HSS system, as well as mechanisms to try and address those challenges are articulated in the response to Request B.

Potential Project Effects on Social Infrastructure and Services

The staffing deficit information presented above aligns with feedback shared by community members: that demand for programs and services may be outpacing current health and social services capacity in communities. Added pressure on health and social services capacity and associated mitigations related to the Project are documented in Section 9.8.3 of the Developer's Assessment Report (DAR). As highlighted in Section 9.5.6 on social pressures, the Project may lead to increased access to drugs and alcohol during the construction and operations phases as a result of LAA community residents being able to leave their communities more easily and affordably by land, and as a result of non-residents working in or near the community(s) and being able to more readily visit the community and bring in drugs and alcohol. This increase in access and consumption may have several effects, including:

- Increased demand for counselling and facility-based addictions treatment for those community members who are using these substances on a more regular basis (which may exceed capacity of those services)
- Increased demand for emergency services associated with impaired driving
- Increased demand for protective services due to alcohol-related crimes or violent incidents

These potential effects may place increased demand on health and social services in LAA communities. It is important to note that issues of alcohol and drug use, and limited community capacity to deal with such issues, are long-standing problems; the Project will therefore exacerbate ongoing issues rather than create new ones.

Request B

<u>Addressing Current System Challenges and Potential Project Effects</u>

Building a robust, stable, and representative workforce remains a priority for the NWT health and social services system. A collaborative approach to strategic human resource planning and support is

maintained across the entire HSS system, including the Department of Health and Social Services (the Department) and the three health and social services authorities - the Hay River Health and Social Services Authority (HRHSSA), the Northwest Territories Health and Social Services Authority (NTHSSA), and the Tłı̨chǫ Community Services Agency (TCSA). An ongoing goal is increased recruitment, retention, and training of qualified staff, supported by strong leadership and an organizational culture rooted in the principles of cultural safety and anti-racism. Additionally, concurrent with the construction and operation of the Project, the Department will continue to facilitate discussions and advocate for federal funding to increase capacity and community resilience related to the delivery of health and social services.

Most recently, through the *Working Together* Agreement (Canada-Northwest Territories Agreement to Work Together to Improve Health Care for Canadians (2023-24 to 2025-26), signed in October 2023), the Government of Canada will provide more than $24 million to support he Northwest Territories' three-year action plan to deliver improvements to its health care system. This plan aims to:

- Increase coordination and access to primary care across the regions
- Support recruitment, retention, and training initiatives for health workers.
- Expand the delivery of addiction services and specialized care.
- Enhance culturally appropriate mental wellness and suicide prevention programming, including crisis response.

Additional examples of GNWT's efforts to address system level challenges and capacity gaps that may be further exacerbated as a result of anticipated Project effects, include:

- Primary Health Care Reform (PHCR) is an initiative to create a system that connects residents with the right care, from the right provider, at the right time and place through the delivery of culturally safe and relationship-based health and social services. It is a move towards supporting residents having equitable access to health and social services' programs and services and in general, improving health care in small communities. PHCR is driven by community priorities and health system data, and currently includes demonstration projects (implementation of integrated care teams[2] in Yellowknife, Fort Smith and Fort Good Hope; and the design of chronic disease management in the Dehcho and Tłı̨chǫ regions).
    - As part of Primary Health Care Reform, an Integrated Care Team demonstration project in Fort Good Hope is being reviewed. The focus has been on the physician aspect of the initiative, specifically on the access to virtual care and integrating mental health practitioners on the Electronic Medical Record.
- Community Wellness Initiatives are intended to reduce health inequalities and improve the health and wellness outcomes of Indigenous individuals, families, and communities in the NWT. Funding is distributed to 31 Indigenous governments in an innovative model that emphasizes

[2] Integrated Care Teams (ICTs) are a relationship-based model of primary health care staffing and delivery, inspired by the Alaskan Nuka model.4 The NWT ICT compositions vary by location depending on existing staff complements, but include family physicians, a program assistant, community health nurses, licensed practical nurses, nurse practitioners, and holistic wellness specialists. All team members have training in relationship-based culturally safe care. See https://nwtspor.ca/sites/default/files/2022-08-29_ht_ict_executive-summary.pdf for more details.

capacity building and community-identified Indigenous health and wellness priorities.

- The GNWT also hears concerns from residents regarding drugs in communities. When toxic drugs deaths are suspected or confirmed, a sub-committee of the territorial Problematic Substance Use Committee is called to work with service providers in the affected regions on a response plan and actions to address the risk. This typically involves the Office of the Chief Public Health Officer, Office of the Chief Coroner, RCMP and regional representatives. The focus is on harm reduction, such as targeted distribution of naloxone and fentanyl testing strips, as well as joint communications and partnership with local organizations to target high risk populations.

Sahtu- and Dehcho-specific efforts to address current community health and social services challenges include:

- In February 2024, the NTHSSA implemented a new model of service delivery for home and community care to provide enhanced services for residents in the Dehcho region (Ft. Simpson) and Sahtu region (Fort Good Hope and Délı̨nę). The Extended Hours Service Delivery Model expands hours of the home and community care program operations in each region to better align with the needs of clients in communities. This means that clients who access homecare will be able to receive services outside of the traditional model that aligned with the business workday by adding services in the evening and/or on weekends. This new (pilot) model is based on information gathered from clients, their families, and the community during engagement sessions.
- The Sahtu Regional Wellness Council (RWC) has advocated for changes in the Mental Health and Addictions program. The RWC met with the Sahtu Secretariat Incorporated to discuss an opportunity for partnership to re-design the mental health and addictions program. This work is being done in collaboration with the NTHSSA – Mental Health team and is adapting the work completed in the Beaufort-Delta on the Mental Health Renewal Project.
- In the Sahtu, communities with the exception of Colville Lake, have Community Justice Committees, which are made up of local volunteers who are interested in justice issues in their community and have a desire to help youth and adult offenders take responsibility for their actions, making their community a safer place to live. Community Justice Committees handle selected criminal matters, as diverted by the RCMP or Crown. Justice Committees hear from all persons involved with the offense and attempt to create a resolution which is satisfactory to all parties.
- Dehcho First Nations is working with Laurier University to research culturally relevant resources to help inform local health care, recognizing that wellness is inherently connected to language, culture, land, family and physical health, and that those values should be reflected in the health-care options available to the Dehcho Dene people.

Request C

The DAR has drawn on lessons learned and data from similar projects, including the Tłı̨chǫ Highway, to inform the assessment of socio-economic effects and mitigations for the Project. Lessons learned related

to a spike in harmful behaviours and adverse health outcomes following the completion of the Tłı̨cho Highway have been incorporated into the assessment of potential Project effects for Human Health and Community Wellness in Section 9.5.

As noted in Section 9.5.6 of the DAR, since the opening of the Tłı̨cho Highway, the community of Whatì has noted increases in negative behaviours and incidents due to increased alcohol and substance abuse that have had adverse effects on the community and community members (Williams, 2022). This was anticipated in that project's effects assessment and incorporated into monitoring and mitigation plans. In August 2022, the RCMP released a statement about significantly higher crime rates in the community and linked it to the first year of operations of the all-season road (Williams, 2022). The RCMP later confirmed that this increase in calls correlated with the opening of the Tłı̨chǫ Highway, and that the volume of calls for service increased in Whatì in 2022 as part of a general trend upward. However, crimes in Whatì now appear to be on a declining trend, but it is too soon to speak confidently about trends in the data (as described in the response to MVEIRB Information Request 80).

Through engagement, community members in Tulita and Norman Wells expressed concern about the increased drug and alcohol abuse in Whatì as a result of the Tłı̨chǫ Highway and worry that the same pattern of behaviour would occur in their communities once they had access to an all-season road (Tucker & Dulewich, 2022).

Although limited due to the nature of where the Project's construction camps will be located and operated, it is possible that there will be interactions between non-resident construction workers and community members that could increase the rate of STIs and teen pregnancies in LAA communities, and to a lesser extent in RAA communities. Concerns of this nature have been raised for similar projects (e.g., Tłı̨chǫ Highway), and so having a workforce drawn in large part from local residents could mitigate the risks.

With other projects such as the Tłı̨chǫ Highway, concerns were raised about all-season access leading to disproportionately higher adverse effects on the safety of young women and girls due in part to increased interactions with non-residents. These are described in additional detail in the Construction section of the assessment of the Project's effects on Public Safety (Section 9.5.9.1.1). Additionally, the risks to Indigenous women and girls associated with travel on long stretches of highways (e.g., the Highway of Tears in British Columbia) (Lheidli T'enneh First Nation et al, 2006) have been documented and are associated with decreased economic and social outcomes facing Indigenous women, girls and youth that contribute to increased risks of hitchhiking.

Based on observations from the work around the Tłı̨chǫ Highway, through the Tłı̨chǫ Highway Corridor Working Group, and the Tłı̨chǫ Highway Socio-Economic Working group, the GNWT will take a similar approach to mitigate potential impacts of the Project. This approach (described in Section 9.16.2 of the DAR) is centred on relying on existing programs and services and creating collaborative working groups – similar to those which have shown progress in addressing the effects associated with the Tłı̨cho Highway – to mitigate potential effects of the Project. The lessons learned on the Tłı̨chǫ Highway, including the use of an adaptive management approach and collaborative monitoring were used to inform the approach and commitments associated with the Community Readiness Strategy. More

specifically:

- The GNWT will establish a Mackenzie Valley Highway Corridor Working Group (MVHCWG) that supports the development and oversight of a Community Readiness Strategy that outlines the overarching approach to enhancing benefits and minimizing risk. The envisioned MVHCWG is modelled to function in a similar fashion as the Tłı̨chǫ Highway Corridor Working Group but will be adjusted to reflect the realities and differences of the socioeconomic environment along the Mackenzie Valley Highway corridor.

- The Safety and Security Plan for Vulnerable Community Members will consider findings from the social and well-being monitoring program for the Tłı̨chǫ Highway and the Social Monitoring and Adaptive Management Plan for the period of construction and a period of five years of operations after Project construction is completed. It will also consider findings and approaches from other jurisdictions (e.g., the 'Community Safety Toolkit' developed by the Lheidli T'enneh First Nation, Carrier Sekani Family Services (2006) along the Highway of Tears). Further, the Safety and Security Plan for Vulnerable Community Members for the Project will consider public findings from the social and well-being monitoring program for the Tłı̨chǫ Highway as part of efforts to address potential changes to public safety that may disproportionately affect young women, girls and other vulnerable populations.

- Several of the effects and associated mitigations documented for the Tłı̨cho Highway were reviewed and informed the scope of areas to be addressed as part of the Well-Being Adaptive Management Plan (Section 9.16.2.3.1 of the DAR) for the MVH Project. For example, as a component of the Bootlegging sections of the Plan, a review of the Tłı̨chǫ Highway monitoring report(s) and results, including spikes in indicators, mitigative responses and adaptive management measures, and incorporation of lessons learned where appropriate will be conducted.

It should be noted that there are limitations and caveats on drawing direct lessons learned between the Tłı̨chǫ Highway and the proposed Project. These are documented in the response to IR 3 previously submitted to the MVEIRB and include:

- Social and well-being impacts in communities associated with the Tłı̨chǫ Highway are not experienced in isolation and are affected by the confounding influence of the long term effects of the COVID-19 pandemic and the 2023 wildfire season; and,

- There are fundamental differences between the two projects from an environmental and a governance (i.e., Tłı̨chǫ Government has more responsibilities and authorities for health and social services than what is in place in the Sahtu or Dehcho regions) perspective that limit direct comparisons.

Further, despite any potential benefits from drawing on lessons learned from the Tłı̨chǫ Highway, mitigations must be identified and tailored to the needs of communities affected by the Project. Communities in the MVH LAA and RAA differ substantially from communities impacted by the Tłı̨chǫ Highway. Through the Community Readiness Strategy, the MVHCWG and sub-working groups for the Project, mitigations will be developed, implemented, and monitored collaboratively with local

communities to ensure that plans and measures are responsive to the local needs of affected communities.

Request D

All strategies and plans developed under the oversight of the MVHCWG are intended to be created in collaboration with communities. Collaborative development is essential to ensuring that communities are able to identify their unique needs and to support development of responsive and appropriate mitigations. In alignment with the principles of adaptive management and community collaboration, many of the details that will be included in the Community Readiness Strategy and other plans (i.e. Road Safety Plan, Safety and Security Plan for Vulnerable Community Members, Contractor Training and Employment Plan, Social Monitoring Plan, Well-Being Adaptive Management Plan) have not yet been determined.

As outlined in the DAR, the GNWT is proposing to advance development of the Corridor Working Group one year prior to the start of construction. The purpose of this action is to ensure that communities are able to benefit from the training, employment, and business opportunities associated with the project, as well as adapt or prepare for other project impacts. The GNWT has heard a desire from communities to commence this work as soon as possible. The GNWT would like to clarify our commitment, in that we commit to establishing these working groups and related sub-committees a minimum of one year prior to construction. Specific commencement dates will be established through further discussions with communities.

The response to this Information Request has been prepared in accordance with the Government of the Northwest Territories' Whole of Government Approach to the Mackenzie Valley Highway Environmental Assessment. Subject matter expertise from all relevant line departments has been considered in the drafting, review, and approval of this response. The GNWT is confident that all line departments are contributing to efforts to minimize negative social, cultural, and environmental impacts, while maximizing benefits for NWT residents from this project. The following departments have been specifically involved in the drafting, review and approval of this response:

- The Department of Health and Social Services
- The Department of Infrastructure
- The Department of Municipal and Community Affairs
- The Department of Education, Culture and Employment

References

GNWT, Department of Health and Social Services. (2023). NWT Department of Health and Social Services Annual Report, 2022-23. Retrieved from: https://www.hss.gov.nt.ca/sites/hss/files/resources/hss-annual-report-2022-23.pdf

GNWT, Department of Health and Social Services. (2022). Integrated Care Teams Research and Evaluation: Executive Summary. Retrieved from: https://nwtspor.ca/sites/default/files/2022-08-29_ht_ict_executive-summary.pdf

GNWT, Department of Infrastructure. (April 12, 2017). Tłı̨chǫ All Season Road EA1617-01:GNWT response to the Mackenzie Valley Environmental Impact Review Board's TASR Adequacy Statement.

Lheidli T'ehneh First Nation, Carrier Sekani Family Services, et al (2006) *Project of Tears Symposium Recommendations Report: A collective voice for the victims who have been silenced.* Retrieved from: https://Projectoftears.org/wpcontent/uploads/2022/04/Project-of-Tears-Symposium-recommendations-Report-January-2013.pdf

Stefanon, B.M., Tsetso, K. Tanche, K., and Morton Ninomiya, E.M. (2023). Effective health and wellness systems for rural and remote Indigenous communities: a rapid review. Int J Circumpolar Health. 2023; 82(1): 2215553. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10228316/

Tucker, Amy and J. Dulewich. (November 30, 2022). *The Tłı̨chǫ Highway opened 1 year ago. Residents say it brought change, both good and bad.* CBC. Retrieved from https://www.cbc.ca/news/canada/north/*tłı̨-chǫ*-highway-open-1-year-anniversary-1.6669709

Williams, Ollie. (August 19, 2022). *Whatì RCMP say crime up 25% so far in first year of all-season road. C*abin Radio. Retrieved from https://cabinradio.ca/102299/news/tlicho/whati-rcmpsay-crime-up-25-so-far-in-first-year-of-all-season-road/

Topic: MVEIRB IR 28 Socio-economic: Vulnerable groups (DAR chapter 9)

Preamble from the Mackenzie Valley Environmental Impact Review Board (Review Board):
"The developer states in the DAR that to mitigate the predicted negative effect on public safety, a Safety and Security Plan for Vulnerable Community Members will be created under the proposed Community Readiness Strategy. The effect on public safety (social pressures) with mitigation is predicted to be significant. The Review Board requires more details of this plan.

When a project is developed, there are typically some individuals who experience more of the benefits and some individuals who experience more of the negative impacts of the project. This issue can be particularly true in a small Indigenous community in the north. Often, those who experience the most negative impacts are also people who have the least power to voice the challenges they face. Although the developer has concluded that the effect on public safety will be significant, the GNWT has not adequately described how the project might affect these vulnerable groups or individuals, or how the proposed mitigation can reduce the predicted impacts.

In responding to this IR, the Review Board requires analysis from HSS and any other relevant expert departments. Please make it clear what information was provided by each department and how that information was used in the developer's response."

Request from the Review Board:
"Please provide an analysis of predicted impacts on vulnerable groups in the communities on the project route, how different vulnerable groups may be differently affected (including in multiple ways simultaneously) and identify how the proposed mitigation measures are expected to reliably reduce these impacts."

Response from the Government of the Northwest Territories:
When looking at potential adverse effects of the Project, a health equity lens was applied to determine if there were sections of the population/community which, by virtue of their circumstances, may be disadvantaged disproportionately by the Project, or would not benefit from the Project in the same way or to the same degree as other segments of the population/community. Health equity is created when all people in a community or population can reach their fullest health potential, and no one is disadvantaged (more vulnerable) from achieving this due to their social position or circumstances (refer to Section 9.5 of the DAR – Assessment of the Potential Effects of the Project on Human Health and Community Wellness – for a more detailed description). The importance of achieving equity in health outcomes has been recognized by the GNWT's Department of Health and Social Services (HSS) as part of the strategic priorities for the NWT health and social services system and includes focusing on delivery of culturally safe and relationship-based health and social services and work to reduce systemic racism through cultural safety and anti-racism training and related efforts (GNWT 2022).

Vulnerable populations are those groups and communities at a higher risk for poor health as a result of the barriers they experience to social, economic, political, and environmental resources, as well as limitations due to illness or disability (National Collaborating Centre for Determinants of Health, n.d.). With respect to the Project, vulnerable community members include groups such as women and girls, youth, Elders, Indigenous Peoples, 2SLGBTQQIA+ persons, single parents, people with abusive partners, individuals with substance abuse issues, and those experiencing mental health problems who may be more susceptible to being adversely affected by social pressures and personal safety (refer to Sections 9.2.2.2 - Summary of Engagement and 9.5 – Assessment of Potential Effects of Human Health and Community Wellness). The legacy of colonialism and residential schools, as well as a range of geographic, social and economic circumstances, cannot be discounted as factors influencing the vulnerability of community members. Vulnerable populations might be further disproportionately affected by the Project including potential effects such as: decreased feelings of personal safety (e.g., traffic accidents, kidnapping), decreased perceived/actual mental health, increased levels of crime and violent crime, increased opportunities/rates for sexual exploitation/trafficking, sexual abuse and/or sexually transmitted diseases; increased access to drugs and alcohol; decreased sense of community cohesion; increased rates of food insecurity; increased rates of domestic violence, sexual violence, and family dysfunction; and increased rates of financial abuse. The assessments of potential Project effects on population health (Section 9.5.3), social pressures (Section 9.5.6), public safety (Section 9.5.9), social infrastructure and services (Section 9.8.3) contain information and acknowledgement of the disproportionate effects that may be felt by vulnerable populations as part of the assessment.

The impact of these effects on vulnerable populations is highly complex and they intersect to shape experiences of individuals and communities in diverse ways. For instance, those with substance use problems are likely to have additional access to addictive substances as a result of the Project. Engagement in Norman Wells indicated that this may result in an increase in overdoses among the affected population, as more access leads to a greater quantity and variety of addictive substances entering the community. Indigenous peoples are particularly vulnerable due to intergenerational trauma which can increase vulnerability to addiction through multitude pathways (Aguiar and Halseth, 2015). Additionally, the increase in substance use, which is likely to result in an increased need for counselling

services and facility-based addictions treatment for those community members who are addicted to substances, may exceed service capacity. Further, the increase in substance use may lead to increased demand on protective services (e.g., RCMP) due to an increase in substance-related crimes. Community members also expressed concerns that women, youth and sex workers would be at increased risk of violent incidents such as domestic abuse as a result of increased substance use, and kidnappings or sexual assault due to more outsiders in or near the communities because of all season road access. These are just some examples of how the Project may affect vulnerable groups differently, and reinforces the importance of working with communities to develop the Safety and Security Plan for Vulnerable Community Members, the Well-Being Adaptive Management Plan, and other aspects of the Community Readiness Strategy. Working collaboratively with communities to address these types of concerns and potential adverse effects of the Project will help ensure that responses are appropriate to community needs, apply a health equity lens, and identify any potential disproportionate effects on vulnerable populations.

In particular, the Safety and Security Plan for Vulnerable Community Members will be developed in collaboration with the GNWT Interdepartmental Missing and Murdered Indigenous Women and Girls (MMIWG) Working Group and community-based organizations that are focused on protecting women, children, youth, and vulnerable populations (e.g., 2SLGBTQQIA+ persons, Elders, single parents, homeless or underhoused, people with abusive partners) from gender-based violence, domestic violence, and family neglect. This Plan will:

- Be based on a trauma-informed approach in order to be flexible enough to allow for the uniqueness of each community's and person's situation.
- Align with the GNWT's response to MMIWG – *Doing Our Part: Initial Response to 'Reclaiming Power And Place: The Final Report of the National Inquiry into Missing And Murdered Indigenous Women And Girls*' (GNWT, 2021).
- Will consider findings from the social and well-being monitoring program for the Tłı̨chǫ Highway and the MVH Social Monitoring Plan and Well-Being Adaptive Management Plan for the period of construction and a period of five years of operations after project construction is completed. It will also consider findings and approaches from other jurisdictions (e.g., the 'Community Safety Toolkit' developed by the Carrier Sekani Family Services (2006) along the Highway of Tears in British Columbia).
- Support the provision of safety education to women, youth and children to help them identify and assess risks of violence (physical, sexual, emotional) and reduce harms.
- Support the provision of public safety information throughout communities to build a culture of safety.
- Support the implementation and coordination of health and wellness promotional campaigns that target preparedness for change, addressing safety and security risks associated with health behaviour change as a result of the Project (e.g., Sexually Transmitted Infections, family violence, mental health and addictions services) to women, children, and vulnerable populations.
- Support increased access to: emergency shelters; safe and affordable transportation (along the Project); education and training opportunities; employment opportunities; and culturally based (on the land) mental health and addictions programs.

The GNWT has also identified mitigation measures in the Well-Being Adaptive Management Plan related to community wellness, substance abuse and community safety that incorporate a health equity lens. The Social Monitoring and Adaptive Management Sub-Working Group that is responsible to develop and oversee the plan will work collaboratively with communities to identify vulnerable populations (e.g., Elders, youth, 2SLGBTQQIA+ persons, women) that may be disproportionately and adversely affected by the Project and determine how best to respond to their needs and the effects of the Project. This approach will ensure that the Plan is appropriately responsive to the effects and needs of these groups and reduce the negative effects of the Project.

The Plan will also identify actions to be implemented at the community level in the LAA and/or the broader RAA to mitigate adverse effects. Activities identified as part of the Well-Being Adaptive Management Plan will be informed by, and build on, existing GNWT policies and programs related to effects of the Project. As a component of community wellness, the Plan will include measures to respond to changes in food security that may be disproportionately affecting vulnerable populations. The GNWT has carried out engagement on the proposed mitigations and remains open to working with communities as the project advances to refine them, if needed. The proposed mitigations may complement the GNWT's existing programs and services to prepare communities to participate in economic benefits associated with the project. As required, adaptive management responses will be developed collaboratively with communities.

The response to this Information Request has been prepared in accordance with the Government of the Northwest Territories' Whole of Government Approach to the Mackenzie Valley Highway Environmental Assessment. Subject matter expertise from all relevant line departments has been considered in the drafting, review, and approval of this response. The GNWT is confident that all line departments are contributing to efforts to minimize negative social, cultural, and environmental impacts, while maximizing benefits for NWT residents from this project. The following departments have been specifically involved in the drafting, review and approval of this response:

- The Department of Health and Social Services
- The Department of Environment and Climate Change
- The Department of Infrastructure

References

Aguiar, W. & Halseth, R. (2015). Aboriginal peoples and Historic Trauma: The processes of intergenerational transmission. Prince George, BC: National Collaborating Centre for Aboriginal Health.

Aalhus, M., Oke, B. and Fumerton, R. (January 2018). The social determinants of health impacts of resource extraction and development in rural and northern communities: A summary of impacts and promising practices for assessment and monitoring. Northern Health and the Provincial Health Services Authority. https://www.northernhealth.ca/sites/northern_health/files/services/office-health-resource-development/documents/impacts-promising-practices-assessment-monitoring.pdf

The Government of Northwest Territories (2022a). *2021-2021 Annual Report: Best Health, Best Care,*

Better Future. Retrieved from https://www.hss.gov.nt.ca/en/content/nwt-health-andsocial-services-system-annual-report-2020-2021

The Government of Northwest Territories (2021d). *Changing the Relationship. Action Plan in response to the calls for justice on missing and murdered Indigenous women, girls and 2SLGBTQQIA+ people.* Retrieved from https://www.eia.gov.nt.ca/sites/eia/files/16352_gnwt_mmiwg_action_plan_8.5x11in_web.pdf

National Collaborating Centre for Determinants of Health (n.d.) Glossary. https://nccdh.ca/images/uploads/comments/English_Glossary_Nov17_FINAL.pdf

Reviewer Preamble

The DAR states that Tulita and Norman Wells residents "indicated there was a need to address existing health needs and health service issues (e.g., staff shortages, the lack of some services associated with mental health, the need for on-the-land treatments) before the Project was operational." (p.9-79).

The DAR responds that the developer will create a Well-Being Adaptive Management Plan that will review "existing uses and demands on health and social services and identify service needs and gaps associated" (p.9-179).

However, an adaptive management plan is reactive, rather than preventative. If there are predicted impacts to a service that is already at capacity, those impacts should be mitigated.

In responding to this IR, the Review Board requires analysis from HSS and any other relevant expert departments. Please make it clear what information was provided by each department and how that information was used in the developer's response.

Reviewer Request

Please describe any actions the GNWT will take to increase mental health services and on-the-land healing before project construction or operation.

Response

The Government of the Northwest Territories (GNWT) monitors its services and system regularly to ensure that it is meeting the needs of residents. Mental wellness and addiction recovery continue to be critical and pressing issues in the Northwest Territories (NWT) and across Canada, with meaningful support looking different for everyone. The GNWT is committed to providing access to health services to help achieve equitable health outcomes. This work requires that the GNWT continue to work with communities to further understand existing conditions and ensure that programs and services are responsive generally; these programs and services form the basis of a mitigation approach to respond to potential adverse effects of the Project.

To that end, and as noted in the reviewer preamble, Section 9.16 of the Developer's Assessment Report (DAR), a Community Readiness Strategy will be developed to mitigate the potential adverse socio-economic effects of the Project on the Local Assessment Area (LAA) and Regional Assessment Area (RAA) communities and enhance the potential positive effects. The Community Readiness Strategy will be developed and overseen by the Mackenzie Valley Highway Corridor Working Group (MVHCWG). The foundation of the mitigation approach for the Project is community readiness and preparedness, continued engagement, and collaboration.

The Community Readiness Strategy will leverage and augment existing programs and services available across the GNWT to mitigate potential adverse effects/enhance positive effects of the Project through the use of adaptive management. This adaptive management approach focused on leveraging and augmenting existing services and programs is consistent with the approach taken by GNWT for similar projects. For example, the adaptive management approach taken for the Tłı̨chǫ Highway focused on implementing initiatives grounded in existing programming and approaches to respond to socio-economic conditions that were identified through collaborative monitoring activities with communities. Through this approach, programs and services are being adapted to respond to the needs of communities. In addition to the specific commitments made as part of the Community Readiness Strategy to adaptively manage Project effects in collaboration with communities, the GNWT is actively working to address

health and social service needs of communities across the territory.
In late 2023 and early 2024, the GNWT and Canada signed the two bilateral agreements to invest more than $36 million to improve health care access and services in the territory (the *Working Together Agreement* and the *Aging with Dignity Agreement*). Through the *Working Together Agreement, which provides more than $24 million to support the health care system*, the NWT will implement a three-year action plan to deliver improvements to its health care system. The action plan will: increase coordination and access to primary care across the regions (establishment of a territorial public health unit to improve planning and support delivery of care); support the recruitment, retention and training initiatives for health care workers that are identified in the 2022 Health and Social Services Human Resources Plan (this plan also promotes Indigenous representation and cultural safety in health care); expand the delivery of addiction services and specialized care (establishing a Territorial Addictions Medicine Team to increase coordination of treatments, and to address higher hospitalization rates); and, to enhance culturally appropriate mental wellness and suicide prevention programming. In addition to this, the GNWT continues to work with communities to increase mental health supports and to respond to acute needs. Programs are refined and responsive based on feedback from communities, and regular surveillance monitoring. and the Health and Social Services system is continually improving how performance of programs and services are measured; for example, revised performance measures for Mental Wellness and Addictions Recovery programs and services are being implemented to, among other things, understand how well programs are meeting the needs of NWT residents, identify gaps in service delivery, and understand the needs of diverse subpopulations. Additionally, GNWT programs and services are continually evolving in response to the outcomes of evaluation, program reviews, and ongoing collaboration with communities that lead to improvement. Some additional initiatives that are underway, include:

- The Sahtu Regional Wellness Council (RWC) has advocated for changes in the Mental Health and Addictions program. The RWC met with the Sahtu Secretariat Incorporated to discuss an opportunity for partnership to re-design the mental health and addictions program. This work is being done in collaboration with the Northwest Territories Health and Social Services Authority – Mental Health team and adapting the work completed in the Beaufort-Delta on the Mental Health Renewal Project.
- Community Wellness Initiatives, which are intended to reduce health inequities and improve the health and wellness outcomes of Indigenous individuals, families, and communities in the Northwest Territories (NWT). The Department will continue to engage all communities to review their Community Wellness Plans prior to construction and operation of the MVH.

- The proposed Wellness and Recovery Centre is intended to expand shelter and community wellness spaces for people from across the NWT experiencing homelessness in Yellowknife. The facility design incorporates Indigenous cultural elements, including a community hall space for gatherings, cultural activities, and traditional healing practices and the preferred suite of programs to be incorporated into the facility has been confirmed through stakeholder engagement meetings.
- The Department of Health and Social Services is implementing a program performance measurement system for Mental Wellness and Addictions Recovery programs and services to, among other things, understand how well programs are meeting the needs of NWT residents, identify gaps in service delivery, and understand the needs of diverse subpopulations.

HSS is continually engaging with the Mental Wellness and Addictions Recovery Advisory Group and the Indigenous Advisory Body, learning from previous consultation / engagements (e.g. Ministers forum, Cultural and Anti-Racism unit, and other departmental engagements) to gain a better understanding of mental wellness and addictions recovery needs on an ongoing basis. This aligns with the importance given to community engagement in the co-development of the Community Readiness Strategy. Community engagement and co-development of the elements of the Community Readiness Strategy is key to ensuring that elements of the plan use an adaptive management approach that is aligned with and responsive to community needs.

One specific element of the Community Readiness Strategy to highlight that is directed towards supporting community health and wellness outcomes including mental health, is the Social Monitoring and Adaptive Management sub-working group (the Sub-Working group), which will leverage and augment existing programs and services available across the GNWT to mitigate potential adverse effects/enhance positive effects of the Project. The Sub-Working group will be responsible for developing appropriate well-being indicators, and annually monitoring changes that may be related to project activities and/or effects and responding with appropriate adaptive management measures. Some examples of existing mental health programs and services which can be leveraged by the Sub-Working group are:

- The Community Counselling Program (CCP), which provides free and confidential counselling and support for mental health and substance use concerns to all people living in the Northwest Territories (NWT). These counsellors are available across all regions, with telephone counselling and fly-in service provided to all communities without a local counsellor; counselling services are primarily delivered in-person. The CCP is a key referral source for specialized services like Facility Based Addictions Treatment.

- Support for mental health includes same day / drop in and scheduled appointments for counselling, eMental health programs, 24/7 help lines including 811, psychiatric care and treatment, specialized substance use/addictions recovery treatment, community-based programming and funds, and virtual support options.
- The Community Wellness and Addictions Recovery Fund (CWAR), provides over $3 million dollars in annual funding for communities to deliver culturally relevant, community-based options addressing mental wellness and addictions recovery. It prioritizes Indigenous Governments and aims to meet the unique needs of the respective communities. The CWAR combines the former On the Land Healing Fund, Addictions Recovery Peer Support Fund, and Addiction Recovery and Aftercare Fund to prioritize Indigenous Governments and reduce the burden of compiling and completing multiple application and reports.
- The Community Suicide Prevention Fund, provides $725,000 annually to support community based suicide prevention programming and support communities to develop and implement suicide prevention strategies.

The response to this Information Request has been prepared in accordance with the Government of the Northwest Territories' Whole of Government Approach to the Mackenzie Valley Highway Environmental Assessment. Subject matter expertise from all relevant line departments has been

considered in the drafting, review, and approval of this response. The GNWT is confident that all line departments are contributing to efforts to minimize negative social, cultural, and environmental impacts, while maximizing benefits for NWT residents from this project. The following departments have been specifically involved in the drafting, review and approval of this response:

- The Department of Health and Social Services
- The Department of Education, Culture and Employment
- The Department of Environment and Climate Change
- The Department of Infrastructure

Reviewer Preamble

According to the DAR, most socio-economic impacts will be addressed through GNWT's existing programing, and the plans proposed under the Community Readiness Strategy. However, decision-making regarding impact mitigation could be taken by the impacted communities and managed at the local level. Information on whether any authority will be deferred to communities regarding impact mitigation, and any other resources made available to them would help communities prepare.

In responding to this IR, the Review Board requires analysis from HSS and any other relevant expert departments. Please make it clear what information was provided by each department and how that information was used in the developer's response.

Reviewer Request

Describe any resources or responsibilities that are given to communities and local health and social service authorities to address social problems directly, rather than through GNWT programming.

Response to IR30

The Community Readiness Strategy and the establishment of collaborative, intergovernmental working groups (the Mackenzie Valley Highway Corridor Working Group and its three Sub-Working Groups) to support monitoring and mitigation through an adaptive management approach, are intended to support collaborative decision making. Such a structure is important, as it provides a seat at the table and a voice to the local affected communities and governments to support collaborative management at multiple levels. This will ensure that programs, services and mitigations are appropriate to community needs.

The Health Care System in the Northwest Territories

Territorial governments are responsible for delivering insured health services to territorial residents, including First Nations and Inuit peoples. Indigenous Services Canada provides funding for a variety of programs, such as home and community care, health promotion and disease prevention programs, the Indian Residential Schools Resolution Health Support Program and the Health Services Integration Fund for First Nations and Inuit in the territories. There is no Indigenous or community government jurisdiction for the delivery of primary health care services – it remains a territorial government responsibility and responsibility cannot be delegated. However, in instances of self-government agreements, Indigenous governments may enter into agreements with the federal or territorial government to manage, administer, and deliver eligible health promotion and disease prevention programs. Every agreement recognizes jurisdiction over traditional healing, and the related training, regulations, and certifications for these practitioners and/or facilities.

The health and social services (HSS) system in the Northwest Territories (NWT) is made up of three health and social services authorities and the Department of Health and Social Services (DHSS). Together they operate under a one-system-approach and single governance structure across the five regions in the territory (the Northwest Territories Health and Social Services System). The Northwest Territories Health and Social Services Authority (NTHSSA), along with the Hay River Health and Social Services Authority (HRHSSA), the Tłı̨chǫ Community Services Agency (TCSA) and DHSS deliver health and social services

including diagnostic and curative services, prevention and promotion services, protection services, mental health and addictions services, continuing care and rehabilitation services. The HRHSSA delivers health and social services in the Hay River region and operates outside of the NTHSSA (employees of the HRHSSA have their own Collective Agreement and are not members of the Government of the Northwest Territories (GNWT) public service). The TCSA was established through the Tłı̨chǫ Intergovernmental Services Agreement and the Tłı̨chǫ Land Claims and Self-Government Agreement, as well as the Tłı̨chǫ Community Services Agency Act, as a result of a unique, comprehensive land claim agreement process. The TCSA delivers education, as well as health and social services in the communities in the Tłı̨chǫ region. The TCSA is a unique organization in the NWT; it is the only Government of the Northwest Territories Agency to deliver both health and social services as well as education programs under a single entity. Communities in the Project Area fall under the NTHSSA.

Role of Communities in the Health and Social Service System

Communities do not have any legal authorities for these health and social services. However, the HSS system does work closely with regions and Indigenous governments to ensure that local and regional voices and concerns are heard. Regional Wellness Councils (RWCs), which consist of local representatives from the area, advise Health and Social Services Authority regional leadership and the Northwest Territories Health and Social Services Leadership Council, as well as the Minister of Health and Social Services. The Northwest Territories Health and Social Services Leadership Council has membership from all three of the Health and Social Services Authorities. RWC members are change leaders in their communities and a voice for residents in their regions. They champion the ideas and concerns of residents and are passionate about using that information to shape and improve health and social services. RWCs help to identify priorities and provide advice and recommendations to support the delivery of culturally appropriate programs and services at the community, regional, and territorial level. RWCs seek opinions and information from individuals, organizations, groups, and community governments regarding the organization and delivery of health and social services and seek feedback and comments from Indigenous organizations regarding regional and local health and social services programs and services. They also play an important role in guiding primary care reform, community wellness activities, quality improvement and other community-based initiatives. RWCmembers have an opportunity to raise important community issues with the Health and Social Services Authorities through the Leadership Council and to communicate back to residents on those issues.

The GNWT is committed to providing support to NWT communities so that they can improve the wellness and health of residents. DHSS and the Health and Social Services Authorities make funding available to Non-Government Organizations to provide services either on behalf of the DHSS system or in addition to those delivered by the DHSS system, such as:

- Early childhood development;
- Family violence shelters and awareness;
- Health promotion activities;
- In-home and in-facility respite services for caregivers of seniors, children, or adults with special needs;

- Supportive services for seniors and persons with disabilities;
- Long-term care;
- On-the-land programs; and
- Prevention, promotion, assessment, early intervention, counselling, and treatment services related to mental wellness and addictions recovery.

Another key way the HSS system works with communities is through the Community Wellness Initiatives, which are intended to reduce health inequities and improve the health and wellness outcomes of Indigenous individuals, families, and communities in the NWT. In 2023-24, funding was distributed to 31 Indigenous Governments and community organizations and several territorial organizations that support Indigenous people's health and wellness throughout the territory based on their priorities. LAA and RAA communities all have Community Wellness Plans. The Department's approach to funding emphasizes capacity building and community-identified Indigenous health and wellness priorities. Locally developed Community Wellness Plans[1] are resourced with this funding. DHSS works with communities to help them develop community-specific wellness plans and offers gatherings for community coordinators where professional development opportunities and best practices are shared, and planning is supported. DHSS hires Indigenous facilitators and writers to engage individual communities to develop their Community Wellness Plans. These plans are flexible and can be updated to meet communities' changing needs. During 2023-24, the Department engaged all communities with wellness plans (all communities except Yellowknife and Hay River) to review their Community Wellness Plans which included priority setting, planning, and designing that will integrate the social determinants of health while continuing to inform the priorities of the health and social services system.

An example of how the Health and Social Service System works with communities can be seen with Délı̨nę (though it is acknowledged that all communities are different). In the Sahtu, the Délı̨nę Got'ı̨nę Government (DGG), through its self-government agreement, is working to establish its own health department. While the majority of health and social services programs and services are still delivered by the GNWT, DGG has been receiving funding to deliver programs related to health and wellness including the Healthy Families Program, the Canada Prenatal Nutrition Program, Community Wellness programming, and Anti-Poverty programming. These health promotion programs represent concepts designed and initiated by Canada and/or the GNWT and are funded through Contribution Agreements to DGG with accountability back to those governments. DGG has been taking on an expanding role in delivering a range of culturally responsive services that may include, but not be limited to, wellness and prevention programming, patient navigation services, mental health and addictions programming, and home and community care.

There are other ways the GNWT and DHSS work with communities to help them address social problems more directly through the provision of funding. Examples are provided below.

- 2023-24 was the first year that the Department administered the Community Wellness and Addictions Recovery (CWAR) Fund. The CWAR is the combination of the former Addictions Recovery and Aftercare Fund, On the Land Healing Fund and the Addictions Recovery Peer Support Fund. The CWAR fund prioritizes Indigenous Governments and supports the delivery of

[1] Community Wellness Plans are public, and can be found here: Community Wellness Plans | Health and Social Services (gov.nt.ca)

community-based mental wellness and addiction recovery programs that meet the unique needs of the respective communities. In 2023-24, there were a total of seven signed agreements, three of which were carried over from previous multi-year agreements.

- The Community Suicide Prevention Fund supports the delivery of culturally safe programs focusing on the prevention of suicide by increasing community wellness, reducing stigma, and supporting the development and implementation of suicide prevention strategies. In 2023-24, the Community Suicide Prevention Program supported eight agreements.

- Please see the response to IR27 for additional ways in which the GNWT works with communities on health and wellness priorities. While these lists are not exhaustive, they provide examples of how the GNWT supports and works with communities.

As well, as part of the development of components of the Community Readiness Strategy for the Project, the GNWT and communities will work together to determine whether and how to make use of community resources as part of the development and implementation of mitigation measures to address human health and community wellness. This will ensure that mitigations are appropriately responsive to community needs. The GNWT is continuing to engage with communities on the proposed mitigation measures related to health and well-being and will continue to do so throughout the environmental assessment process.

The response to this Information Request has been prepared in accordance with the Government of the Northwest Territories' Whole of Government Approach to the Mackenzie Valley Highway Environmental Assessment. Subject matter expertise from all relevant line departments has been considered in the drafting, review, and approval of this response. The GNWT is confident that all line departments are contributing to efforts to minimize negative social, cultural, and environmental impacts, while maximizing benefits for NWT residents from this project.

The following departments have been specifically involved in the drafting, review and approval of this response:

- The Department of Health and Social Services
- The Department of Infrastructure
- The Department of Environment and Climate Change